greatest extent possible, the natural soundscapes of units of the national park system. Additionally, NPS will restore to the natural condition wherever possible those soundscapes that have become degraded by noise. *Director's Order 47: Soundscape Preservation and Noise Management* further guides toward the maintenance and restoration of natural soundscapes. Director's Order 47 states that "nearly as many visitors come to national parks to enjoy the natural soundscape (91 percent) as come to view the scenery (93 percent)" (NPS 2000).

According to NPS, "Although noise has been used as a synonym for sound, it is essentially the negative evaluation of sound by people and is extraneous or undesired. Humans perceive sound as an auditory sensation created by pressure variations that move through a medium such as water or air and is measured in terms of amplitude and frequency" (NPS 2011j). Sources of noise within national parks are dependent on the particular park and may include vehicular sources (cars, buses, or other vehicles) used for tours and access to trails and campgrounds; aircraft overflights from planes, helicopters, and military jets along with airport development; snowmobiles and watercraft; park operations; and energy development (NPS 2009f).

Sound consists of pressure variations that move through a medium such as water or air, which are measured in terms of amplitude and frequency. The magnitude of noise is usually described by its sound pressure level. The range of sound pressure varies greatly, so a logarithmic scale in decibels (dBA) is used to relate sound pressures to a reference standard (20 microPascals in air, 1 microPascal in water). Sound pressure levels are often defined in terms of frequency-weighted scales (A, B, C, or D). The A-weighted decibel scale is used most commonly; it reflects the varying frequency sensitivity of the human ear to low level sounds (low level meaning 40 dBA above the human threshold of hearing at 1 kilohertz [kHz]). All of the sound level measurements in this document represent 1 second A-weighted average level measurements, or L_{Aeq},1s in the standard terminology of the American National Standards Institute (ANSI 1994). However, for simplicity and conformance with many other public documents, all sound level values will be denoted by "dBA," a more common term for the same measurement. Table 3-2 provides a reference list of sound levels for comparison.

SOUND LEVELS AT DRAKES ESTERO

Data were collected at the Seashore in 2009 to establish ambient sound levels in several areas of distinct vegetation, topography, elevation, and climate. Drakes Estero was identified as being a unique area within the Seashore, and measurements were taken at a bluff on the eastern shore of Drakes Estero over the course of 30 days in July/August of 2009. This site is located approximately 2 miles from the onshore DBOC operations. The measurement from this report that is used to roughly characterize the acoustic environment is the L_{50} measurement, L is a standard variable for sound measurements, and the L_{50} represents the sound level (in A-weighted decibels) that is exceeded 50 percent of the time. In other words, it is the median sound measurement. The daytime L_{50} for this site was 34 dBA, although daily L_{50} values varied between 44 dBA and 25 dBA (John A. Volpe National Transportation Systems Center [Volpe] 2011). These measured levels included noise from DBOC operations and other human activities, and they included natural sound energy from portions of the audio spectrum well above the noise energy generated by DBOC. Thus, these values overstate the natural background sound level in Drakes Estero relative to DBOC noise; however, it is the best available data and is a reasonable measurement of the existing soundscape against which comparisons can be made.

TABLE 3-2. INDOOR AND OUTDOOR SOUND LEVELS

Outdoor Sound Levels	Sound Level (dBA)	Indoor Sound Levels
	110	Rock band at 5 meters
Jet overflight at 300 meters	105	
	100	Inside New York subway train
Gas lawnmower at 1 meter	95	
	90	Food blender at 1 meter
Diesel truck at 15 meters	85	
Noisy urban area—daytime	80	Garbage disposal at 1 meter
	75	Shouting at 1 meter
Gas lawnmower at 30 meters	70	Vacuum cleaner at 3 meters
Suburban commercial area	65	Normal speech at 1 meter
	60	
Quiet urban area—daytime	55	Quiet conversation at 1 meter
	50	Dishwasher next room
Quiet urban area—nighttime	45	
	40	Empty theater or library
Quiet suburb—nighttime	35	
	30	Quiet bedroom at night
Quiet rural area—nighttime	25	Empty concert hall
Rustling leaves	20	
	15	Broadcast and recording studios
	10	
	5	
Reference pressure level	0	Threshold of hearing at 1 kHz

Source: Federal Highway Administration (FHWA) 1980.

Noise sources at DBOC are summarized in table 3-3. At 50 feet from the receptors, DBOC operations contribute between 71 and 85 dBA of noise to the natural soundscape within the study area. These dBA levels can be expressed in terms of NPS regulations regarding audio disturbances. The limit specified by NPS regulation is 60 dBA at 50 feet (36 CFR 2.12). A 71 dBA source (at 50 feet) has the same effect as more than 12 sources at the limit specified by NPS regulation. Additional perspective on how this sound is perceived and how it alters the soundscape of an area is discussed below.

