APPENDIX H
MARINE MAMMAL TECHNICAL REPORT

PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Report.
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1.0 Introduction

1.1 Report Goals

The proposed CCCSIP Project would take place in central California. The main component of the Project is to undertake a 3D seismic survey in the relatively shallow waters depths (<400 m) in the vicinity of the Diablo Canyon Power Plant. The proposed Project description has an 81¼ day schedule and includes up to 40¼ days of nearshore 3D seismic surveys across four target areas. There are also related onshore activities. Two alternatives are proposed. Alternative 1 excludes one of the northern target areas. Alternative 2 has a 93 day schedule and includes up to 53 days of seismic surveys across 2 zones (Zone 1, the northern area and Zone 2, the southern area). The proposed Project was modified in January 2012. Prior to this date, Alternative 2 was considered the Project. A sound source verification period of 5 days is scheduled to validate expected source output characteristics and propagation predictions based on empirical measurements.

At least 22 species of the order *Cetacea* (whales, dolphins, and porpoises), 6 species of the suborder P*innipedia* (seals, sea lions and fur seals) and 1 species of the family *Mustelidae* (sea otters) are known to occur in the waters (<2000m depth) of central California. This supplementary technical report aims firstly to review the CCCSIP Project to assess the potential level of impacts to marine mammals from the Project, especially from in-water airgun-related seismic activities. Secondly, it makes recommendations for additional mitigation measures aimed at reducing any residual impacts. Lastly, it assesses the proposed alternatives for comparison.

Significance thresholds for the project were pre-defined as the following:

- ***a)*** ***Result in the "take" of special status species in accordance with current NOAA Fisheries policies for marine mammals, and/or result in underwater or in-air noise levels that are equal to or exceed current NOAA Fisheries guidelines for Level A or B harassment of marine mammals (i.e. in-water levels exceeding 160 dB re: 1 µPa root mean square (rms), or in-air levels generally at or above 90 dBA re: 20 µPa for level B harassment; higher levels are used for level A harassment).***
- ***b)*** ***A substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the California Department of Fish and Game, the U.S. Fish and Wildlife Service, or the NOAA Fisheries.***
- ***c)*** ***A substantial interference with the movement of any native resident or migratory fish or wildlife species, or with established native resident or migratory wildlife corridors, or impede the use of a native wildlife nursery site.***
- ***d)*** ***A substantial reduction in the habitat of a fish or wildlife species.***
- ***e)*** ***Cause the population of a fish or wildlife population to drop below self-sustaining levels.***

Thus, the main goals were firstly, to define the key Project stressors, as well as the appropriate geographical scope of potential impacts, relevant time period and methods for the assessment. Secondly, to determine those species that are likely to have a "take" at NOAA Level B harassment levels or above (Significance Threshold a). Thirdly, determine a 'shortlist' of candidate species and assess residual (after incorporating the applicant proposed measures, APMs) potentially substantial adverse effects at the population (stock) level (i.e., Significance Threshold b-e), including Level A or B harassments. For the population level assessment, a **dual threshold criteria** approach was adopted to estimate acoustic takes and assess potential impact. Newly developed threshold criteria (aiming to incorporate recent scientific findings and methodologies, notably those recommended by Southall et al.

2007), were used in the population level assessment and results compared with takes using the current NOAA Fisheries (NMFS) thresholds for defining Level A and B acoustic harassment.

1.2 Population Impact Assessments

There are major limitations in the existing information available to support the development and application of any procedure for accurately assessing potential seismic impacts on marine mammal populations, particularly on the west coast of the U.S. where these events and scientific measurements of their potential impact are quite rare. Consequently, the level of scientific uncertainty underpinning many elements of our assessment framework varies considerably. Notably, data is clearly limited in determining appropriate species-specific noise thresholds to determine the radius of both hearing and behavioral impacts (e.g., Southall et al. 2007; Gedamke et al. 2011), as well as quantitatively linking subsequent cumulative individual-level effects to population demographic parameters (see NRC 2005). Population viability, energetic and behavioral/movement models, while considered informative, were not within the scope of this assessment review. Our information review instead aims to make a balanced, pragmatic but precautionary (where data is sparse or highly variable) evaluation based on information in the literature, our dual criteria take analysis and expert opinion. Following preliminary scoping, we focused our impact assessment on 16 key species considered at potential risk of substantial adverse effects. Robust estimates of animal density that incorporate temporal and spatial variability are considered a vital input to any impact assessment. However, for wide-ranging species, accurate local estimates for a particular season are hard to obtain and certainly (for many species) are not easily predictable, as they can often reflect environmental fluctuations and the vagaries of lower-level trophic recruitment success (Peterson et al. 2006). In such cases, scenario assessments that explore potential variability in density are useful and relevant verification information from field scientists and local operators should be utilized to ensure reality and reliability. In addition, appropriate pre-survey assessment measures become increasingly important for potentially susceptible species that show strong inter-annual density variability, as does the evaluation of the biological importance of the zone of impact and levels of life-history adaptability that vary across resident, migrating or dispersed wide-ranging species.

For this project, we developed a simple matrix-based methodology to evaluate the significance of potential impacts based on their context, intensity and likelihood of occurrence (taking into account the APMs). Criteria for ESA-listed species require lowered thresholds for precautionary reasons.
Given the levels of known variance in key parameters affecting potential responses as well as the acknowledged uncertainty in assessing acoustic impacts, it was also considered necessary to explore the potential effects of differing circumstances and methodological approaches. The resulting ranges in the number of harassments (or takes) predicted in various theoretically “possible” scenarios, potentially may lead to a range of different impact predictions from best to worse case scenarios. Precautionary scenarios combined with the impact matrix methodology are considered useful to focus the assessment on which taxa or species in particular require additional mitigation and highlight potential population scale of effects considerations that include non-standard approaches.

The potential effects of anthropogenic noise on marine mammals is a rapidly expanding field of science and a review of current knowledge is warranted, especially when developing and interpreting acoustic take analyses.

2.0 Summary review of anthropogenic noise effects on marine mammals

2.1 Noise overview

Both solitary and social mammals rely on communication and sensing of their environment for various important life functions (reproduction, foraging, etc.). This communication and environmental sensing utilizes a number of production and sensory organs. However, a species' ability to utilize different modalities depends on physical limitations imposed by the environment in which that species communicates. Water is relatively opaque to light and chemicals diffuse slowly. This has placed a selective pressure on marine mammals that has resulted in a heavy reliance on sound to sense and communicate within their environment. Because of this, an increase of acoustic noise in the marine environment can have potentially serious implications for the basic life functions of marine mammals.

The oceans are noisy environments. Sources of noise include wind, waves, rain and earthquakes (abiotic noise sources) as well as shrimp, fish and marine mammals (biotic noise sources). However, over the last two decades, concern has been mounting over the noises that human activity generates (anthropogenic noise). This noise is either generated as a byproduct of an activity (shipping, construction, etc.) or used as a method of gathering data (sonar, depth sounding, seismic surveys).

The impact this anthropogenic noise has on marine mammals varies a great deal depending on a variety of biological and environmental factors, from no effect to potentially lethal. A large amount of research over the last two decades has attempted to quantify these effects. There are a number of reviews on this subject (Richardson et al. 1995; Southall et al. 2007; Nowacek et al. 2007; Gotz et al. 2009), which we briefly review, then focus specifically on reported effects from seismic surveys, especially the more recent and relevant scientific studies.

2.2 Classification of noise and species hearing to predict noise effects

Mammalian hearing evolved on land and follows a fairly standard architecture with an outer ear that collects sound from the environment and conveys it to the middle ear where it is amplified and conveyed into the inner ear which acts as a bandpass filter. This filtering happens in the cochlea where hair cells in different regions are sensitive to different frequencies of sound. This basic architecture holds true for most terrestrial mammals and, with a few modifications for an aquatic existence, for marine mammals as well. Most marine mammals have lost external evidence of the outer ear and have developed alternative pathways to convey the sound to the middle ear. However, the middle and inner ear are little changed, other than specializations that allow for different hearing ranges (Wartzok and Ketten 1999).

Southall et al. (2007) classify marine mammals into five functional hearing groups. While these fall along taxonomic lines to some extent, they were more explicitly defined based on similarities in known or expected hearing capabilities, as well as underwater and aerial hearing for relevant groups. These groups include three cetacean groups (low-frequency, mid-frequency, high-frequency) and two pinniped groups (in water, in air). Low frequency cetaceans include all the baleen whales (suborder Mysticeti), while toothed whales (suborder Odontoceti) are split between mid and high-frequency groups. The mid-frequency group comprises most dolphin species, false killer whales, sperm whales, beaked whales, etc., while the high-frequency group is made up of porpoises and a few other high frequency specialists. Pinniped in-air versus in-water reflects this amphibious group's different hearing capabilities in water and air. This group includes all species of seals, sea lions, fur seals and the walrus. Based on the hearing similarities within these functional hearing groups, Southall et al. (2007) developed a series of frequency weighting curves (termed M-weighting) that allow one to compensate for the hearing abilities of these groups while calculating the received levels of various sounds.

Because of the lack of direct data on hearing and the effect of noise on hearing in most marine mammal species, it more appropriate to make inferences on hearing damage and hearing loss in marine mammals based on research on terrestrial mammals when data are not available for marine mammals (Southall et al. 2007). When permanent hearing loss occurs in terrestrial or marine mammals, it is usually caused by damage to the hair cells in the cochlea. For all mammals therefore the following general ‘rules’ apply to patterns of hearing loss. Sudden, loud and impulsive sounds can cause hearing damage, as can long exposures to quieter sounds. Temporary or permanent loss of hearing will occur almost exclusively for noise within the animals hearing range, with the maximum hearing loss commonly occurring ~ ½ an octave above the frequency of the main energy of the damaging noise.

Because of this amplitude/duration aspect of noise and the frequency dependency of the receiver in terms of the potential for hearing damage (and other noise effects), it makes sense to classify noise by its amplitude/duration, and the receivers (animal taxa) into groups that hear similar frequency ranges. Southall et al. (2007) classify anthropogenic sounds into the following groups: non-pulses, single pulses, and multiple pulses. Non-pulses are single or repeated acoustic events that have less than 3 dB of difference between amplitude measures using a long versus short time window. Examples include ship noise, construction, low frequency sonar, etc. Single pulses are single acoustic events (one per 24 hour period) that have a greater than 3 dB difference in amplitude measurements using long versus short time windows. Examples include a single explosion, a sonic boom, etc. Multiple pulses are more than one pulse in a day and include activities like pile driving, some depth sounders and multiple firings of seismic airguns.

2.3 Types of noise effects

Sound is limited in duration by the time over which the source produces it. To be detected by an animal at sufficient levels to induce an impact, the receiver must be within sufficient proximity to the source. In other words, the animal must be within sufficient range at the time the sound is being produced, for the sound to have an impact on it. In addition, the amplitude, duration and frequency of the noise, as well as the hearing ability and behavioral state of the animal, all influence how or if there is an impact on the animal. Impacts (if any) range from acoustic masking to disturbance, temporary hearing loss, permanent hearing loss, and other physiological effects, including stranding and/or death. Evidence has been mounting that acoustic impacts are occurring at all these levels in marine mammals. For example, killer whales increase the amplitude of their calls to avoid masking by boat noise (Holt et al. 2009), commercial shipping may dramatically increase calls of con-specific baleen whales (Clark et al. 2009), migrating gray whales change direction to avoid noise from seismic surveys (Malme et al. 1984) and temporary hearing loss has been demonstrated in a captive bottlenose dolphin (e.g., Mooney et al. 2009a). Of higher concern, there have been a number of strandings of beaked whales in areas where naval sonar exercises have recently occurred. There is uncertainty about the mechanism of injury (whether the injuries were caused by high levels of sonar or by a behavioral reaction of the animals to the sonar at levels below those which would cause direct tissue damage), but strong evidence exists that beaked whale species are at risk from naval sonar in some circumstances (Cox et al. 2006; D’Amico et al. 2009).

In spite of this mounting evidence, there are still large data gaps and uncertainty. For example masking can be tested directly in captive species (e.g., Erbe 2008), but in wild populations it must be either modeled or inferred from evidence of masking compensation (see masking section below). Likewise in studies of hearing loss, tests can be done in captivity and models applied to estimate this impact in the wild. All of these impact models rely on three main inputs; the propagation of the noise, the hearing abilities of that species, and the behavioral reaction of that species to the noise. All of these inputs are complex and require a number of other additional inputs themselves. Modeling noise propagation has benefited from concerted efforts over many years, but can vary a great deal with local bathymetry and local oceanographic conditions, such that noise is not always lower in amplitude the further it has travelled (e.g., Madsen et al. 2006a). A number of propagation models are however available (Range Dependent Acoustic Models (RAM), ray tracing, normal modes, parabolic equations, wave number integration) that do well at approximating *in situ* noise propagation. These predictions can and should be verified with tests on site (as has been proposed for this study) and can vary a great deal by distance, depth and frequency.

Hearing in marine mammals is multifaceted and much more complicated than just understanding the hearing sensitivity across frequency (auditory curve). For example, robust masking predictions require knowledge of the frequency integration of the ear (critical bandwidth), as well as temporal integration, critical ratio, directivity index, etc. Hearing loss is affected by the amplitude, frequency, duration, duty cycle, and directionality of the noise to which the animal is exposed, as well as intrinsic features of the exposed animal including its susceptibility to and recovery from noise exposure. Many of these variables can only be tested accurately in captive animals, but it is costly, time consuming and limited to certain marine mammal groups given logistical considerations (e.g., the lack of a sufficient facility to house and test the hearing of a large whale). Due to this fact, while the hearing abilities of over 20 species have been tested so far, only a few species (3-4) and a few individuals have been tested comprehensively. Therefore most of these variables have not been tested directly in most species of marine mammals, and little to nothing is known about the individual variation of these variables within a species. Likewise behavioral reactions are easier to quantify in captivity, but suffer from small sample size and difficulty in extrapolating these measurements to wild populations. Meanwhile behavioral reactions in wild populations are difficult to quantify (especially if the reaction is subtle), are logistically challenging, and can vary a great deal depending on a number of factors (see behavioral reaction section below). This leads to a situation where our ability to predict acoustic impacts is impaired by our lack of appropriate input parameters and lack of understanding of the variability in those parameters.

2.4 Masking

Acoustic masking occurs when a noise impedes the ability of the animal to perceive a signal. For this to occur the noise must be loud enough, have similar frequency content to the signal, and must happen at the same time. We consider each of these signal and noise characteristics (loudness, frequency content and timing) in sequence. The minimum amplitude at which a signal can be heard above the background noise is termed the Critical Ratio (CR). More specifically, the CR is the amplitude difference between the pure tone signal (in dB re 1µPa) and the spectrum level of the background noise at that frequency (in dB re 1 μPa^2/Hz) that is needed for the animal to hear the signal. A signal that is received at a level below the CR in relation to the background noise will be masked. Critical ratios at low frequencies are fairly constant, but at mid frequencies start to increase with frequency. Johnson et al. (1989) found a roughly constant CR for a Beluga whale from 40 to 2,000 Hz (~18 dB), but that the CR increased up to ~40 dB at 100 kHz. Au and Moore (1990) measured CRs in a bottlenose of ~31 dB at 30 kHz and ~45 dB at 140 kHz.

Likewise Southall et al. (2003) found increasing CRs with frequency in pinnipeds and also that they were very similar for individual seals and sea lions tested both in air and water; that is, for pinnipeds the masking effect of noise is similar regardless of the medium in which they are exposed.

In addition to the amplitude difference between the signal and the noise, the frequency content of the signal and noise also affect the level of masking. As discussed above, the inner ear acts as a bandpass filter in converting the received sound from mechanical to electrical energy. This bandpass filtering is achieved by having different hair cells along the cochlea ‘tuned’ to different frequencies.
However these hair cells are not just sensitive to the frequency they are ‘tuned’ to, but also to a range of frequencies (a band) around this frequency of highest sensitivity. Thus the same hair cell that responds to a pure tone signal, will at the same time be responding to a band of frequencies from any noise that is present. The energy from this band of noise will be added to the stimulation of that hair cell and if enough noise it present will have more combined energy than the signal tone and therefore cause masking. The width of the frequency band over which hair cells are sensitive is called the Critical Bandwidth (CBW). Noise outside the CBW will have little effect on the detection of a signal in that band, unless the noise is very loud. CBWs tend to be proportional to the frequency of sensitivity, rather than a constant bandwidth (i.e. CBW are described as 1/3 of an octave rather than 1 kHz).The wider the CBW the more likely broadband noise is to mask a signal. At the upper and lower end of hearing though, CBWs tend to be wider, and therefore these regions may be more susceptible to masking (Richardson et al. 1995).

The relative timing of a signal and noise also impacts the level of masking. The noise must occur at the same time as the noise to produce masking. In addition, repeating a signal, or lengthening it may also reduce the amount of masking. For example, there is some evidence that repetition of signals in seals and odontocetes increases their detectability (Moors and Terhune 2004; Johnson 1991). Likewise, on small time scales, increases in duration of a signal can increase their detectability (Kastelein et al. 2010).

Studies demonstrating the masking effects of anthropogenic noise on marine mammals typically find masking impacts by documenting masking compensation strategies (responses the animals use to overcome the masking effects of the noise). For example, in response to anthropogenic noise marine mammals have increased the duration of their calls (humpback whales: Miller et al. 2000), altered the pitch of their calls (right whales: Parks et al. 2007), called more or less often (blue whales: Di lorio and Clark 2009) and called louder (killer whales: Holt et al. 2009). There have also been efforts to quantitatively predict the spatial zones associated with potential masking effects from anthropogenic sounds (e.g., Clark et al. 2009). Although masking effects have been documented in a number of species, it is very difficult to quantify the survival or reproductive consequences of this masking on an individual, let alone quantifying the effect of masking on the population. The National Research Council (NRC, 2005) developed a conceptual model (termed Population Consequences of Acoustic Disturbance: PCAD) to help guide the process of quantifying these population level effects from acoustic disturbances of individuals. Research in this area is ongoing and it is expected that potential impacts on communication ability for marine mammals in areas of elevated noise may increasingly become part of the process in future environmental assessments.

The sound generated by seismic surveys are, by design, brief, impulsive and low frequency (strongest from 10 to 120 Hz), but energy has been measured up to 100 kHz (Richardson et al. 1995; Bain & Williams 2006; Gotz et al. 2009), resulting in overlap with the hearing sensitivities of not only baleen whales, but also odontocetes and pinnipeds. For example, Goold and Fish (1998) found that noise from seismic airguns dominated the 200Hz-22 kHz bandwidth at ranges of up to 2km from the source and that even at 8km airgun noise exceeded background noise at frequencies of up to 8 kHz. Airgun direct path pulses are quite short on the order of tens of milliseconds, but the effective source level of full-scale airgun arrays can be quite high (up to ~260 dB (p-p) re 1 µPa @ 1m; Gotz et al. 2009) and the duration of the signal is affected by multipath propagation (e.g., reverberation can occur). The CCCSIP Project description states that airgun pulses would occur every 15 to 20 seconds (giving a pulse every 30 to 50m) during the survey, however the narrative also discusses producing pulses every 25m which translates into an airgun pulse every ~11 seconds, and more recently every 37m. Masking impact of this temporal scale of noise source needs to consider how vocal species use different sounds (phrases, songs, bouts) and the timescales they occur over. The frequency overlap between the primary energy of airgun pulses and baleen whales is considerable, which increases the likelihood of masking. The overlap in time between transmitted airgun impulses and communication however is relatively small with most species producing sounds from 1 to 30 seconds long, and humpbacks making songs up to 30 minutes long (Richardson et al. 1995; Stafford et al. 2011). Given the disparity in temporal features, baleen whales are considered likely to be able to detect conspecific calls in between airgun pulses, but some of the salient acoustic features that code information could potentially be obscured. However, although the amplitude of the seismic pulses will usually be lower at greater distances from the source, multipath arrivals can increase the relative duration of a transmitted pulse because the energy gets there through multiple paths, thus adding to the potential for masking. Related to these multiple arrivals, in a reverberant environment, the duration of the seismic pulses will also increase with transmission distance, such that at large distances the pulse may become more of a continuous noise. For example, Clark and Gagnon (2006) documented a cessation of fin whale vocalizations across an area of 10,000 square nautical miles during a seismic survey. Vocalizations resumed after the end of the survey suggesting the whales were not displaced, but merely stopped vocalizing. This may be an indication that masking was occurring and that cessation of vocalizing during the occurrence of the airgun noise was the best option from a cost-benefit perspective for the exposed whales. It is therefore plausible that either, baleen whales exposed to this proposed survey may stop vocalizing, or that their calls may be masked. Further evidence of potential baleen whales masking is suggested by Di Iorio and Clark’s (2009) finding that Blue whales increased their calling rate during a seismic survey using sparkers (a lower amplitude seismic survey technique). However migrating whales would be exposed to the seismic pulses for less than a day and therefore not cause long term masking for these individuals.

There is evidence that mid frequency cetaceans continue to utilize calls and echolocation during seismic surveys. Goold and Fish (1998) reported whistles and clicks from common dolphins during a seismic survey although they did not specifically test for masking effects. Miller et al. (2009) also reported a continuation of foraging clicks from sperm whales exposed to airgun noise. There was some evidence (although not significant perhaps due to small sample size) that buzz train rates decreased during seismic exposure and one whale rested on the surface for longer than usual, but began a foraging dive after the end of the seismic exposure period of the experiment. However, because of the lower frequency overlap, masking is less likely in mid frequency cetaceans than it is in baleen whales. Likewise, with high frequency cetaceans, the frequency overlap will be even lower. No data is available to our knowledge of vocalizing high frequency cetaceans exposed to seismic airguns; however data are available for pile driving (another multiple impulse noise). Carstensen et al. (2006) report detecting echolocation clicks of harbor porpoises before and during construction of an offshore wind farm, although the latency between echolocation bouts was much larger during construction than before. This could mean that harbor porpoise were displaced during construction or that they ceased echolocating during the construction. Given known harbor porpoise skittishness to human activities (Johnston 2002; Olesiuk et al. 2002; Kastelein et al. 2006, Madsen et al. 2006b), the former is more likely, which would also likely lead to less masking potential from multiple impulsive sounds such as airguns.

Pinniped vocalizations are generally low frequency (<10 kHz) and are usually associated with mating displays, territoriality or mother-pup interactions (Richardson et al. 1995). Harbor seals produce low frequency (<4kHz) displays under water for courtship and pups make calls with fundamental frequencies of ~350Hz. Elephant seals, California sea lions, and Steller sea lions all produce low frequency sounds, but usually above water in relation to social interactions, aggression, territoriality and mother-pup interactions (see Richardson et al. 1995). Some of these sounds either travel through the water when made by an individual with its head above the surface, or are made underwater. However given the nature of the context in which these sounds are made (close distance social situations), they are likely but one of several modalities in which those interactions are mediated. Sea otter vocalizations seem to be restricted to airborne signals (Richardson et al. 1995) so reducing likelihood of masking from underwater airgun noise.

2.5 Behavioral disturbance

Disturbance from noise can take many different forms from very subtle shifts in breathing patterns or slight changes in direction of swim to startle responses that lead to flight of the animal from the area. As more studies have documented noise disturbance in various species, it has become apparent that the response of an individual to noise will vary greatly depending on a number of different factors. Wartzok et al. (2003) categorized these variables into two groups as follows; **internal**, animal-specific factors that affect an individual's response to noise and **externa**l factors related to the context of exposure that mediate the probability of different types of behavioral response. Internal factors include:

- individual hearing capability, activity pattern, and motivational and behavioral states at the time of exposure;
- past exposure of the animal to the noise, which may have led to habituation or sensitization;
- individual noise tolerance; and
- demographic factors such as age, sex, and presence of dependent offspring.

While external factors include:

- non-acoustic characteristics of the sound source, such as whether it is stationary or moving;
- environmental factors that influence sound transmission;
- habitat characteristics, such as being in a confined location; and
- location, such as proximity of the animal to a shoreline.

These internal and external factors make it logical to develop separate thresholds for behavioral disturbance for cetaceans and pinnipeds (e.g., see Ellison et al. 2011). Behavioral responses of cetaceans and pinnipeds to noise have been extensively reviewed (NSF-USGS 2011; Nowacek et al. 2007; Southall et al. 2007) and all report that responses, even within a species, vary greatly as a function of a number of biological and environmental parameters.

Mysticetes: A number of baleen whale species exhibit clear behavioral reactions to seismic surveys. Bowhead whales (*Balaena mysticetus*) have received the most research attention in regards to noise from seismic surveys. At received levels from 120-130 dB re: 1 μPa (rms) migrating bowhead whales show strong avoidance reactions (Richardson et al. 1999; Manly et al. 2007). However bowheads appear much more tolerant of seismic noise while they are feeding and remain in the area until levels exceed ~160 dB re: 1µPa (rms) (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 2005). Likewise feeding humpback whales show behavioral responses starting at levels from 150-159 dB re: 1µPa (rms) (McCauley et al. 1998). Migrating gray whales changed their course starting at received levels of 110 dB re: 1µPa (rms) and by the time the levels reached 130 dB re: 1µPa (rms), 80% of the migrating whales were changing their course (Malme et al. 1984).

Odontocetes: Dolphin and other toothed whale species seem to show a variety of reactions to seismic surveys. Stone and Tasker (2006) reported on observations undertaken during 201 seismic surveys in UK and adjacent waters and results demonstrate that cetaceans can be disturbed by seismic exploration. Small odontocetes showed the strongest lateral spatial avoidance (extending at least as far as the limit of visual observation) in response to active airguns, while killer whales (and mysticetes) showed more localized spatial avoidance. Long-finned pilot whales showed only a change in orientation and sperm whales showed no statistically significant effects. The authors suggested that the different taxonomic groups of cetaceans may adopt different strategies for responding to acoustic disturbance from seismic surveys; some small odontocetes move out of the immediate area, while the slower moving mysticetes orient away from the vessel and increase their distance from the source, but do not move away from the area completely. In contrast, sperm whales show little response to seismic surveys, but may disrupt/delay foraging (Mate et al. 1994; Madsen et al. 2002; Stone 2003; Stone and Tasker 2006; Jochens et al. 2008; Miller et al. 2009). Other studies document that small odontocetes show some avoidance at distances less than 1 km (Stone 2003; Gordon et al. 2004; Stone and Tasker 2006), however some also approach the seismic vessel and even bow ride (Haley and Koski 2004; Smultea et al. 2004; Holst et al. 2005). Dall's porpoise also show little avoidance of seismic survey vessels, but harbor porpoise have been reported moving away from surveys at received levels <155 dB re: 1 µPa (rms) (Calambokidis and Osmek 1998; Bain and Williams 2006). Harbor porpoise have also been shown to be displaced from an area for 24 to 72 hours after being exposed to a cumulative M-weighted Sound Exposure Level (SEL) of 157 dB re: 1 $\mu Pa^2 \cdot s$ from pile driving, another repeated impulsive sound (Brandt et al. 2011). The metric SEL is considered to be biologically realistic in the sense that it incorporates the duration of the noise into the noise metric as well as the received level, unlike rms that only incorporates the received level. No direct measurements of beaked whale responses to impulsive sounds are available, but given their strong avoidance of vessels, it seems likely that they will demonstrate behavioral avoidance at received levels comparable to harbor porpoises.

Pinnipeds: Little data exists on pinniped exposure to seismic pulses and what is available indicates limited reaction or short term localized avoidance (Harris et al. 2001; Miller et al. 2005).

Mustelids: Malme et al. (1984) reported no foraging or behavioral change in Southern sea otters exposed to playbacks of seismic survey noise as close as 900 m. They may however demonstrate local avoidance response to the presence of the survey vessels. Udevitz et al. (1995) report 30% of the sea otters in an area displayed avoidance when a vessel was at 100 m.

2.6 Temporary and Permanent Hearing Loss and Basis for Acoustic Thresholds

Temporary hearing loss (Temporary Threshold Shift: TTS) and permanent hearing loss (Permanent Threshold Shift: PTS) are natural factors of aging and noise exposure. Industrial sounds increase the occurrence of TTS and PTS in humans, which explains government attempts to mitigate this issue with occupational safety standards that limit human exposure to industrial noise (e.g., OSHA standard 29 CFR 1910.95). Given our shared mammalian ancestry, anthropogenic noise has the potential to cause TTS and PTS in marine mammals as well. PTS has not been demonstrated experimentally in marine mammals for ethical reasons, but a growing body of work has demonstrated TTS onset in several different species of marine mammals caused by noise (e.g. Finneran et al. 2002; Lucke et al. 2009; Finneran et al. 2010). The onset of TTS has generally been defined as a 6 dB difference in hearing sensitivity before versus after the noise exposure. In humans a TTS beyond ~40 dB increases the likelihood of PTS significantly (Kryter et al. 1966) and Southall et al. (2007) therefore use this threshold to estimate the PTS threshold in marine mammals. In chinchillas, the growth rate of TTS beyond the TTS threshold of 6 dB follows a slope of roughly 2.3 dB of additional TTS for every dB increase in impulsive noise (Henderson & Hamernik 1986). Thus, Southall et al. (2007) estimate that PTS from impulsive sound is likely to occur in marine mammals at ~15 dB above TTS onset. This is based on 40 dB TTS (from humans) – 6 dB TTS (TTS onset definition), divided by 2.3 dB TTS per dB of noise exposure (based on growth functions measured in chinchillas). Evidence of TTS onset will be discussed below, but it is important to note that there are a number of acoustic measurements that could be used as PTS/TTS thresholds.

Current NMFS acoustic thresholds for seismic and sounds other than those associated with U.S. Navy activities are based exclusively on dB rms measurements and 1980s estimates of such levels associated with hearing impact as opposed to the direct measurements that have been made subsequent to establishment of the thresholds. As discussed above, the duration over which the rms is calculated can vary significantly for impulsive sounds and the use of this metric for characterizing impulse noise has been questioned (Madsen et al. 2006b). In addition, the duration and impulsive nature of the sound also determine the potential level of PTS. Therefore thresholds based on rms values alone are not very predictive of the likelihood of PTS onset. Using an alternate threshold such as SEL, that incorporates the duration of the noise into the noise metric as well as the received level, is considered to be more biologically realistic. Consequently, Southall et al. (2007) suggest SEL thresholds for TTS onset and consequently the predicted PTS-onset levels they estimated. As has been observed for humans (see Kryter et al. 1996), recent work in marine mammals also demonstrates that TTS onset is not perfectly correlated with received SEL levels either; rather duration appears to have a larger impact on TTS onset than predicted by SEL levels and that recovery time between noise exposure also has an impact on the levels of TTS (Mooney et al. 2009b; Finneran et al. 2010b). At this point, SEL remains a better metric for the prediction of injury onset than rms, but with some demonstrated limitations similar to those observed in predicting TTS dependence on sounds of different exposure level and duration in terrestrial mammals; these threshold metrics will clearly need to be re-evaluated regularly as new data are reported.

There are no direct measurements of TTS/PTS in baleen whales given our inability to test their hearing in the wild. Gedamke et al. (2011) did model the potential for TTS onset for baleen whales. Their model does suggest that TTS (and possibly PTS) onset from seismic surveys is plausible over ranges of several kilometers, however the uncertainty of the inputs to the model (i.e. the extrapolations of noise impacts and hearing in other species) as well as individual variation can have a large impact on the estimates which must at this point be considered speculative (as the authors themselves state). In addition, much of the cumulative SEL is due to the loudest airgun pulses when the animal is closest to the airgun array. Onset of TTS from pulsed watergun/airgun noise has been tested in three species of cetaceans. Finneran et al. (2002) exposed a beluga whale and bottlenose dolphin to watergun noise. The beluga showed TTS onset at 186 dB re: 1 µPa^2·s (equivalent to 183 dB M-weighted), however the dolphin did not show indication of TTS at the levels this experiment was able to produce. The level for the beluga was therefore used in the initial Southall et al. (2007) threshold for all cetaceans (198 = 183 + 15). However, Lucke et al. (2009) found a TTS onset in a harbor porpoise exposed to airgun noise at 164 dB re: 1 µPa^2·s, considerably lower than reported by Finneran et al. (2002) for belugas. Whether this difference is due to species or individual difference or a combination of the two is difficult to say. Onset of TTS in pinnipeds in water has been tested for several species (e.g., Kastak et al. 2005), but only with non-pulsed sounds (Southall et al. 2007). As a result, Southall et al. (2007) used the relationship between TTS onset from non-pulsed sounds in belugas and harbor seals (~ 12 dB) to estimate TTS onset levels for pinnipeds in water exposed to pulsed sounds.