The actual sound levels that would be experienced by a specific receptor would depend on the distance between that receptor and the noise source and the path noise would have to travel between the two points. In most environments, sound levels fall off with the square of distance from the source (spherical spreading loss), in addition to absorption and scattering losses that are directly proportional to distance. Spherical spreading loss alone causes a 20 dBA reduction in level with every tenfold increase in distance, or an approximate 6 dBA reduction for every doubling of distance. Therefore, if a motorboat is measured to produce 71 dBA at 50 feet, a kayaker would experience approximately 51 dBA at a 500 foot distance. Note that the temperature inversions may form when the water of Drakes Estero is substantially colder than the ambient air. Under these conditions, sounds can travel much farther over water than would be predicted by spherical spreading loss.

TABLE 3-3. NOISE GENERATORS AT DBOC

Equipment	Description†	Frequency of Use (Weather Permitting)†	Representative Sound Level at 50 Feet (dBA)[a]
Motorboat	20 HP, 4-cycle engine	Up to 12 40-minute trips/day	71*
Motorboat	40 HP, 4-cycle engine	Up to 12 40-minute trips/day	71*
Forklift	60 HP diesel engine	2 to 4 hours/day	79**
Pneumatic drills	Handheld hydraulic drills	Approximately 2 hours/day	85**
Oyster tumbler	Tube for sorting oysters by size, run by electric motor	Approximately 2 hours/day	79**

Sources: †DBOC [Lunny], pers. comm., 2011h; *Noise Unlimited, Inc, 1995; **FHWA 2006.
[a] Hourly values

Topography can affect sound transmission through air. Steep topography such as the bluffs around some of Drakes Estero can block sound transmission. Because the 2009 sound measurements used in this EIS were taken on a bluff well above Drakes Estero, the measurements may have recorded limited mariculture-related noises.

Wind conditions also have the potential to impact noise levels. Wind can increase the natural background sound level. Wind also can cause sound to bend away from the ground in the upwind direction and towards the ground in the downwind direction. Therefore, sounds may carry farther downwind than would be predicted by spherical spreading and may carry less far upwind. Strong winds inhibit formation of the temperature inversions discussed in the previous paragraph. Because the project area is located near the ocean it is likely to experience frequent winds, capable of carrying sounds greater distances downwind and dissipating them in other directions.

The closest weather station to the project area is at the Point Reyes Light Station. Average wind speeds over the past year have ranged between 9 miles per hour on April 1, 2010, and 22 miles per hour on March 30, 2011. Over the course of the year, over 30 percent of days experienced an average wind speed of 10 miles per hour. This area is exposed along the coastline and is subject to high winds, with maximum wind gusts of 79 miles per hour on March 19, 2011 (Western Regional Climate Center 2011). Because of its exposed location, this weather station may experience more windy conditions than are experienced within the relatively sheltered Drakes Estero.

The hourly wind speed recorded at the bluff above Drakes Estero during the July/August 2009 sound monitoring varied between 1 and 9 miles per hour (Volpe 2011). For the sake of comparison, daily average wind speed at the Point Reyes Light Station during the same period ranged between 2 and 25 miles per hour, with maximum gusts between 11 and 52 miles per hour (Western Regional Climate Center 2011). The actual sound levels at a particular receptor would be calculated based upon reference sound level data, the noise paths between the source and the receptor location, and the attenuation of sound levels over distance (FTA 2006). For instance, hikers along the Estero Trail would be unlikely to hear any of the noises associated with DBOC operations because of the noise attenuation associated with distance, wind, and topography.

Underwater sound levels at Drakes Estero have not been monitored by NPS, but several qualitative factors suggest that its natural sound levels would be unusually low. First, the relatively small expanse of Drakes Estero prevents generation of any substantial waves by wind. Second, this area is free from underwater sounds of breaking surf. Third, the narrow entrance and shallow bottom of Drakes Estero will prevent most sound originating outside of the system from intruding. Underwater soundscapes are generally more heavily affected by motorized boats than the above water environment. This is due to the capacity of sound to travel much farther in water than in air, the underwater exhaust systems of most boat engines, and the noise generated by cavitation from the propellers.

HUMAN AND WILDLIFE RESPONSE TO NOISE

The contribution of human-caused noise to the natural soundscape has the potential to impact wildlife and visitor use of the project area as well as the wilderness values of Drakes Estero. Noise has similar adverse effects on humans and wildlife. Noise interferes with sleep and communication, and it can present distraction or interference for other activities. Noise also interferes with hearing, preventing wildlife and humans from perceiving sounds they otherwise would have heard. Noise also causes physiological responses, and chronic exposure has been shown to elevate the risk of hypertension and stroke in humans (Jarup et al. 2008). Noise has been shown to annoy humans, though the degree of annoyance is idiosyncratic. Humans vary in their sensitivity to noise. Subjective responses to noise also depend upon the context. In the context of park noise management, it is important to characterize the resources and activities that are essential to the park's purpose (NPS 2000).

In the context of community noise management, some agencies have utilized laboratory studies of perceived loudness to interpret the effects of elevated levels of background sound. This practice has produced the generalization that a 10 dBA increase is perceived as roughly twice as loud. This subjective interpretation has several problems that discourage its application in national park settings. To illustrate its most serious defect, consider that a 10 dBA increase in noise exposure is produced when the number of noise sources is increased ten-fold. The subjective loudness interpretation asserts that ten times as many sources sound twice as loud, and one hundred times as many sources sound four times as loud. These assertions cannot be supported by science or everyday experience. In the dose-response studies where sound level is related to annoyance, the fraction of the community expressing annoyance roughly doubles with every 6 dBA of increase in noise level (ANSI 2008; ISO 2003).