2.7 Other physiological effects (stranding, bubble formation)

At extremely close distances, loud sounds could cause physical damage to gas filled chambers (e.g., lungs) in animals. This is caused by the rapid and extreme pressure differentials that make up the sound wave (Gotz et al. 2009). Given many species tendency to move away from very loud sounds, this is unlikely to occur during seismic surveys. Another potential impact of sound on marine mammals is the formation of gas bubbles in the animal’s tissues, much like nitrogen bubbles form in human divers and cause decompression sickness. This is based on evidence of lesions in the tissues of beaked whales that stranded after naval sonar exercises (Fernandez et al. 2005). The acoustic pressure itself, a rapid change in depth, or a combination of the two may possibly lead to the formation of bubbles (reviewed in Southall et al. 2007). No evidence links seismic surveys to stranding events or bubble formation in cetaceans.

In addition to the above discussed impacts, noise also has the potential to cause stress and immune responses in marine mammals (Romano et al. 2004; Wright et al. 2007, Rolland et al. 2012). However these are difficult to measure in wild settings and are generally associated with behavioral responses (e.g., startle response, avoidance, etc.). We will therefore utilize behavioral take estimates as discussed above to quantify these effects.

2.8 Echosounders and sub-bottom profilers

Multibeam echosounders typically ensonify a broad swath (150º beam pattern) of the bottom perpendicular to the movement of the vessel, but a very narrow swath (2º beam pattern) in the direction of travel of the vessel. The wide beam pattern is achieved by aiming multiple pulses at successive angles. Sub-bottom profilers are narrow with a cone 30^o wide. Maximum source levels and dominant frequencies for echosounders are higher than sub-bottom profilers. Firing rate, source level, and pulse duration can be varied depending on the depth of the area under investigation.

Given the high source levels and mid-frequency (~3-15 kHz) content, there is the potential for an acoustic impact on marine mammals from these sources. Kremser et al. (2005) modeled the potential for TTS in blue, sperm and beaked whales from a Hydrosweep MBES and Parasound SBP. These units have similar frequency and amplitude specification to the units used on the *R/V Langseth*, however they have narrower beam patterns (90º for the MBES and 5º for the SBP). In addition Kremser et al. (2005) modeled ship movement at 12 knots, almost three times the survey speed that will be used by the Langseth. Thus Kremser et al. (2005) estimates of the potential for TTS will likely be underestimates for the potential TTS from the Langseth operations in this study as TTS measurements are based on SEL levels which are dependent on the number of pulses an animal is exposed to. At lower speeds and wider beam patterns, individual animals will be exposed for longer durations and thus higher SEL levels. However, their models suggest that TTS would only occur at very close ranges to the hull of the vessel (on the order of 100 m or less). Lurton and DeRuiter (2011) also modeled the potential impacts (PTS and behavioral reaction) of echosounders on marine mammals. Based on SEL threshold levels of 198 dB re: 1 µPa^2-s per Southall et al. (2007), they estimated PTS onset at distances of 10 to 100 m generally and possibly 200 m for lower frequency (i.e. 12 kHz) and highest source levels (240 dB re: 1 µPa (rms)). The results from Kremser et al. (2005) and Lurton and DeRuiter (2011) only apply in the cone that is ensonified by the modeled echosounders, meaning that the animal would have to be below the ship to be exposed to these levels. At the same distances, but to the side of the vessel, animals would not be exposed to these levels. This greatly decreases the potential for an animal to be exposed to the most intense signals from MBES or SBP.

It is more likely that animals would be exposed to sound levels from MBES and SBP that cause behavioral responses if they are exposed to the relatively narrow beams of sound from these units. Based on a behavioral response at received levels of 130 dB re: 1 µPa (rms) Lurton and DeRuiter (2011) estimate behavioral response from 4 to 20 km for a 12 kHz MBES with source levels from 210 to 240 dB re: 1 µPa (rms). Studies on captive animals show behavioral responses of beluga whales and bottlenose dolphins to intense 1 second tones at frequencies similar to the MBES and SBP that will be used for this project (Schlundt et al. 2000; Finneran and Schlundt 2004). Likewise harbor porpoise and gray seals have shown behavioral responses to MBES in captivity (Hastie & Janik 2007; Hastie 2007). In wild populations documented reactions have included changes in direction of travel of gray whales, showing that even baleen whales are able to detect sounds from echosounders (in this case 21-25 kHz sounds; Frankel 2005).

3.0 Methods

3.1 Temporal Scope

The time period encompassed by this report is a high energy survey conducted between September potentially through to December. The mid-point of the seismic survey was considered October 20th. For gray whales, the time period of the assessment was extended to Jan 15th (the predicted mid-point date of the southerly migration; Rugh et al. 1999).

3.2 Geographical Scope and Animal Density Estimates

NOAA-NMFS SWFSC scientists (Drs. J. Barlow, J. Carretta and K. Forney) recommended that the most appropriate source for density estimates for most cetaceans in the Project area would be obtainable based on estimates using the online Strategic Environmental Research and Development Program (SERDP) spatial decision support system (SDSS) Marine Animal Model Mapper on Duke's Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations (OBIS-SEAMAP) website (http://seamap.env.duke.edu/). This online tool uses predictive habitat modeling based on survey data to estimate densities in a given area of interest (see Barlow et al. 2009). SERDP-SDSS models of cetacean densities are based on SWFSC ship line-transect data collected from 1986 to 2006. Model grid cell resolution is 25 by 25 km.

To use this density estimation tool, the area of interest needs to be defined. Following an interagency meeting discussion and advice from a co-author of the model (Dr. K. Forney, NOAA, pers. comm., 2011), we selected a 50 km buffer (equivalent of 2 grid cells) of the GIS layer provided by PG&E of the offshore Investigation area. The application of a buffer is considered appropriate given the grid square resolution and large scale habitat input parameters of the model (Barlow et al. 2009) developed for SERDP-SDSS, the spatial area covered by the Investigation area and the movement patterns of most species at the temporal scale of this survey. The resulting buffer zone including the investigation area was approximately 193 km by 81 km, with a total area of 11,362 km^2. This buffer zone area was used simply to estimate mean animal densities per km^2. This contrasts with PG&E using a smaller 4.1-6.2km buffer equivalent to their 160 dB re: 1 µPa (rms) estimate.

The buffered Investigation area GIS layer was loaded into the online tool of the SERDP-SDSS Marine Animal Model Mapper on Duke's OBIS-SEAMAP website. Densities were calculated for cetaceans with the exception of harbor porpoise and gray whales (see below for details). When available the summer Density Model was used for each species. This season encompasses NOAA surveys June through November, however communications with Dr. K. Forney (NOAA, pers. comm., 2011) indicated that most surveys of the study area were undertaken in fall (and therefore relevant to this study period). When the summer Density Model estimate was not available the Stratum Model estimate was used. This estimate has densities for much larger areas (a coarser estimate) and in some cases represent winter estimates (Table 3.1). Beaked whales (*Ziphiidae* sp.) were combined by Barlow et al. (2009) into one grouping termed 'small beaked whales'. All stocks of killer whales were similarly combined. The vast majority of California coastal bottlenose dolphin sightings are within 1km of the shore and densities were therefore confined to this coastal strip (Carretta et al. 1998, Dr. K. Forney, NOAA, pers. comm., 2012, SERDP-SDSS).

Lognormal 90% confidence intervals (termed Upper - Lower) were available for the SERDP-SDSS Density Model outputs. Upper density estimates averaged 1.59 (range 1.4-1.7) times higher for ESA-listed mysticetes and 1.87 (range 1.4-2.9) times higher for odontocetes (Tables 3.1 and 3.11). Lower 90% confidence interval estimates when calculated were close to zero for many species (Table 3.1).

Harbor porpoise (Morro Bay stock) are restricted in their distribution and have been systematically surveyed by NOAA. For harbor porpoise, Dr. K. Forney (NOAA NMFS SWFSC) provided a GIS layer (shapefile) with their distribution and densities (based on stock survey data from Carretta et al. 2009). This layer is split between two density strata; the first with higher density, shoreward of the 50 fathom line (inshore strata), and the second extending from 50 fathoms to ~200m offshore (offshore strata).

Numbers of gray whales, because of the migratory pattern of this species, were calculated by referring to the timing of the southbound migration along the California coast (Malme et al. 1984; Rugh et al. 2001) and the most recent stock assessment (Rugh et al. 1999). From these sources, we estimated the likely start (December 15th) and end (February 15th) dates of the southbound migration, as well as the dates when 10% (December 29th), 50% (January 15th) and 90% (February 1st) of the whales are likely to pass Morro Bay. By fitting a 3rd order polynomial to that cumulative probability distribution we could then estimate the number of whales that would likely have passed the Morro Bay area at various dates into the migration. Before the start of the southbound migration, density of gray whales in the study area was assumed to be zero, though a small number of animals may be potentially present before this date.

Dr. L. Lowry (NOAA-NMFS-SWFSC 2011) provided aerial survey ground (haul-out) counts of the region to estimate minimum population sizes for seals and sea lions. For the compilation of land based counts of pinnipeds, the area from Point Sal to San Simeon was used. Koski et al. (1998) used US Federal research sighting surveys between 1975-1998 to estimate pinniped densities for a suitable area (termed Stratum 1), defined as <12 nm from shore, north of Point Conception and south of the Piedras Blancas area. Densities for the fall time period were selected.

Sea otter densities were calculated from the USGS Western Ecological Research Center's Spring 2010 survey results (http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=16&ProjectID=91). These data are available in GIS shapefiles with various density estimates in many polygons along the coast of California. These polygons are roughly 500 meters wide and stretch out to the 60 meter isobath and are further divided between those areas <30m and those >30m. The reported densities in this dataset are averaged over three years and by a 10km moving window to account for spatio-temporal variation in otter movements and survey conditions

Table 3.1 Density estimates of marine mammal species and species groups. Lower and Upper estimates represent 90% lognormal confidence intervals in the SERDP-SDSS Density Model. Also provided are Standard deviation (SD) and Coefficient of Variation (CV) and source of the density estimate. Potential substantial effects analyses were undertaken for those species highlighted in bold (see Sections 3.5 and 3.6 for justification).

Species	**Mean**	**Lower**	**Upper**	**SD**	**Density estimate source**
Mysticeti					
California gray whale ***Eshchrichtius robustus***	n/a See text				Malme et al. (1984); Rugh et al. (1999, 2001)
Fin whale ***Balaenoptera physalus***	0.00872	<0.0001	0.0126	0.0044	SERDP-SDSS Density Model – Summer
Humpback whale ***Megaptera novaeangliae***	0.00410	<0.0001	0.0069	0.0023	SERDP-SDSS Density Model – Summer
Blue whale ***Balaenoptera musculus***	0.00472	<0.0001	0.0077	0.0026	SERDP-SDSS Density Model – Summer
Minke whale ***Balaenoptera acutorostrata***	0.00028				SERDP-SDSS Stratum Model – Winter
Northern right whale *Eubalaena japonica*	0.00006				SERDP-SDSS Stratum Model – Winter
Sei whale *Balaenoptera borealis*	0.00009				SERDP-SDSS Stratum Model – summer
Odontoceti					
Short-beaked common dolphin ***Delphinus delphis***	0.61420	0.0017	0.9373	0.3199	SERDP-SDSS Density Model – Summer
Long-beaked common dolphin ***Delphinus capensis***	0.01890	0.0180	0.0550		SERDP-SDSS Stratum Model – Summer
Small beaked whale species (combined) ***Ziphiidae* sp.**	0.00310	<0.0001	0.0048	0.0015	SERDP-SDSS Density Model – Summer
Harbor porpoise (Morro Bay stock - inshore area)	0.95900	1.805	0.510		Carretta et al. (2009)

Phocoena phocoena					
Harbor porpoise (Morro Bay stock - offshore area) ***Phocoena phocoena***	0.06200	0.164	0.023		Carretta et al. (2009)
Dall's porpoise ***Phocoenoides dalli***	0.02892	0.0001	0.0486	0.0150	SERDP-SDSS Density Model – Summer
Pacific white-sided dolphin ***Lagenorhynchus obliquidens***	0.06511	0.0001	0.0996	0.0334	SERDP-SDSS Density Model – Summer
Risso's dolphin ***Grampus griseus***	0.02804	0.0001	0.0548	0.0174	SERDP-SDSS Density Model – Summer
Northern right whale dolphin ***Lissopelphis borealis***	0.04083	0.0001	0.0585	0.0203	SERDP-SDSS Density Model – Summer
Striped dolphin *Stenella coeruleoalba*	0.00379	<0.0001	0.0071	0.0021	SERDP-SDSS Density Model – Summer
Bottlenose dolphin – California coastal ***Tursiops truncatus***	0.3612				SERDP-SDSS Stratum Model – Year round
Sperm whale ***Physeter macrocephalus***	0.00069	<0.0001	0.0011	0.0003	SERDP-SDSS Density Model – Summer
Short-finned pilot whale *Globicephala macrorhynchus*	0.00031				SERDP-SDSS Stratum Model – Summer
Killer whale (all stocks) *Orcinus orca*	0.00071				SERDP-SDSS Stratum Model – Summer
Pinnipedia					
Harbor seal ***Phoca vitulina richardsi***	0.02336			CV0.94	Koski et al. (1998) – Fall Stratum 1
Elephant seal *Mirounga angustirostis*	0.15493			CV0.68	Koski et al. (1998) – Fall Stratum 1
Northern fur seal *Callorhinus ursinus*	0.03095			CV0.65	Koski et al. (1998) – Fall Stratum 1
California sea lion ***Zalophus californianus***	1.50039			CV0.25	Koski et al. (1998) – Fall Stratum 1
Guadalupe fur seal *Arctocephalus townsendi*	No data See text				NCCOS (2007)
Northern (Steller) sea lion *Eumetopias jubatus*	No data See text				NCCOS (2007)
Mustelidae					
Southern sea otter ***Enhydra lutris nereis***	1.59332				USGS WERC Otter Survey 2010

3.3 Impact Assessment Methodology

Project stressors may have direct impacts (caused by the action and occurring at the same time and place), indirect impacts (caused at a later time or farther removed) or may cause both due to different mechanisms. Potential project stressors include acoustic, entanglement, oil contamination, habitat alteration and vessel collision, most of which have both direct and also indirect impacts. For each of these stressors we evaluate potential impacts on key marine mammal species by comparing primary stressor characteristics with pre-determined thresholds. Using this systematic methodology, we simply aim to use threshold criteria to predict a level of significance for identified stressors, flag any eventual potential high impacts on marine mammal species and provide mitigation recommendations.

We present the basic flow of this assessment process in this section, with more details provided in subsequent sections. Following scoping of the Project's stressors, a review of the biological context and potential susceptibility of those species that may be locally present during the Project's proposed timeline (September to December) was carried out based on Figure 3.1. Key biological context criteria include seasonal occurrence and relative density, population demographics, listed status, habitat use for critical life functions, habitat suitability and known/presumed susceptibilities to the key stressors identified. The review aimed at identifying those recipient species ecologically sensitive and present at densities sufficient to lead to potential significant adverse effects. After identifying the stressors and these key recipients, we use the derived severity and impact matrices to identify potential significant impacts (those with high impact ratings), and synthesize the results into an adverse effects conclusion, given the individual species biological context.

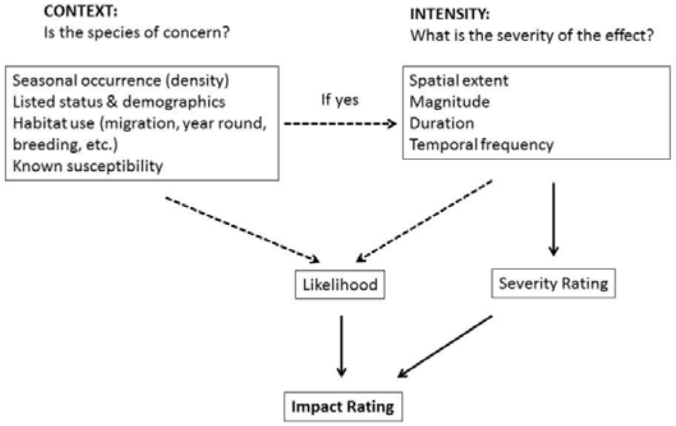


Figure 3.1. Outline of impact assessment methodology.

3.3.1. Severity ratings

The severity of an impact is estimated based on the intensity of several key factors of the stressor. Components considered to affect severity are magnitude, geographical extent and temporal duration and frequency.

NMFS (NOAA Fisheries) has set two statutory thresholds for stressors on marine mammals; Level A and Level B harassment which can lead to a 'take'. A Level A take occurs when the stressor causes an injury or mortality in the animal whereas a Level B take occurs when a significant behavioral change is caused by the stressor. In terms of acoustic injury from any sound type (Level A), NMFS relies on the HESS (1999) panel assessment based on information available at that time (prior to most of the existing literature on marine mammal TTS). These Level A thresholds are 180 dB re: 1 µPa (rms) for all cetaceans and 190 dB re: 1 µPa (rms) for all pinnipeds. Level B is presently set by NMFS at 160 dB re: 1 µPa (rms) for impulsive sound sources and 120 dB re: 1 µPa (rms) for continuous sound sources.

We use these two regulatory distinctions in our analysis to estimate levels of potential impact for acoustic stressors based on both Level A and Level B harassment. The take estimates for acoustic thresholds rely on calculating the amount of area ensonified by the acoustic stressor, and identifying areas where the thresholds are exceeded. We have assumed that any Level A or B harassment would result in a take. These takes are used to define the magnitude level.

Calculating an acoustic take requires a number of important assumptions, including using appropriate density estimates and threshold criteria. This report estimates Level A and B takes using a dual threshold criteria approach. The two sets of acoustic threshold criteria vary across the metric selected, whether hearing sensitivity is taken into account and the threshold levels used. Summary details are provided below in Table 3.2, with full justification provided in Section 3.7.

Table 3.2 Summary of dual threshold criteria for estimating acoustic takes and steps for determining magnitude of effect.

Threshold Level	**Dual criteria term**	**Key metric**	**M-Weighted for hearing sensitivity**	**Threshold information**	**Steps to determine Magnitude level**
Level A	NMFS rms[1]	Root mean square (rms)	No	NMFS levels Pinnipeds: 190dB re: 1 µPa Cetaceans: 180 dB re: 1 µPa	Compare take with residual Potential Biological Removal (Table 3.3)
Level A	Injury SEL	Cumulative 24 hour Sound Exposure Level (SEL)	Yes	Southall et al. (2007) levels, but revised SEL for low and high frequency cetacean groupings (Table 3.8)	Compare take with residual Potential Biological Removal (Table 3.3)
Level B	NMFS rms[1]	Root mean square (rms)	No	NMFS Levels All species (pulsed): 160 dB re: 1 µPa	Compare take with regional minimum population (Table 3.3)
Level B	Probabilistic Disturbance rms	Root mean square (rms)	Yes	Varied response at range of thresholds, varying by species sensitivity and context (Table 3.9)	Compare take with regional minimum population (Table 3.3)

[1] Two take estimate approaches were calculated for NMFS criteria: using the ‘Minimum’ area ensonified (which excludes all areas of overlap and represents the minimum number of individual takes) and using the ‘Maximum’ area ensonified (which includes all overlap areas and therefore includes repeated takes of the same individual).

One goal of this review is to estimate potential levels of acoustic ‘take’ using the dual criteria and put them into context with regards to magnitude of the effect at the population level. A precautionary or conservative approach was adopted; both by setting magnitude levels lower for listed species, as well as in our metrics for comparison. Many marine mammals, especially cetaceans rely upon hearing for critical life history functions (such feeding, breeding and predator avoidance; Richardson et al. 1995); therefore permanent hearing loss may, in some cases, indirectly lead to mortality or a removal through reduced fecundity (NRC 2005). Acoustic takes are often compared to the percentage of the local population affected (see NSF 2011). To assess the magnitude of the Level A effects on biological resources relative to the population, we however used Potential Biological Removal (PBR) as the most appropriate metric to evaluate the relevance of potential mortality/injury effects. This tacitly assumes, as a worst case approach, that all Level A takes may cause the eventual equivalent of mortality (whether indirectly or directly) of an individual. This assumption overestimates the potential significance of Level A acoustic takes and should be considered precautionary. The magnitude of Level B takes were assessed using the percentage of the minimum stock population affected. The use of the minimum stock population is also precautionary.

The Marine Mammal Protection Act (MMPA), as reauthorized in 1994, defined PBR as, "...the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population." PBR was intended to serve as an upper limit guideline for fishery-related mortality for each species. The MMPA also provides some rationale for establishing certain numerical thresholds for the magnitude of mortality relative to PBR. Section 118 of the MMPA requires NMFS to classify fisheries according to their relative levels of mortality for each marine mammal stock (16 U.S.C. 1387 (c)(1)). Fisheries that cause mortality of a marine mammal stock totaling 10 percent of PBR or less are classified as Category III fisheries and are not required to register with NMFS or obtain authorizations for incidental take (50 CFR 229.2). In addition, the MMPA established a requirement that the level of incidental mortality and serious injury of marine mammals in fisheries be reduced to “insignificant levels approaching a zero rate”, which is commonly referred to as the Zero Mortality Rate Goal (ZMRG). To implement the MMPA, NMFS defined the insignificance threshold for fisheries related mortality, the ZMRG, as being 10 percent of PBR for the stock of marine mammals (69 FR 43338). Fisheries that cause mortality equal to or exceeding 50 percent of residual PBR for a marine mammal stock are classified as Category I fisheries and are required to register with NMFS, follow a take reduction plan, and may be required to carry marine mammal observers on board to monitor take. Residual PBR estimates are termed PBR minus the reported annual anthropogenic mortality estimate.

In this assessments, the magnitude of Level A takes are defined as; Level A takes less than or equal to 10 percent of residual stock PBR will be considered ‘negligible’ magnitude; between 10 and 50 percent of residual PBR will be considered ‘Low’ magnitude; between 50 to 100 percent of residual PBR will be considered ‘moderate’ and greater than 100 percent of residual PBR will be considered as ‘High’ magnitude (see Table 3.3).

Defining magnitude for disturbance (Level B) effects is considered particularly subjective. Negligible impacts are identical to those presented in the NSF (2011) programmatic review. For the purpose of defining significance in the Environmental Impact Report (EIR) for this proposed Project, CSLC established thresholds that consider a level B harassment to one special status species as significant. For the purpose of this analysis, this report defines Level B magnitude as follows: Less than 1 ESA-listed species and less than 5 percent for a non-listed species minimum population is considered negligible (Table 3.3). Low magnitude, extends from one ESA-listed species to <1.25 percent of the minimum regional population, and 5-15 percent for a non-listed species minimum regional population. High magnitude extends greater than 2.5% of the ESA-listed species minimum regional population and above 25 percent for a non-listed species regional minimum population (see Table 3.3). for example, using these values, a high magnitude Level B take would correspond to the harassment of 47 humpback whales (California/Oregon/Washington stock), 51 blue whales (Eastern north Pacific stock) or 370 harbor porpoise (Morro Bay stock).

The geographical extent allows for the categorization of the spatial extent of the stressor. This is an important distinction since some stressors will not extend beyond the immediate vicinity (Local) of the Project area, while others may extend to Regional, or State-wide levels. The duration and temporal frequency components provide measures of the temporal aspect of the stressor. Duration denotes the longevity of the effect caused by the stressor while temporal frequency denotes how often the stressor events take place. 'Short-term' refers to a temporary effect that last up to one month and the affected animals or resource reverts back to a 'normal' condition. 'Long-term' refers to more permanent effects that last beyond one season up to years and from which the affected animals or resource never revert back to a 'normal' condition. Moderate-term is defined as between 1-3 months with effects potentially permanent (Table 3.3). Duration levels were designed to highlight those stressors that may endure for the full length of the proposed Project versus ones lasting shorter time periods. For clarification, the pathway of impact (direct or indirect) has a duration component to it, but should not be confused with duration of the effect. An indirect effect may start later than the initial stressor, but that does not determine how long the effect lasts. The pathway describes the onset of the stressor, the duration how long the effects of the stressor last. Frequency levels range from continuous to isolated (may occur one or two times), with intermittent defined as an intermittent but repeated action (see Table 3.3).

Table 3.3 Descriptions of the levels within four intensity components used to rate severity

Geographical Extent:

State-wide	Effects extend outside regional boundary, but within state setting.
Regional	Effects likely to extend outside of project boundary to regional setting.
Local	Effects likely to be limited within project boundary.

Magnitude (Mortality/Injury/Level 'A' take):

High	>100% of stock population residual PBR affected
Moderate	50-100% of stock population residual PBR affected
Low	10-50% of stock population residual PBR affected
Negligible	<10% of stock population residual PBR affected

Magnitude (Disturbance/Level 'B' take):

High	>25% of regional non-listed species minimum population / >2.5% ESA-listed regional minimum population
Moderate	15-25% of regional non-listed species minimum population / 1.25-2.5% of ESA-listed regional minimum population
Low	5-15% of regional non-listed species minimum population / 1 ESA-listed animal and <1.25% of ESA listed minimum population
Negligible	<5% of regional minimum population / <1 ESA listed animal

Duration:

Long-term	refers to more permanent effects that may last for more than 3 months (a season) to years and from which the affected animals or resource never revert back to a "normal" condition
Moderate-term	refers to a temporary effect that lasts 1 to 3 months and the affected animals or resource may revert back to a "normal" condition.
Short-term	refers to a temporary effect that lasts from days to one month and the affected animals or resource revert back to a "normal" condition.

Frequency:

Continuous	Effects continuous.
Intermittent	Effects intermittent, but repeated.
Isolated	Effects confined to one or two periods.

Intensity component levels, once established, were used to determine a severity rating using a matrix approach depicted below in Table 3.4. Severity ratings were described as High, Medium, Low or Negligible.

Table 3.4 Severity rating matrix methodology.

Magnitude	Extent	Temporal Duration/Frequency	Severity Rating
High	Regional	Any	High
Moderate	Regional	Any except Short-term/isolated	
High	Local	Any	
Any	State-wide	Any	
Moderate	Regional	Short-term/isolated	Medium
Moderate	Local	Any	
Low	Regional	Any	
Low	Local	Any except Short-term/ intermittent or isolated	
Low	Local	Short-term/Intermittent or Isolated	Low
Negligible	Any	Any	Negligible

3.3.2 Impact Ratings

The final impact rating is then determined using a matrix combination of severity rating and likelihood of occurrence depicted below in Table 3.5. The likelihood of occurrence component serves to assess whether the potential effects are plausible or just speculative. High likelihood is described as those that could arise from reasonable or demonstrated mechanisms and the probability of those mechanisms arising from the alternatives is very likely or greater than 50 percent. Medium likelihood is described as possible or probable, Low likelihood is described as unlikely and Very low likelihood is described as very unlikely. This does not imply that we will perform a formal probability calculation but, that in our professional judgment, the probability of the effect occurring is more likely than not. Stressor component levels are quantitative for some sources and qualitative for others, necessarily requiring the analyst to make a judgment about where a particular effect falls, or make assumptions about the likelihood of an effect after mitigation measures are applied.

Table 3.5. Impact rating matrix methodology

Severity Rating	Likelihood of Occurrence	Impact Rating
High	High or Medium	High
High	Low	Moderate
Medium	High or Medium	
Low	High	
High	Very Low	Low
Low	Medium	
Low	Low	
Medium	Low or very Low	
Low	Very Low	Negligible
Negligible	Any	

It is important to recognize that this impact assessment methodology is designed to highlight those species and stressor combinations with potentially high impact. Judging whether the impact is potentially significant at the stock or local population level also requires integration of information on its capacity to withstand the impact, taking into account whether the impact might occur during a sensitive or critical part of the year, within potentially important habitat and the assumed flexibility of the species to adjust to disturbance. Perhaps of equal importance, given the uncertainty levels in many components, is to ensure consideration is given to potential variability, for example, in predicted animal densities, behavioral response and the environmental factors that may influence temporal and spatial distribution.

3.4 Scope of potential Project stressors

A review of the proposed Project application materials provided resulted in the following potential stressors and sources being identified (Table 3.6). Stressors considered to have both direct and indirect pathways are identified individually for use in the impact assessment. Level B harassment is considered an indirect stressor due to the pathway mechanism of potential effects.

Table 3.6 Potential Project stressors[1] identified in scoping process

Stressor	**Source**	**Possible pathway/mechanism**
Acoustic	*Air-gun array*	*Level A harassment (direct)*
		Level B harassment (indirect)
		Secondary prey effects (indirect)
Acoustic	*Mitigation (single) air-gun*	*Level A harassment (direct)*
		Level B harassment (indirect)
		Secondary prey effects (indirect)
Acoustic	Echo-sounder and profiler	Level A harassment (direct)
		Level B harassment (indirect)
Acoustic	*On-shore seismic sources*	*Level B harassment – land (indirect)*
		Level B harassment – water (indirect)
Acoustic	*Vessels (propeller/engine)*	*Level B harassment (indirect)*
Acoustic	*Survey aircraft*	*Level B harassment (indirect)*
Entanglement	Air-gun/hydrophone strings	Injury/Mortality (direct)
Entanglement	Geophone offshore strings	Injury/Mortality (direct)
Oil contamination	*Vessels*	*Injury/Mortality (direct)*
		Life function effects (indirect)
Habitat alteration	*Use of offshore geophones*	*Life function effects (indirect)*
Vessel interaction	*Vessels*	*Injury/Mortality (direct)*
		Non-acoustic disturbance (indirect)

[1] Where a stressor has potentially different pathways or mechanisms of effect they have been partitioned. Stressors highlighted in italics have explicit or incidental forms of APMs.

Direct effects or wide-scale indirect effects should be considered a priority for impact assessment. Overall, acoustic harassment (due to geographical and temporal scale and likelihood) is considered as the primary stressor for the proposed activity. The Draft Biological Assessment (Appendix A of the Application) highlights various Applicant Proposed Measures (APMs) to reduce the impact of four stressors: Acoustic noise, oil spill, vessel collision and on-land geophone placement. In addition, the *R/V Langseth* has a quiet propulsion system (PG&E 2011b) and will not use bow thrusters during seismic operations. For the majority of time, all vessels will be moving at relatively slow speeds and together these are considered incidental mitigation measures with respect to subsequent level B acoustic disturbance from vessels.

A negligible magnitude and low likelihood assessment (negligible impact rating) were determined for the following stressors: Acoustic effects of on-shore seismic sources and Habitat alteration by placement and retrieval and use of offshore geophones. These stressors were not assessed further in this technical report but are addressed in the EIR.

3.5 Estimation of acoustic Impact (Ensonified area)

3.5.1 Preliminary scoping

The estimation of acoustic impact was undertaken first in a scoping assessment, which aimed to determine which species would be expected to exceed a NMFS level B minimum take of at least 1 individual (thus meeting CSLC Significance threshold a), but also contribute in identifying 'candidate' species for a full acoustic take analysis and a comprehensive consideration of potential substantial adverse effects by the proposed Project (see section 3.6 for detailed selection criteria). The area of Alternative 2 (overall the largest noise footprint, 1,935 km^2) predicted to be ensonified to received levels of 160 dB re: 1 µPa (rms) threshold was estimated and based on this area, mean species density estimates exceeding 0.00051 km^2 would be expected to exceed a NMFS level B take of at least 1 individual (CSLC Significance threshold a). The Project area footprint in comparison is lower at 1757 km^2.