Table 3-4 below provides reference points for how different sound levels can affect the ability for humans to communicate vocally. A normal speaking voice is approximately 65 dBA.

TABLE 3-4. EFFECTIVE COMMUNICATION DISTANCES

Sound Level (dBA)	Approximate Distance at which Vocal Communication Becomes Difficult (feet)
30 dBA	64
40 dBA	16
50 dBA	10
60 dBA	5
70 dBA	3
80 dBA	2

Source: EPA 1981

Given the wilderness context for evaluating effects in Drakes Estero, more appropriate measures of acoustical environmental quality address the capacity to hear natural sounds, or the capacity for park visitors to communicate without raising their voices. One useful index is the change in the maximum distance at which a sound can be detected (Barber, Crooks, and Fristrup 2010). By this measure, a 10 dBA increase in background sound levels reduces detection (or communication) distance to $1/\sqrt{(10)}$ of its original value, a 68 percent reduction. The area in which this sound could be heard is correspondingly reduced by 90 percent. This metric may be applied to wildlife and human perception of natural events, as well as to speech communication by park visitors. The only qualification applied to this metric is that the animal's hearing threshold must be lower than the natural ambient sound levels. This is true for many wildlife species, and all humans with normal hearing.

Wilderness areas are valuable for their undeveloped character, where humans are visitors and do not remain. Wilderness areas are also valuable as an opportunity for solitude. These values are articulated in the Wilderness Act (PL 88-577) and reiterated in related policies such as NPS *Management Policies 2006* and *Director's Order 41: Wilderness Stewardship* (NPS 2006d, 2011b). The noise from DBOC operations can detract from these values. The sounds serve as evidence of man's imprint on the natural landscape and can disrupt opportunities for solitude. Similarly, visitors wishing to enjoy a natural experience within the congressionally designated potential wilderness of Drakes Estero may not welcome these disturbances; noise may reduce visitor enjoyment of recreational use of the project area. For additional background on wilderness qualities, please see the "Impact Topic: Wilderness" section.

Wildlife also is very sensitive to sound, as animals often depend on auditory cues for hunting, predator awareness, sexual communication, defense of territory, and habitat quality assessment (Barber, Crooks, and Fristrup 2010). High ambient sound levels from human voices, and sound events associated with human activities (e.g., driving cars, hiking), have been observed to have negative population-level, behavioral, and habitat-use consequences in many species (Frid and Dill 2002; Landon et al. 2003; Habib, Bayne, and Boutin 2007). Human activities can disturb seals at haul-out sites, causing changes in seal abundance, distribution, and behavior, and can even cause abandonment (Suryan and Harvey 1999; Grigg et al. 2002; Seuront and Prinzivalli 2005; Johnson and Acevedo-Gutierrez 2007). The impacts of underwater noise on marine mammals have been widely documented during the past 40 years, and have been the subject of three reports by the NAS (NAS 2003).

The effects of noise on birds have been studied extensively, because of their prominent acoustical displays to attract mates, maintain bonds with mates and offspring, and alert others to predators (Francis, Ortega, and Cruz 2009). Similar to physical degradation of the habitat caused by development or other human activities, the low-frequency, high-amplitude, nearly omnipresent sound produced by roads, vehicles, airports, and mechanical equipment has been found to cause a decline in species diversity, abundance, and breeding success (Rheindt 2003). Additional detail on the ways in which sound levels impact wildlife can be found in the separate impact topic sections on wildlife and wildlife habitat.

IMPACT TOPIC: WILDERNESS

Point Reyes National Seashore is one of 46 units within the national park system that includes congressionally designated wilderness areas. The Wilderness Act (PL 88-577) was passed on September 3, 1964, to establish a national wilderness preservation system made up of designated wilderness areas.

Wilderness areas are defined, in part, as follows:

> An area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain. . . . An area of undeveloped Federal land retaining its primeval character and influence, without permanent improvements or human habitation. (PL 88-577)

Section 3(c) of the Wilderness Act required that the Secretary of the Interior review “every roadless area of five thousand contiguous acres or more” within the national park system and report to the president his recommendation as to the suitability of these areas for preservation as wilderness. The president is then to advise Congress of his recommendation with respect to the designation of each area. A presidential recommendation for designation as wilderness becomes effective only if so provided by an act of Congress (PL 88-577).

In 1972, the Seashore published its initial wilderness recommendation for an area of about 5,150 acres for the purpose of preservation of wilderness areas. As required by the Wilderness Act, a public hearing was held on the preliminary wilderness proposal for the Seashore at the Marin County Civic Center in San Rafael, California, on September 23, 1971. A total of 211 people attended, and a total of 4,658 responses to the proposal were received (NPS 1972b). Public comments received were varied. Several nationwide conservation groups (such as the Sierra Club and the National Parks Conservation Association [NPCA])