3.5.2 Full acoustic take analysis

The project has multiple sources of acoustic stressors. The airguns are fired concurrently with the use of the echosounder and sub-bottom profiler, therefore a noise footprint (ensonified area) that **combined** all the main active acoustic survey sources was calculated. For rms metrics, this entailed using the source with the greatest acoustic radii (typically the air-gun array, but often the echosounder during the turns), which were calculated by Jasco Applied Science for nine representative depth/bottom types (Appendix I). For SEL, this entailed calculating the 24hr cumulative SEL total by combining the values calculated for each instrument. Combined source takes were calculated for Level A and B using the dual criteria thresholds and modified to take into account of various factors such as depth preferences, behavioral response and Project APMs. Takes were converted to magnitude levels (Table 3.3) and severity and impact ratings determined as described above. For the main acoustic take analyses, three different animal density scenarios (termed Base, Upper and Potential) were modeled, aiming to reflect uncertainties in model-predicted density estimates. Combined active acoustic source takes were calculated and impact ratings determined for the proposed Project and the three alternatives. Adverse effects conclusions were generated using these acoustic impact ratings, as well as ratings based on the remaining stressors. The newly developed noise criteria thresholds (Injury SEL and Probabilistic Disturbance rms) were preferentially weighted in this final population level assessment.

3.6 Scope of individual effects and selection of candidates for substantial adverse effects review

Section 4.4.4 within the EIR document provides a summary of the species of marine mammal that may be encountered within the Project area. Within the EIR's biological resource section, life history information has been compiled, including minimum and best population estimates for the relevant stock, population trajectory, PBR and residual PBR estimates and hearing sensitivities. In this report, identifying 'candidate' species for consideration of potential substantial adverse effects by the CCCSIP Project were based on a qualitative integration of the following broad criteria:

Firstly, protected status, population and PBR level. PBR is considered a precautionary metric to assess possible population-level effects. The PBR level is the product of the following factors: the minimum population estimate of the stock; one-half the maximum theoretical or estimated net productivity rate of the stock at a small population size; and a recovery factor of between 0.1 and 1.0 (depending on the stock status). PBR levels used in the acoustic take assessment are 'residual' PBR estimates (i.e., reported annual anthropogenic mortality estimate removed) and are based on latest NMFS NOAA/USFWS reports for the relevant local stock area/population as follows;
http://www.nmfs.noaa.gov/pr/pdfs/sars/po2011_draft_summary.pdf,
http://www.fws.gov/ventura/species_information/so_sea_otter/SSO_SAR_2008_FINAL.pdf,
http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2009.pdf,
http://www.nmfs.noaa.gov/pr/pdfs/sars/ak2010whgr-en.pdf.

Secondly, habitat use, relative density and habitat suitability assessment. This assessment draws upon key biological resource information (including section 4.4.4 of the EIR) about the occurrence, level and type of use (e.g., breeding, feeding, migrating, etc.), and seasons of use by marine mammals in the study area (including information from local field scientists). The justification of including these thresholds was two-fold. Firstly, it aimed to identify those protected status populations with very low likelihood of occurring in the Investigation area, due to very low sighting rates and/or habitat preferences. Secondly, it aimed to provide a means to identify those species without protected status, but that may be more vulnerable to impacts for a variety of factors. For example, those populations/stocks that are known to be resident in the south Central California region (e.g., Morro Bay Stock of harbor porpoises, Southern sea otters), those species considered to be a species with potential for high relative seasonal density (e.g., Common dolphin, Risso's dolphins, California sea lions) or known to use the Investigation area as a migratory pathway (e.g., gray whales). Finally, consideration was also given to notable regional bathymetric features (for example submarine canyons) that might imply potential for preferred habitat use by typically low density species. The time period September to December was used as a temporal cut-off in the seasonal presence assessment.

Thirdly, the known or inferred sensitivity of a particular marine mammal species to low-frequency sounds from airguns (e.g., mysticetes, see section 2, HESS 1999) or known high sensitivity to anthropogenic noise (e.g., harbor porpoise, Beaked whales - see section 2) was included in the scoping review.

A synopsis of the information needed to evaluate these three broad thresholds is included in the column 'summary of biological context' in Table 3.7 below.

Table 3.7. Summary of biological context and preliminary acoustic effects scoping review. A detailed biological resources review is presented in Section 4.4.4 of the EIR document.

Common Name	**Summary biological context** [1]	**Preliminary individual and population acoustic effects scoping review**	**Candidate for full take analysis**
Mysticeti			
California gray whale	Eastern North Pacific Stock. Migration route for majority of best population estimate 19,126 individuals. Southward transit through investigation area starts mid-December and peaks mid-January. Majority of population likely to travel within 3 nautical miles of coast and pass through study area in <24 h. (Rugh et al. 1999, 2001). Feeding limited. Localized avoidance to seismic exploration sound indicated (Malme et al. 1984).	Potential Biological Removal = 360. Anthropogenic mortality = 127. Estimated NMFS Minimum Level B take >1 individual only if survey delayed past mid-December. Scale of impact on population proportional to extent of delay, with cause for concern if survey continues past late December. **Quantification of project and acoustic impacts on population required.**	Yes
Fin whale	**Endangered**. California/Washington/Oregon stock best population estimate 3,044. Seasonally present from continental slope to offshore. Inter-annual density variability documented (Peterson et al. 2006). Key prey is krill and small fish, seasonal movement unclear but lower density in winter and spring. Vocal behavior September - February observed in Northern California may indicate breeding activity. Changed vocal behavior (cessation) in response to seismic exploration sounds. Mysticeti show localized avoidance to seismic exploration sound.	Potential Biological Removal=16. Annual strike related mortality= 1. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Humpback whale	**Endangered.** California/Washington/Oregon stock best population estimate 2,043. Seasonally present (non-breeding) from inshore to slope with summer to October peak. Green et al. (1992 cited in Calambokidis et al. 2008) reported that encounter rates off Oregon/Washington in the summer were highest on the slope, and in the fall, they were highest on the shelf. Late-fall southerly migration route. Low density by mid-November. Inter-annual density variability documented (Calambokidis et al. 2004, 2008; Peterson et al. 2006). Key prey is both krill and small fish. Humpback whales are often sighted singly or in groups of two or three, but while in their breeding and feeding ranges, they may occur in groups of up to 15. Foraging aggregations have been observed in the vicinity of Morro Bay, Avila Beach and Pismo Beach in some years (K. Forney, NOAA, pers. Comm. 2011). Church Rock documented foraging hotspot (K. Winfield, Sub Sea Tours, pers. Comm. 2011). Changed vocal behavior (cessation) in response to seismic exploration sounds. Mysticeti show localized avoidance to seismic exploration sound.	Potential Biological Removal=11.3. Anthropogenic mortality=3.6. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Blue whale	**Endangered**. Eastern North Pacific stock best population estimate 2,497. Seasonally present (non-breeding) from shelf (typically >80m depth, J. Calambokidis, Cascadia, 2011) to offshore. Peak density in summer months at around 200 m depth (J. Calambokidis, Cascadia, pers. Comm., 2011), typically with decreasing density from September through November. The Northeast Pacific stock of blue whales may be the largest remnant population in the world. Feed on dense concentrations of krill which make them vulnerable to perturbations in prey abundance. Blue whales travel 100s of km between foraging patches (Bailey et al. 2010) and respond to environmental variation by feeding further north rather than within smaller prey patches. Area considered a transit route between Santa Barbara basin and Monterrey area (typically northwards in mid-summer and southwards in fall). Migratory movement south towards Baja California and the Costa Rica Dome region appears to start in November (Bailey et al. 2010), with low local area density by mid-November. Blue whales usually occur alone or in small groups. High inter-annual density variability documented (Calambokidis et al. 2004, 2008; Peterson et al. 2006). Time on surface increases at night (Bailey et al. 2010). Changed vocal behavior (increased call rates) in response to seismic exploration sounds. Mysticeti show localized avoidance to seismic exploration sound.	Potential Biological Removal=3.1. Annual strike related mortality= 1. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean area density estimates (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Minke whale	California/Washington/Oregon stock best population estimate 478. Habitat selection variable. Seasonally present, with breeding in winter. The SERDP-SDSS winter stratum density estimate for minke whales was 0.000276 km^2, but this was not corrected for missed diving animals. However, unpublished NOAA density estimates (based on 1990-1997 uncorrected survey data) yielded 0.0071 animals per km^2 (K. Forney, NOAA, pers. comm., 2011).	Potential Biological Removal=2. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and unpublished NOAA species density estimate (K. Forney, NOAA, 2011). **Quantification of project and acoustic impacts on population required.**	Yes
North Pacific right whale	**Endangered.** Eastern North Pacific stock. The likelihood of a North Pacific right whale being present in the Investigation area is considered extremely low. There is no reliable population estimate, although the population in the eastern North Pacific Ocean is considered to be very small, perhaps in the tens to low hundreds of animals. Multiple years of systematic aerial and ship-based surveys for marine mammals off the western coast of the U.S. has documented seven sightings of right whales between 1990-2000, with most whales assumed to be in Alaskan waters (Wade et al. 2011). The SERDP-SDSS winter stratum density estimate for Right whales was 0.000061 km^2. Mysticeti show localized avoidance to seismic exploration sound.	**Chance of any North Pacific right whales appearing near the Project site is extremely remote. Likelihood of individual effects (including NMFS level A or B take) considered remote due to extremely low density prediction.** **Project is not likely to adversely affect North Pacific right whales.**	No
Sei whale	**Endangered.** Eastern North Pacific stock best population estimate 126. Most often found in deep, oceanic waters of the cool temperate zone. Sei whales are now rare in California waters, with just nine confirmed sightings of sei whales made in California, Oregon and Washington waters during extensive ship and aerial surveys between 1991- 2008. Sightings were mainly in deeper, offshore waters of Northern California and Oregon, with no confirmed sightings made within 200 km of the Investigation area (Carretta et al. 2011). The SERDP-SDSS winter stratum density estimate for sei whales was 0.000086 km^2. Mysticeti show localized avoidance to seismic exploration sound.	**Chance of any sei whales appearing near the Project site is extremely remote. Likelihood of individual effects (including NMFS level A or B take) considered remote due to extremely low density prediction.** **Project is not likely to adversely affect sei whales.**	No

Odontoceti			
Short-beaked common dolphin	California/Oregon/Washington stock best estimate 411,211. This species is the most abundant cetacean off California and occurs from the coast out to at least 500 km offshore; off central California, it mostly occurs well offshore, over slope habitats and beyond. Sightings from the NCCOS (2007) central California data set, 2003, include 35 sightings of 2,255 common dolphins, mostly seaward of the 200 m contour. Occurs in large groups, sometimes very large (~2500, K. Forney, NOAA, 2011). Padre (2011) sighted 144 Common dolphins. Frequent occurrences of Common dolphins entering safety zone of seismic surveys (Calambokidis et al. 1998).	Potential Biological Removal=3,440. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Long-beaked common dolphin	California stock best estimate 27,046. The Long-beaked common dolphin partially overlaps some of the distribution of the Short-beaked common dolphin; the Long-beaked common dolphin occurs mostly off southern California and Baja California generally within about 90 km of the coast. Can occur in large groups (300-600, K. Forney, NOAA, 2011). Padre (2011) sighted 144 Common dolphins. Frequent occurrences of Common dolphins entering safety zone of seismic surveys (Calambokidis et al. 1998).	Potential Biological Removal=164. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Small beaked whale sp.	Combined best estimate for California/Oregon/Washington stocks 4,074. Due to the rarity of sightings, species of Beaked whales in the study area have been grouped. Data in the NCCOS (2007) central California data set (1980-2003) include sightings of Baird's beaked whale (*Berarduis bairdii*), Cuvier's beaked whale (*Ziphius cavirostris*), and unidentified beaked whale (*Mesoplodon* spp.). Baird's beaked whales are distributed along continental slopes and throughout deep waters of the North Pacific; Cuvier's beaked whale is the most commonly sighted beaked whale in US West Coast waters (Carretta et al. 2011). Mesoplodont beaked whales are five different species are distributed along continental slopes and throughout deep waters in the North Pacific Ocean (Koski et al. 1998). Beaked whales considered to have high sensitivity to anthropogenic sound (Tyack et al. 2011).	Combined species Potential Biological Removal=25. NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean area density estimates (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Harbor porpoise	Morro Bay stock estimated at 2,044. Resident, near-shore species with limited range. A total of 1,776 were estimated in waters <50 fathoms (91m), with 268 estimated offshore (<200m, Carretta et al. 2009). Respective densities are 0.959 $km^2$and 0.062 km^2. Population increasing since gill net restrictions imposed in recent years. Typically occur in small groups. The Investigation area encompasses a significant portion of the range of this stock. Spring and summer births, with breeding likely in fall. Padre (2011) documented 39 local sightings. Harbor porpoise are considered to have high sensitivity to seismic exploration sound (Lucke et al. 2009).	Potential Biological Removal=15. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Carretta et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Dall's porpoise	California/Oregon/Washington stock best estimate 42,000. The NCCOS (2007) central California data set (1980-2003) contained 818 sightings, the most commonly sighted (number of sightings) of the small cetaceans and was present during all seasons. Overall density distribution of Dall's porpoise was widespread over the shelf, slope, and deep ocean habitats (mainly >100m). The distribution of Dall's porpoise is highly variable among years/seasons and appears to be affected by oceanographic conditions.	Potential Biological Removal=257. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Pacific white-sided dolphin	California/Oregon/Washington stock best estimate 26,930. Pacific white-sided dolphins are found in cold, temperate waters of the North Pacific Ocean from North America to Asia. They become most abundant in shelf waters off southern California from November to April and then off Oregon and Washington in May. Population may be migrating seasonally from the south to the north in the eastern North Pacific. Generally found in deeper/more offshore water, but can be seen fairly close to shore (Koski et al. 1998). Risso's, Northern right whale dolphin and Pacific white-sided dolphin often seen together in groups.	Potential Biological Removal=193. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes

Risso's dolphin	California/Oregon/Washington stock best estimate 6,276. The distribution of Risso's dolphin off California, Oregon, and Washington is highly variable, apparently in response to seasonal and inter annual oceanographic changes (Forney and Barlow, 1998). Dolphins found off California during colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer. Near-shore year-round species locally and most often sighted cetacean by Padre (2011) with 364 sightings. Risso's, Northern right whale dolphin and Pacific white sided dolphin often seen together in groups. Seen in small to moderate groups (1-250) but also in large schools (Koski et al 1998).	Potential Biological Removal=39. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Northern right whale dolphin	California/Oregon/Washington stock best estimate 8,334. Generally considered offshore, but in also regionally seen fairly close to shore. Padre (2011) reported 10 sightings. Risso's, Northern right whale dolphin and Pacific white sided dolphin often seen together in groups.	Potential Biological Removal=48. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Striped dolphin	California/Oregon/Washington stock best estimate 10,908. Abundant in eastern tropical Pacific waters where they form large mixed schools. Typically sighted within about 100-300 nautical miles from the coast.	Potential Biological Removal=82. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). Offshore and wide-ranging species with relatively low densities in inshore waters. **Project may affect, but is not likely to adversely affect Striped dolphin**	No

Bottlenose dolphin – California coastal and offshore stocks	The California coastal stock best estimate is 323. This stock occurs mostly off southern California and into Mexican waters, but moves northward into central California during warm-water periods (Carretta et al. 2011). The Investigation area is considered within the northern part of the range. Found largely with 1km of shore and surveys by Carretta et al. (1998) found 48.8 animals per 100 km of coast. Groups of 13+ animals were recorded in the Investigation area (NCCOS 2007). The California/Oregon/Washington offshore stock has been sighted mostly in the southern California Bight; north of there the sightings are well offshore.	Potential Biological Removal (California coastal) =2.4. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required (California Coastal).**	Yes
Sperm whale	**Endangered** California/Oregon/Washington stock best estimate 971. Sperm whales are widely distributed across the entire North Pacific, and although seasonal movements of sperm whales in the North Pacific are unclear, it is thought that males move north in the summer to feed in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands, while females and young sperm whales usually remain in tropical and temperate waters year-round (Angliss and Outlaw, 2007). Off California, sperm whales occur year-round (Barlow et al. 1997), with peak abundance from April through mid-June and from end of August through mid-November. Mostly over the slope and deep ocean habitats. May delay foraging due to seismic exploration sound.	Potential Biological Removal=1.5. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Barlow et al. 2009). **Quantification of project and acoustic impacts on population required.**	Yes
Short-finned pilot whale	Best estimate for California/Oregon/Washington stock 760. Considered rare and distributed offshore.	Potential Biological Removal=4.6. **Likelihood of individual effects (NMFS level A or B take) considered remote due to extremely low density prediction. Project impacts considered insignificant.**	No

Killer whale – Eastern North Pacific Southern Resident, Eastern North Pacific Transient and Eastern North Pacific Offshore stock	**Southern Resident stock only Endangered.** Three of the five killer whale stocks recognized within the Pacific U.S. EEZ may occur in the Project area. Eastern North Pacific Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California; Eastern North Pacific Transient stock - occurring from Alaska through California; Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California. Off the coast of Oregon and California, 105 Transient whales and 56 Offshore whales have been identified (Carretta et al. 2011). Sightings of killer whales occur very infrequently in the Investigation area (Padre 2011, K. Winfield, Sub Sea Tours, 2011), but the Endangered Southern Resident stock of killer whale is considered not likely to be present within Central California waters. This stock is most commonly seen in the inland waters of Washington state and southern Vancouver Island; however, individuals from this stock have been observed in Monterey Bay, California, in January 2000 and March 2003, near the Farallon Islands in February 2005, and off Point Reyes in January 2006. The SERDP-SDSS summer stratum density estimate for all stocks of killer whales was 0.000709 km^2.	**Southern Resident stock: Chance of any Southern Resident stock killer whales appearing near the Project site is extremely remote. Likelihood of individual effects (including NMFS level A or B take) considered remote due to extremely low density prediction.** **Project is not likely to adversely affect Southern Resident stock killer whales.** **Eastern North Pacific Transient stock:** Potential Biological Removal=2.8. **Eastern North Pacific Offshore stock:** Potential Biological Removal=1.6 Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density (all stocks) estimate (Barlow et al. 2009). Wide-ranging populations with chance of sightings considered remote. **Project may affect, but is not likely to adversely affect Eastern North Pacific Transient and Eastern North Pacific Offshore stocks**	No

Pinnipedia			
California sea lion	The US stock best population estimate is 296,750. Seasonal abundance of California sea lions off central California is linked to spring and fall pre- and post-breeding migrations, with greater numbers of sea lions present during the Oceanic season, just after breeding (August –November, NCCOS 2007). Mainly males and sub-adults present during study period. Numbers inter-annually variable due to El Niño events, when numbers in central California may increase. Typically forage within 20 nmi of shore. Species with maximum number of sightings by Padre (2011). A NOAA aerial survey in September 2008 counted 2,385 animals at 7 locations between Point Sal and San Simeon, with 870 animals counted at Lion Rock, near Point Buchon. During summer counts small numbers (<20) of pups have been counted at sites within the Investigation area (M. Lowry, NOAA, 2011).	Potential Biological Removal=9,200. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and mean species density estimate (Koski et al. 1998). Very abundant pinniped that uses Investigation area as migration route and for haul-out. **Quantification of project and acoustic impacts on population required.**	Yes
Northern elephant seal	Best population estimate is 124,000 for California breeding stock. Widely distributed offshore, shelf, shelf-break, and slope habitats. Adult males feed along the continental margin between coastal Oregon and the western Aleutian Islands. Adult females range across a wider area in the northeastern Pacific. Large rookery at Piedras Blancas (15,000+ population, B. Hatfield, USGS) north of the Investigation area. Rookeries are occupied year-round; abundance, age, class and sex of the seals at each site change throughout the year. Yearling/juvenile molt September-November and breeding in December-mid March, with peak pupping in late January. Central California at-sea data set reported by NCCOS 2007 (surveys 1980-2003) indicated infrequent single animals within the investigation area. A total 10 sightings were made within nine 10x10 km quadrats adjacent to the Investigation area. No sightings reported by Padre (2011). At-sea density estimated by Koski et al. (1998), August-November for Stratum 1 = 0.15593 km^2.	Potential Biological Removal=4,382. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and at-sea density (Koski et al. 1998). Very large PBR relative to local density. Forage largely offshore, less frequent inshore. Juveniles and yearlings likely at or near molt site to North. **Project may affect, but is not likely to adversely affect Northern elephant seals.**	No

Pacific harbor seal	California stock best estimate 30,196. Harbor seals are a widely distributed coastal species. Considered resident to area. Foraging is typically near shore (less than 5 miles) on fish and cephalopods. Pupping generally occurs March – June and molting generally occurs May – July. Haul-out counts were undertaken by NOAA in summer 2002, 2004 and 2006. A maximum estimate of 1,858 individuals for the area Point Sal to San Simeon was recorded in 2004 using aerial surveys (Mark Lowry, NOAA, 2011). Concentrations (~50-300) were recorded in the vicinity of Cayucos Point, Diablo Canyon, Estero Point, China Harbor, Morro Bay Estuary, Fossil Point, South Point, Point San Luis, and Point Buchon. Based on aerial surveys, total population likely >3,000 individuals (assuming an at-sea correction factor of 1.65, Lowry et al. 2008). At-sea density estimated by Koski et al. (1998), August-November for Stratum 1=0.02336 km^2.	Potential Biological Removal=1,600. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and density estimate (Koski et al. 1998). **Quantification of project and acoustic impacts on population required.**	Yes
Northern fur sea	Eastern Pacific stock population is 653,171 and San Miguel Island stock population is 9,968. The great majority of fur seals breed and pup off Alaska. Considered pelagic with a strong preference for offshore waters (Bonnell et al. 1992 cited in PG & E 2011). A small percentage of Northern fur seals (recognized as a separate stock) breed in the summer at San Miguel Island off Southern California and occur there year-round. A small rookery recently was re-established in 1996 at Southeast Farallon Island. Central California at-sea data set reported by NCCOS 2007 (surveys 1980-2003) indicated zero density estimates for Investigation area during the Oceanic season (August 15 – November 15). At-sea density estimated by Koski et al. (1998), August-November for Stratum 1=0.03095 km^2.	Potential Biological Removal=324 for San Miguel stock. Estimated NMFS Minimum Level B take >1 individual based on area ensonified above received levels of 160 dB re: 1 µPa (rms) and at-sea density estimate (Koski et al. 1998). No haul-outs in Investigation area. Strong preference for pelagic habitat. Flexible foraging strategy and habitat use. **Project may affect, but is not likely to adversely affect northern fur seals.**	No

Guadalupe fur seal	**Threatened.** Mexico to California stock best population estimate 7,408. Guadalupe fur seals reside in the tropical waters of the Southern California/Mexico region (Carretta et al. 2011). During breeding season, they are found in coastal rocky habitats and caves. Little is known about their whereabouts during the non-breeding season (September to May), but some individuals travel north in late summer to the Channel Islands (NSF 2011) and may occur in small numbers in Central California but no sightings were recorded in the review by NCCOS (2007). Foraging is considered to be mainly pelagic.	**Likelihood of individual effects (NMFS level A or B take) considered remote due to extremely low density prediction.** **Project may affect, but is not likely to adversely affect Guadalupe fur seal.**	No
Northern (Steller) sea lion	**Threatened.** Eastern Stock best population estimates range between 58,334 to 72,223. The center of abundance of the Eastern Steller sea lion stock is BC and South East Alaska. The closest rookery to the Investigation area is Año Nuevo Island, in San Mateo County, Northern California, where 308 adults and juveniles were counted in 2009 and no critical habitat has been designated to the south (Allen and Angliss 2011). The two haul-outs in the Investigation area have mean July counts (averaged across 2002-2004) of 1-2 animals, with only 5 individual animal sightings south of San Simeon and north of Point Sal based on the Central California at-sea data set reported by NCCOS 2007 (surveys 1980-2003). No densities were calculated by Koski et al. (1998)	Potential Biological Removal for Eastern stock=2,378. **Likelihood of individual effects (NMFS level A or B take) considered remote due to very low density prediction.** Species is at the extreme end of their southerly range. Large population with large PBR. Chance of Steller sea lions being within Project area rare. **Project may affect, but is not likely to adversely affect Steller sea lions.**	No

Mustelidae			
Southern sea otter	**Threatened.** California stock best population estimate 2,862. Resident species with year-round occupancy. The southern sea otter inhabits the near shore waters of the central California coast and at present the range extends from about Half Moon Bay in the north to Santa Barbara in the south. Breeds June-July and October-November. Invertebrates form majority of diet. Although sea otters occasionally make dives of up to 100 m, the vast majority of feeding dives (~99%) occur in waters less than 40 m in depth (Tinker et al. 2006). Typically, dive depths of females <30m and males <40m. Spring 2010 USGS survey from San Simeon to Point Sal, there were 788 independent otters and 86 dependent pups for a total of 874 sea otters (T. Tinker, USGS, pers. comm., 2011). Minimum population estimate=2723. Highest density within Investigation area is in the Point Buchon area (USGS 2010).	Potential Biological Removal=8. Annual anthropogenic mortality=6.6 Investigation site overlaps major portion of range and contains ~30% of population. One of two annual breeding times occurs during survey. **Quantification of project and acoustic impacts on population required.**	Yes

[1] Data was collated from a variety of sources quoted within the text and also including NOAA stock assessment reports; Koski et al. 1998 Section 2; EIR section 4.4.4; and NCCOS (2007).

3.7 Justification for use of additional threshold for acoustic take assessment (dual threshold criteria)

3.7.1 Current status of marine mammal noise exposure threshold: Auditory and behavioral thresholds of Southall et al. (2007) and implications of subsequent data

Over the last decade, there has been an increasing amount of new science to assess the potential effects of noise on marine life, including marine mammals. Recently, an expert panel was convened to summarize the available data on marine mammal hearing and behavioral and physiological responses to sound and to propose new exposure thresholds (Southall et al. 2007). The proposed thresholds for the onset of these effects were segregated according to differing functional hearing capabilities of five groups of marine mammals (low, mid, and high-frequency cetaceans and pinnipeds in air and water) and different noise metrics (peak and rms sound pressure and SEL for both impulsive and non-impulsive types of sound).

The resulting review and interpretation of the available literature on injury and behavioral data, using precautionary extrapolation procedures, resulted in the derivation of frequency-weighting functions for each functional group, quantitative dual-metric exposure threshold s for auditory injury, and derivation of a "severity scale" for behavioral responses. There were clear and acknowledged data gaps in many areas, some of which are quite relevant to the consideration of noise impacts in the proposed CCCSIP Project, and Southall et al. (2007) clearly stated both the need for a precautionary application and the acknowledgement that application of new thresholds would not necessarily be uniform or simple in practice. Where the science suggests a more protective approach (e.g. particularly sensitive species, endangered species with few data), a more protective approach was believed warranted. Further, Southall et al. (2007) expected that this first broad assessment of noise exposure criteria for marine mammals would evolve and improve with the acquisition of subsequent scientific data. This has clearly been the case since the publication of the initial noise exposure criteria, resulting in some slightly different interpretations or modifications to the Southall et al. (2007) conclusions.

As predicted, additional data have become available that would clearly modify the conclusions reached by Southall et al. (2007). These include several important papers on auditory impacts, including TTS in harbor porpoise hearing (Lucke et al. 2009) and an expanded understanding of TTS in other odontocete cetaceans (e.g., Mooney et al. 2009a; 2009b; Finneran and Schlundt 2010; Finneran et al. 2010a; 2010b). A recent study (Kujawa and Liberman 2009) involving human subjects demonstrates the onset of PTS in hearing from repeated TTS. Despite recent assertions, however, this would not affect the conclusion reached in Southall et al. (2007) that 40-dB onset TTS is a reasonable proxy for injury onset (PTS) given that large TTS onset values were involved in the Kujawa and Liberman (2009) assessment. New data regarding the behavioral responses of marine mammals have also become available since the Southall et al. (2007) criteria. Among these are data related to the clear and sustained behavioral responses of beaked whales to simulated and actual military sonar (McCarthy et al. 2011; Tyack et al. 2011).

The Southall et al. (2007) noise exposure criteria, with some modifications based on more recent scientific data, are considered the current state-of-the-art standard in terms of marine mammal noise impacts. However, the more recent results must be considered and integrated as appropriate, in a current assessment of potential hearing and behavioral impacts. In the U.S., the NMFS has not undertaken a wholesale acceptance of the Southall et al. (2007) exposure criteria as a stated policy for all sound sources, although elements have been used in regulatory decision-making regarding military sonar (NOAA 2009a; 2009b). For impulse noise associated with seismic surveys, NMFS is currently using estimated thresholds derived earlier and incorporated into current regulations. For the CCCSIP Project EIR, we assess the potential impacts according to these current regulatory thresholds, as well as relative to a derivation of those proposed by Southall et al. (2007) that take into account some of the more recent scientific data. The justification for this dual-threshold approach is described below.

3.7.2 Proposed dual-threshold approach for take assessment

3.7.2.1 Current NMFS thresholds

For the past several decades, NMFS has used single thresholds for the assessment of potential auditory and behavioral impacts from the noise associated with seismic surveys and continuous noise. These thresholds are based on early studies and assessments and do not include some of the considerations regarding acoustic metrics or differential auditory sensitivity to different frequencies among different mammal groups.

In terms of acoustic injury from any sound type, NMFS relies on the HESS (1999) panel assessment based on information available at that time (prior to most of the existing literature on marine mammal TTS). These thresholds are 180 dB re: 1 µPa (rms) for all cetaceans and 190 dB re: 1 µPa (rms) for all pinnipeds. For behavioral harassment from noise exposure, different thresholds are used for different sound types. A single threshold of 160 dB re: 1 µPa (rms) is used for impulsive noise, based on the results of Malme et al. (1983; 1984) and Richardson et al. (1986). A single threshold of 120 dB re: 1 µPa (rms) is used for continuous noise, based on the findings of Malme et al. (1984) and Richardson et al. (1990).

These thresholds are used in the current EIR assessment of potential auditory and behavioral impacts for comparison with the approach currently conducted and required by NMFS under the Marine Mammal Protection Act of 1972.

3.7.2.2 Southall et al. (2007) derived exposure thresholds

In addition to the standard NMFS thresholds for assessing potential effects of noise exposure, the Southall et al. (2007) exposure thresholds were used following a series of modifications described below that are intended to account for more recent data. We thus use firstly 'Injury SEL' thresholds (modified from SEL thresholds reported in Southall et al. 2007) as equivalent to NMFS Level A takes and secondly 'Probabilistic Disturbance rms' thresholds (a derivation based on the Southall et al. (2007) recommendations) as equivalent to NMFS Level B takes.

3.7.2.2.1 Acoustic injury thresholds (PTS-onset)

Southall et al. (2007) estimated PTS-onset as noise exposures estimated to result in 40dB of TTS for different sound types, using both a peak pressure and an SEL criterion; the SEL threshold is ultimately the functional criteria for most realistic exposure scenarios. For all cetacean functional hearing groups, estimated TTS onset levels for both impulse and non-impulse noise were based on data obtained in a few individuals of two mid-frequency species (bottlenose dolphins and belugas). For pinnipeds, some data were available on non-impulsive noise but extrapolations to PTS-onset for impulsive noise (such as that associated with seismic airguns) also included extrapolations involving data from bottlenose dolphins. The SEL threshold for PTS-onset to impulse noise for mid-frequency cetacean species (198 dB re: 1 µPa^2-s) and pinnipeds (186 dB re: 1 µPa^2-s) remain as valid (given the underlying assumptions) as when they were initially presented by Southall et al. (2007). However, subsequent data require some modification for other species groups.

For high-frequency cetaceans (e.g., harbor porpoises), subsequent data are available by Lucke et al. (2009). These data indicate lower TTS onset value both in terms of SEL and peak pressure. In this analysis, these directly relevant data form the basis for estimating TTS onset and potential for injury for harbor porpoise and other high-frequency cetaceans, rather than the extrapolated predictions of Southall et al. (2007). A PTS-onset threshold of 179 dB re: 1 µPa^2-s is used for this functional hearing group, based on Lucke et al. (2009) TTS-onset levels and the Southall et al. (2007) extrapolation procedure to PTS.

An additional consideration regards the assessment of potential auditory effects of impulse noise on low-frequency cetaceans (mysticetes). In the absence of direct measurements of hearing or noise impacts in any mysticete species, subsequent data on TTS in other cetaceans calls into question the hearing group extrapolation of results proposed by Southall et al. (2007). Specifically, Finneran and Schlundt (2010) recently demonstrated a greater sensitivity to non-impulse noise exposure for mid-frequency cetaceans at higher frequencies (within their region of best sensitivity) than had been tested when the Southall et al. (2007) criteria were published. Given the measurements of lower TTS onset values in the region of best hearing sensitivity for mid-frequency cetaceans, a more conservative extrapolation of results to low-frequency cetaceans, given the low frequency nature of seismic airgun impulses, was considered justified (see Southall et al. 2007). For reasons relating to the much higher natural ambient background levels at low frequencies and presumed adaptations in basic hearing capabilities of these species than for other cetacean species (see Wartzok and Ketten 1999), rather than a direct application of the high-frequency cetacean TTS-onset values, a more conservative extrapolation of the mid-frequency TTS onset data for impulse noise than proposed by Southall et al. (2007) was applied by subtracting 6 dB (which is halving the magnitude in terms of sound pressure) from the original Southall et al. (2007) level, for a resulting PTS-onset threshold for mysticetes of 192 dB re: 1 µPa^2-s.

3.7.2.2.2 Behavioral response thresholds

Southall et al. (2007) reviewed the available marine mammal literature and proposed a severity scaling for behavioral response applied to the available data, but did not present explicit step-function thresholds for behavioral response. This was because of the lack of convergence in the data on broadly-applicable exposure levels resulting in significant behavioral responses. The Southall et al. (2007) review found that contextual factors of sound exposure relating to different animal groups, sound types, exposure conditions, and differing activity states complicate efforts to derive simple step-function thresholds for all species. The approach proposed was to make efforts to account for both species and contextual differences. That approach has been adapted for this analysis.

For the majority of marine mammal species, a method similar to the NMFS step-function threshold (160 dB re: 1 µPa (rms)) for impulse noise is used. As reviewed in detail in Appendix II ("Studies Involving Marine Mammal Behavioral Responses to Multiple Pulses") of Southall et al. (2007), most marine mammals exposed to impulse noise demonstrate responses of varying magnitude in the 140-180 dB re: 1 µPa (rms) exposure range, including the mysticetes in the Malme et al. (1983; 1984) studies on which the NMFS threshold is based. Potential disturbance levels at SPL above 140 dB re: 1 µPa (rms) were also highlighted in HESS (1999). For the current assessment, a probabilistic metric is applied at which 10%, 50%, and 90% of individuals exposed are assumed to produce a behavioral response at exposures of

140, 160, and 180 dB re: 1 µPa (rms), respectively. One final difference is that frequency weighting curves (the M-weighting of Southall et al. (2007)) is applied to these exposure estimates.

As noted by Southall et al. (2007) and supported by subsequent data, certain marine mammal species and certain marine mammals in specific behavioral modes, appear to be significantly more sensitive to noise exposure. For instance, migrating Bowhead whales are much more likely than other mysticetes (including feeding bowhead whales) to respond clearly to seismic airgun noise at much lower (~120-140 dB re: 1 µPa (rms)) received sound levels (Richardson et al. 1999). As a protective approach for this behavioral state – 10%, 50%, and 90% response probability for migrating mysticetes is estimated to occur at M-weighted exposure levels of 120, 140, and 160 dB re: 1 µPa (rms).

Finally, certain species including harbor porpoises and beaked whales appear to have a categorically-different level of response than other marine mammals to much lower received levels. As reviewed in Southall et al. (2007), for harbor porpoises this appears to be consistent across sound types and laboratory and field settings. As recently demonstrated by Tyack et al. (2011), beaked whales appear to share this particular sensitivity, which may in part explain their disproportionate representation in marine mammal stranding events associated with sound exposure. Based on the initial assessment of Southall et al. (2007) and considering the more recent supporting evidence for beaked whales specifically, a particularly sensitive behavioral response category for these species and porpoises is assessed here. NMFS also recognizes species and contextual factors in setting behavioral response thresholds, the most obvious being the use of a 120 dB re: 1 µPa threshold for behavioral response of harbor porpoise to Navy acoustic sources with a wide range of activities (U.S. DON 2008). Thus, for these species groups, independent of behavioral state, 50%, and 90% behavioral response probabilities are calculated for M-weighted exposure levels of 120, and 140 dB re: 1 µPa (rms). The 10% probability was not modeled in this case, but the 50% criterion is used as a step function.

Table 3.8 provides a summary of the Injury SEL thresholds used for the proposed Project to estimate Level A takes, and compares these thresholds with those published in Southall et al. (2007). Only low frequency and high frequency cetacean thresholds change. Table 3.9 provides a synopsis of the thresholds and the probability of a Level B behavioral response. Probabilities are not additive and reflect single points on a theoretical response curve.

Table 3.8 Modified Injury Sound Exposure Level (SEL) thresholds for multiple pulses used in this analysis and those originally proposed by Southall et al. (2007) to estimate onset of acoustic injury (Level A - PTS).

Marine Mammal Group	**Injury SEL thresholds used in this analysis (dB re: 1 µPa^2-s)**	**Southall et al. (2007) – published SEL (dB re: 1 µPa^2-s)**
Low frequency cetacean	192	198
Mid frequency cetacean	198	198
High frequency cetacean	179	198
Pinniped (in water)	186	186

Table 3.9. Probabilistic Disturbance rms sound pressure level thresholds (M-weighted) used in the current analysis to predict a Level B behavioral response. For comparison, the NMFS threshold for behavioral response for all marine mammals is 160 dB re: 1 µPa (rms, un-weighted). Probabilities are not additive and reflect single points on a theoretical response curve.

	Probabilistic Disturbance rms thresholds M-weighted dB re: 1 µPa (rms)			
Marine Mammal Group	**120**	**140**	**160**	**180**
Porpoises/beaked whales	50%	90%		
Migrating mysticete whales	10%	50%	90%	
All other species/behaviors		10%	50%	90%

3.8 Marine mammal density estimate verification and validation

SERDP-SDSS models of cetacean densities in the Investigation area are based on SWFSC ship line-transect data collected from 1986 to 2006 and include over 17,000 sightings of cetacean groups on over 400,000 km of transect line, but coverage of the Investigation area is below average (see Barlow et al. 2009), partly due to sighting conditions such as fog (K. Forney NOAA, pers. comm. 2011). The output from an ecological model is an approximation to the truth with two components: a point estimate (such as the predicted number of whales resulting from a GAM) and an estimate of uncertainty associated with the point estimate. There are numerous sources of uncertainty in the cetacean-habitat population density models used. Barlow et al. (2009) state 'In our analyses, the greatest source of uncertainty is inter-annual variability in actual population density due to movement of animals within or outside of the study areas'. Across all years, density ratios (density calculated using standard line-transect methods divided by density predicted by the habitat model, Barlow et al. (2009)) were close to unity for most species (range 0.86 - 1.50), indicating that - on average - model density estimates were similar to line-transect density estimates. However, individual annual density ratios were more variable ranging from approximately 0.3 to 3.0, indicating that predictions for any given year were within a factor of three of the standard line-transect density estimates.

The SERDP-SDSS model is optimized for large scale density predictions using broad habitat variables and consequently is not optimal for accurate predictions at the scale of this study. Density estimates were therefore verified independently by two senior scientists who have undertaken more than two decades of surveys and abundance estimates in the region (K. Forney NOAA, 2011; J. Calambokidis, Cascadia, mysticete only, 2011). Following review, both scientists independently considered the mean density for humpback whales to be low (by a factor of 2 or 3) and considered that the upper confidence interval SERDP-SDSS Model density estimate for humpbacks does not reflect potentially high density 'hotspot' years that have been observed in previous years by smaller scale surveys not included in the model (see section 3.8.1). Similarly, high densities of blue whales have been occasionally encountered in early fall in the area (J. Calambokidis, Cascadia, Pers. Comm. 2011, see section 3.8.1).

Validations undertaken by Barlow et al. (2009) for central California (east sector) across 5 survey years confirmed line transect estimates were on average 2.3 times higher than model predictions for humpback whales. At a large scale abundance and subsequent density estimates take account of area movements by animals, but on smaller geographical scales the model does not reflect turnover of animals. In addition to incorporating baseline density estimates into acoustic take models, upper confidence density estimates were used as well as a ‘potential’ density that reflected SERDP-SDSS Model underestimates for Fin and humpback whales and applied a conservative level of turnover to reflect ‘Potential’ non-static densities. In addition, aerial survey estimates for minke whales were not corrected for animals that were on the track line but missed because they were diving and therefore they are considered an underestimate. An analysis of NOAA unpublished data provided a considerably higher density estimate for minke whale (K. Forney NOAA, Pers. Comm., 2011), and though these are not incorporated into the present population estimate nor PBR estimates, they were considered in the adverse effects assessment of this report.

3.8.1 Inter-annual variability in mysticete

Euphausiids (krill) form a key trophic link in coastal upwelling systems between primary production and higher trophic level consumers. The California Current Ecosystem is a highly productive ecosystem driven by seasonal wind driven upwelling. However the timing, duration and intensity of this upwelling varies significantly inter-annually and consequently affects euphausiid abundance (Benson et al. 2002). Bailey et al. (2010) highlight that changes in the location and duration of foraging activity are driven by this variation and blue whales modify their foraging response accordingly. For example, the El-Nino event of 1997-1998 led to high concentrations of baleen whales observed in Monterrey Bay (Benson et al. 2002) and increasing numbers of blue whales in Washington state waters and off Vancouver Island. A delayed upwelling in 2005 also led to blue whales moving further north due to a lack of prey. Humpback whales switch between krill and forage fish, but also show large inter-annual variations in density and location (Peterson et al. 2006; Calambokidis et al. 2008). Overall, for both species, the Investigation area is considered a transit/migration route, often for a substantial portion of the population, especially in fall when both species migrate south. Locally high abundances can occur within the Investigation area if and when suitable foraging conditions occur (NCCOS 2007). Suitable conditions vary between species, as humpbacks are able to take advantage of inshore fall (September/October) concentrations of anchovy/sardines. Mean time within a foraging patch was calculated for 159 satellite-tagged blue whales as averaging 21 days (Bailey et al. 2010) and is considered a representative temporal scale for other foraging mysticetes.

Cascadia Research Collaborative (e.g., Calambokidis et al. 2008) have undertaken and collated boat-based Photo-ID studies of humpback whales and blue whales off the US west coast since 1986. Effort has focused on a number of key areas (including the Santa Barbara Channel and Monterey Bay) with sporadic effort (often limited to 1-2 days of survey efforts in summer and/or fall) in the Investigation area off the Central California Coast. Expert opinion predictions for blue whales and humpback whales within 50 km of the Investigation area for early fall resulted in potential estimates of 100+ blue whales and 200-300 humpback whale individuals (J. Calambokidis, Cascadia, Pers. Comm., 2011), based on experience from these long-term surveys. Concentrations of this scale do not however occur regularly, but reflect temporal variation in foraging opportunities.

For example, in 2008, 3 days of local area effort (Point Conception to Point Sur) in mid-August yielded 100 sightings (87 unique IDs) of humpback whales. As well as 2008, humpbacks had high relative regional resight numbers in 2005 (168), 2004 (72), 2002 (44), 2000 (138), 1991 (195) and 1988 (117), in some years mostly between Point Conception to Point Buchon (1988, 1991, 2000, 2002) and other years between Point Buchon and Point Sur (2005, 2008) (Calambokidis et al. 2009). Table 3.10 provides summary information of humpback whale sighting in the locale of the Investigation area made by

Calambokidis et al. (2002; 2003). Data is also available from 1988-2007 NOAA harbor porpoise surveys (K. Forney, NOAA, Pers. comm., 2011) which noted concentrations of humpback whales

Blue whales are typically found concentrated in the Santa Barbara channel region to the south, (<100 km away) mainly between June and October, as well as the Farallones in September and October (Calambokidis et al. 2009). However, large numbers of blue whale were encountered during local based surveys in 2003 (42), 2002 (48), 2001 (21) and 2000 (37), and most of these sightings (88%) were found between Point Conception and Point Buchon (Calambokidis et al. 2009). Table 3.10 provides summary information of blue whale sighting in the locale of the Investigation area made by Calambokidis et al. (2002a; 2003; 2004). Data is also available from 1988-2007 NOAA harbor porpoise surveys (K. Forney, NOAA, Pers. comm., 2011) which also noted concentrations of blue whales.

Table 3.10 Summary of notable humpback and blue whale sightings during local vessel sighting surveys by Calambokidis et al. (2002a; 2003; 2004) and during NOAA porpoise surveys (1998-2007).

Species	**Number**	**Location**	**Date**	**Source**
Humpback whale	4	Survey around San Luis	4 November 2001	Calambokidis et al. 2002a
Humpback whale	36	Survey around San Luis	4 October 2002	Calambokidis et al. 2003
Humpback whale	12	Survey around San Luis	5 October 2002	Calambokidis et al. 2003
Humpback whale	8	Survey around San Luis	29 October 2002	Calambokidis et al. 2003
Humpback whale	25-35	N35°23.86' W120°56.41', Morro Bay Area	August 27 1991	K. Forney, SWFSC NOAA
Humpback whale	20-40	N35°01.31' W120°46.59', Pismo Beach area	1 November 1991	K. Forney, SWFSC NOAA
Humpback whale	12	N34°34.55' W120°44.07', South of Point Sal	7 October 2002	K. Forney, SWFSC NOAA
Humpback whale	Multiple	N34°52.51' W120°45.44', off Avila Beach	18 September 2006	K. Forney, SWFSC NOAA
Blue whale	0	Survey around San Luis	9 November 2001	Calambokidis et al. 2002a
Blue whale	23	Survey around San Luis	4 October 2003	Calambokidis et al. 2003
Blue whale	20	Survey around San Luis	5 October 2003	Calambokidis et al. 2003
Blue whale	2	Survey around San Luis	29 October 2003	Calambokidis et al. 2003
Blue whale	36	Survey around San Luis	August 31 2003	Calambokidis et al. 2004
Blue whale	25	N34°34.55' W120°44.07', South of Point Sal	7 October 2002	K. Forney, SWFSC NOAA

Less local area information is available for fin whales due to their deeper water habitat preferences. Overall, however, local fall survey information highlight that densities of both humpback and blue whales can in some years exceed Upper confidence level densities predicted by the SERDP-SDSS model, which amount to no more than 15 animals within the total area predicted to be ensonified to received levels of 160 dB re: 1 µPa (rms).

3.8.2 Depth dependent density assumptions

The SERDP-SDSS model incorporates depth as a potential variable (Barlow et al. 2009), but following additional scientific consultation (K. Forney NOAA, 2011; J. Calambokidis, Cascadia, 2011; Koski et al 1998), depth cut-offs were applied to five species, below which density was assumed to be zero (blue whales [<80m], beaked whales, Dall's porpoise, Northern right whale dolphin and sperm whale [<100m]. A maximum depth cut-off of 200m was applied to harbor porpoise (based on survey sighting data by Carretta et al. 2009). Coastal bottlenose dolphins were modeled only within the 1 km strip from shore.

3.9 Acoustic take methodology

Acoustic takes were calculated using two (dual) different sets of thresholds as summarized in Table 3.2 and described in Section 3.7 (NMFS rms Level A and B thresholds and Injury SEL Level A and Probabilistic Disturbance rms Level B thresholds). The NMFS and Southall methodologies used to estimate take are generally distinguished from each other as follows:

- NMFS take estimates: NMFS Level A and B thresholds are used to estimate ensonified areas representing the two types of effects. The NMFS thresholds do not account for differences in hearing sensitivity among cetacean species. Take is based on the area within the respective contours defined by the 95 percentile thresholds radii (i.e., outliers removed), and using three scenarios of estimated animal density (see Section 3.9.4). Contours were based on the maximum 95% radii from any active sound source using nine representative depth and bottom type location. Level A takes were modified to incorporate species-specific depth dependency, an estimate of expected avoidance reaction and the proposed use of MMOs and PAM to monitor the exclusion zone (Table 3.11). Level B takes were increased accordingly and also incorporated species-specific depth dependency.
  The proposed seismic lines run parallel to each other in close proximity (200-400 m); thus, there are areas were radii overlap (often multiple times), therefore, theoretically an individual may be exposed numerous times during the survey. Two take estimate approaches were calculated using NMFS threshold criteria: Using the 'Minimum' area ensonified (which excludes all areas of overlap and thus represents the absolute minimum number of individual takes based on the proposed Project footprint and a static density distribution, assuming no net immigration or emigration, *sensu* LGL 2009); Using the 'Maximum' area ensonified (which includes all overlap areas and includes repeated takes of the same individual). The NMFS 'Maximum' estimate is thus a cumulative total of the maximum area ensonified that incorporates the length of all the survey tracklines. The NMFS Maximum take estimate includes a contingency of 25% which was added to account for production lines that have to be reshot for various reasons (sensu LGL 2009), as well as the sound source verification period. The ratio of Maximum to Minimum take represents the 'intensity' of the entire survey within the Project footprint or the number of repeated times the Project footprint is ensonified. Repeated ensonification within the Project footprint can increase the number of individuals taken if net immigration occurs due to, for example, seasonal migration patterns. NMFS Maximum estimates apply an average density

throughout the survey period. Given reductions in mysticete density are likely to occur in November, then NMFS Maximum estimates will be overestimated to some extent.

- New take estimate based on Southall et al (2007): Level A thresholds (termed Injury SEL) are taken from Southall et al. (2007), but threshold values were reduced for Low and High frequency cetacean groupings (Table 3.8). In contrast to NMFS metrics, a cumulative 24 hour sound exposure level (SEL) was used that incorporated group-specific hearing sensitivities (termed M-weightings). Jasco Applied Sciences used a representative 24 hour period of track lines (~200 km) for each survey box to model the 24 hour cumulative M-weighted SEL due to all sound sources. The distance from the representative track line to the edge of the M-weighted area ensonified was then measured for turns as well as deep (>150m) and shallow (<150m) production areas to be used as buffer radii. Track lines for each survey box were then split into continuous segments that could be completed in 24 hours (~200km) and buffered by their appropriate radii. Overlaps in buffers within a day were dissolved, but not between days. Thus the area ensonified to a 24 hour cumulative SEL isopleth could be calculated and used to estimate a cumulative SEL take representative of the entire survey (plus an additional 25% reshoot contingency). Takes were modified to incorporate species-specific depth dependency, an estimate of expected avoidance reaction and the proposed use of MMOs and PAM (Level A) to monitor the exclusion zone (Table 3.11).

  Level B thresholds (termed Probabilistic Disturbance rms), like NMFS thresholds used rms metrics, but in addition included the use of group-specific M-weightings. A range of thresholds were selected ranging between 120- 180 dB re: 1 µPa (rms), with the probability of response (10%, 50%, or 90%, see Table 3.9) varying by species groupings and context (migrating versus non-migrating mysticete). Take is based on the area within the respective contours defined typically by the 95 percentile thresholds, and three scenarios of estimated animal density. Accurate estimates of transmission to the 120 dB re: 1 µPa (rms) isopleths are problematic and exhibit strong directionality (propagated greater distances downslope). Representative contour shape-files were therefore used to optimize the estimated area of ensonification. Level B takes incorporated species-specific depth dependency. Probabilistic Disturbance rms is comparable to NMFS Minimum in that it represents the Project's noise footprint and excludes areas of overlap.

In summary, a number of different parameters are required to calculate an acoustic take. These are the radii ensonified (RAD) by the airgun(s) to a predetermined noise threshold (see Section 3.6), the length of the survey track (T), the density of marine mammals (D) and weighting factors that take into account the APMs (APM: Level A only) and any assumptions on behavioral avoidance response (BAR: Level A only).

For rms based takes, calculation estimates were based generally on the following method

$$\text{Take} = RAD_{das} \times T_{da} \times D_{dvs} \times (BAR_s) \times APM_s$$

d = depth dependency component
a = airgun array or single airgun (or echosounder or sub-bottom profiler)
v = marine mammal density variability scenarios
s = species specific

3.9.1 Depth and substrate dependent radii

Acoustic isopleth radii from Jasco Applied Sciences were available for four (# 1,2,3,4 and 8) depth strata (<50 50-90m, 90-150m, 150-300m, >300m) for production lines and three (# 5, 6, 7 and 9) depth strata (< 50 50-150m, 150-300m, >300m) for the turns (Figures 3.2 and 3.3). Sites 8 and 9 were modeled on hard bottom substrate and are relevant to the proposed Project and Alternative 1 tracklines only. Two depth strata representing shallow and deep water were typically available for cumulative SEL based take estimates (See Appendix I). ArcGIS 10.0 was used to partition the study area into appropriate depth strata. Other assumptions include 1) Radii are representative across all water depths within that depth stratum, 2) diving by marine mammals does not impact received levels.

3.9.2 Production tracklines and the inclusion of echosounder and sub-bottom profiler

The length of the turns and production lines were calculated separately for the proposed Project and each Alternative. Based on information in PG&E Letter DCL-2011-646, thresholds for 3km of run-out and the last 3km of run in were buffered using the radii of the full airgun array. A Kongsberg EM 122 multibeam echosounder (MBES) and a Knudsen 320B sub-bottom profiler (SBP) will be used continuously during the CCSIP Project to better characterize the local bathymetry and sedimentary features. The MBES ensonifies a broad swath (150º beam pattern) of the bottom perpendicular to the movement of the vessel, but a very narrow swath (2º beam pattern) in the direction of travel of the vessel. The wide beam pattern is achieved by aiming multiple pulses at successive angles. The SBP ensonifies a cone 30^{o} wide. The maximum source levels for the MBES and SBP are 242 dB re: 1 µPa (rms) and 204 dB re: 1 µPa (rms) respectively at dominant frequencies of 12 (MBES) and 3.5 kHz (SBP). Pulse duration for the units can vary from 2-15 ms for the MBES and 1-4 ms for the SBP. Therefore, in addition to array and single mitigation airgun sound sources, Jasco Applied Sciences modeled the propagation of sound from the MBES echosounder and sub-bottom profiler (Appendix I).

Predicted MBES or SBP radii for Level B rms threshold criteria clearly exceeded those of the single airgun at certain threshold levels. For rms-based estimates, Project tracklines were buffered by depth-specific array airgun, mitigation airgun, echosounder or sub-bottom profiler threshold radii (which ever was largest). This provided a combined active source take estimate. Cumulative SEL estimates for the proposed project and Alternative 1 included the contribution from the echosounder and sub-bottom-profiler, whereas they were not included in cumulative SEL estimates for Alternative 2. The impact of including the echo-sounder and sub-bottom profiler was assessed using data from Box 1 of the proposed Project. Cumulative 24 hour SEL estimates using data for airguns only represented 99.7% of the area for Low Frequency cetaceans, 91.4% for Mid Frequency cetaceans, 84.3% for High Frequency cetaceans and 97.7% for Pinnipeds. Cumulative SEL Modeling results for one day are depicted for the four proposed Project boxes 1,2,3,4 (Figures 3.4, 3.5, 3.6 and 3.7), as well as for Alternative 2 Zone 1 (Figure 3.8) and Zone 2 (Figure 3.9). Combined active acoustic source Level B area footprints were determined for the Project for both Probabilistic Disturbance rms and NMFS (Figure 3.10) thresholds, as well as all Alternatives. For further explanation of acoustic modeling for active sounds sources see Appendix I.

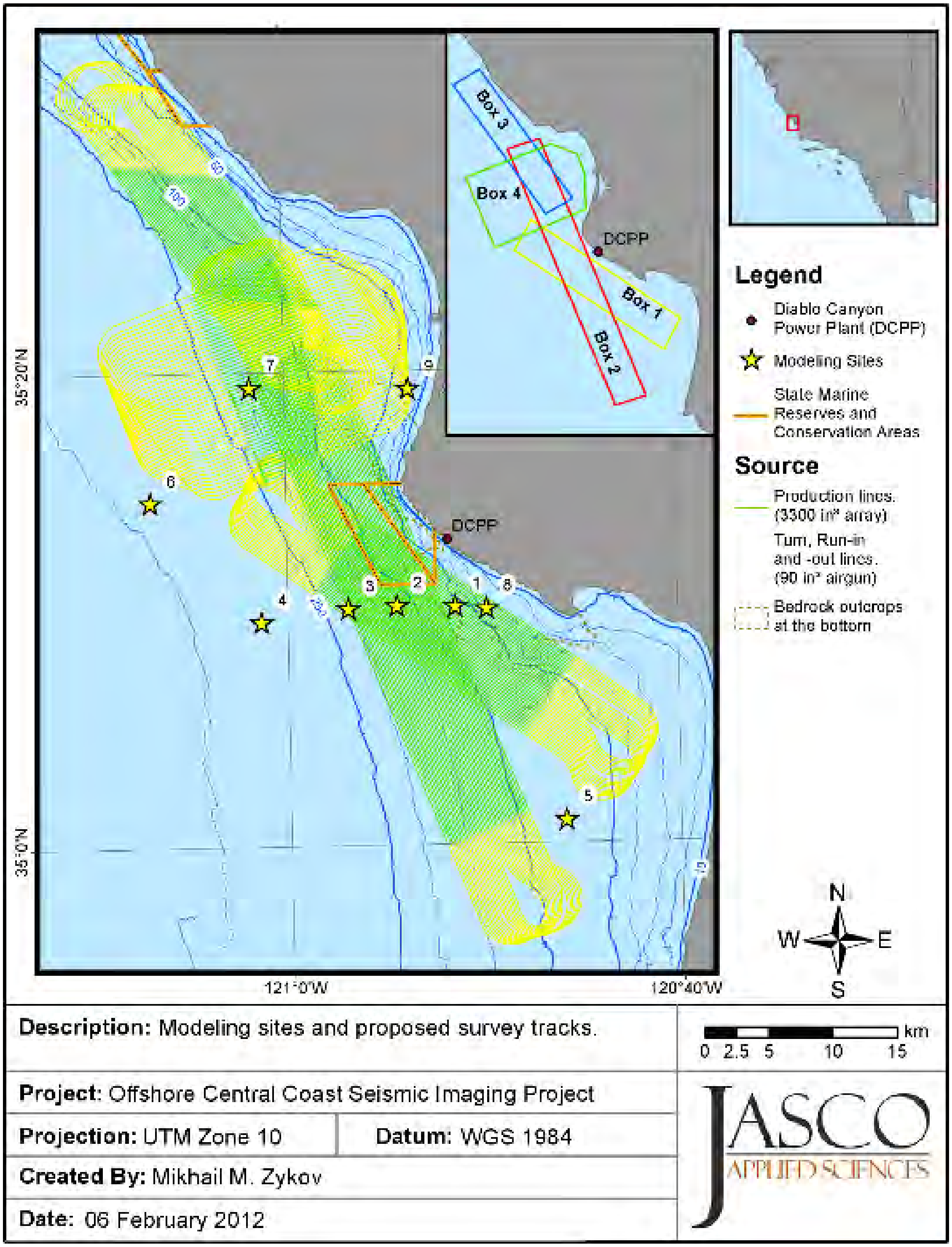
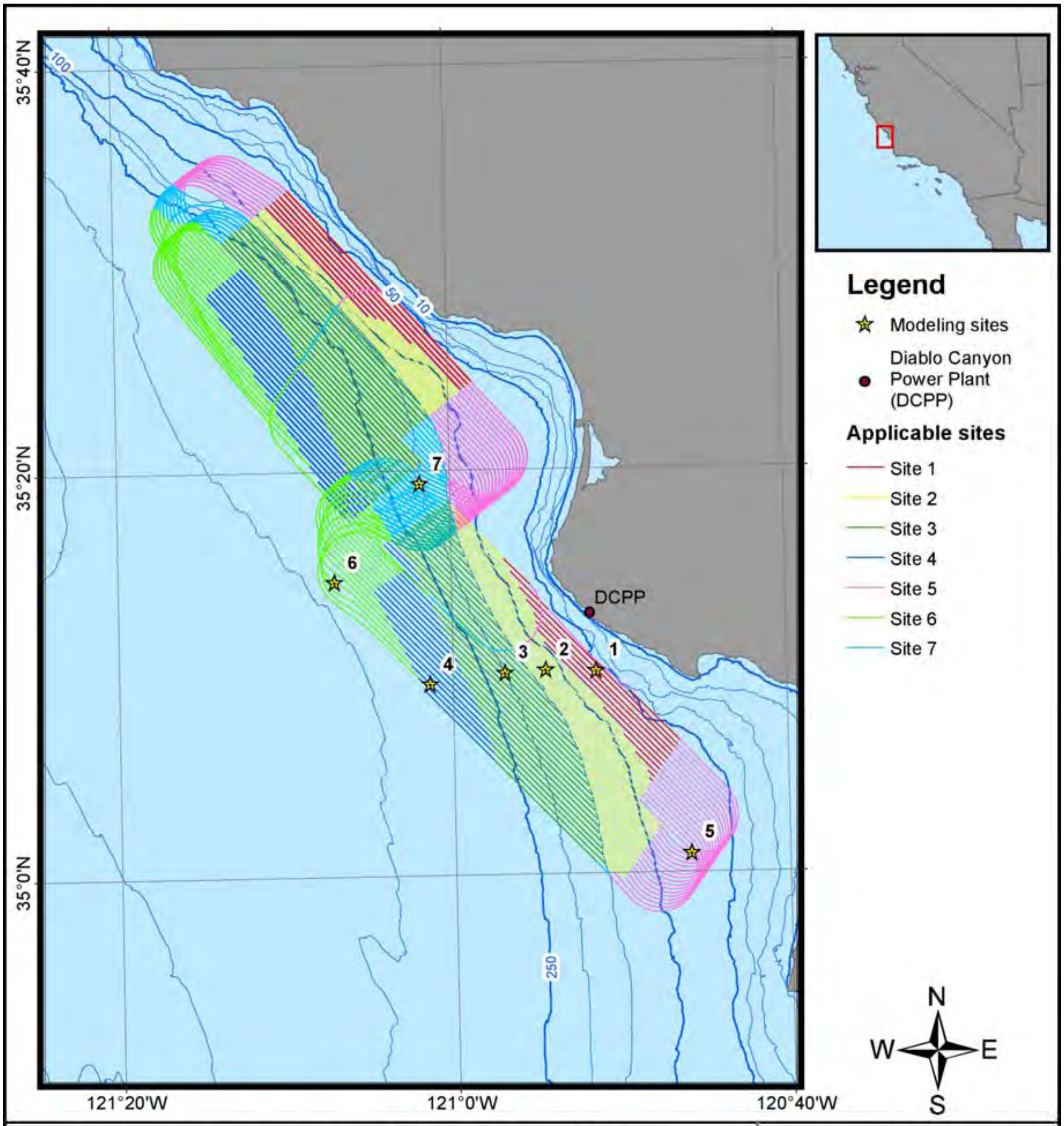


Figure 3.2 Application of the individual sites modeling results to the seismic tracklines relevant to the proposed Project and Alternative 1.



Description: Application of the Individual Sites Modeling Results to the Seismic Tracklines

Project: Offshore Central Coast Seismic Imaging Project

Projection: UTM Zone 10 **Datum:** WGS 1984

Created By: Mikhail Zykov

Date: 09 November 2011

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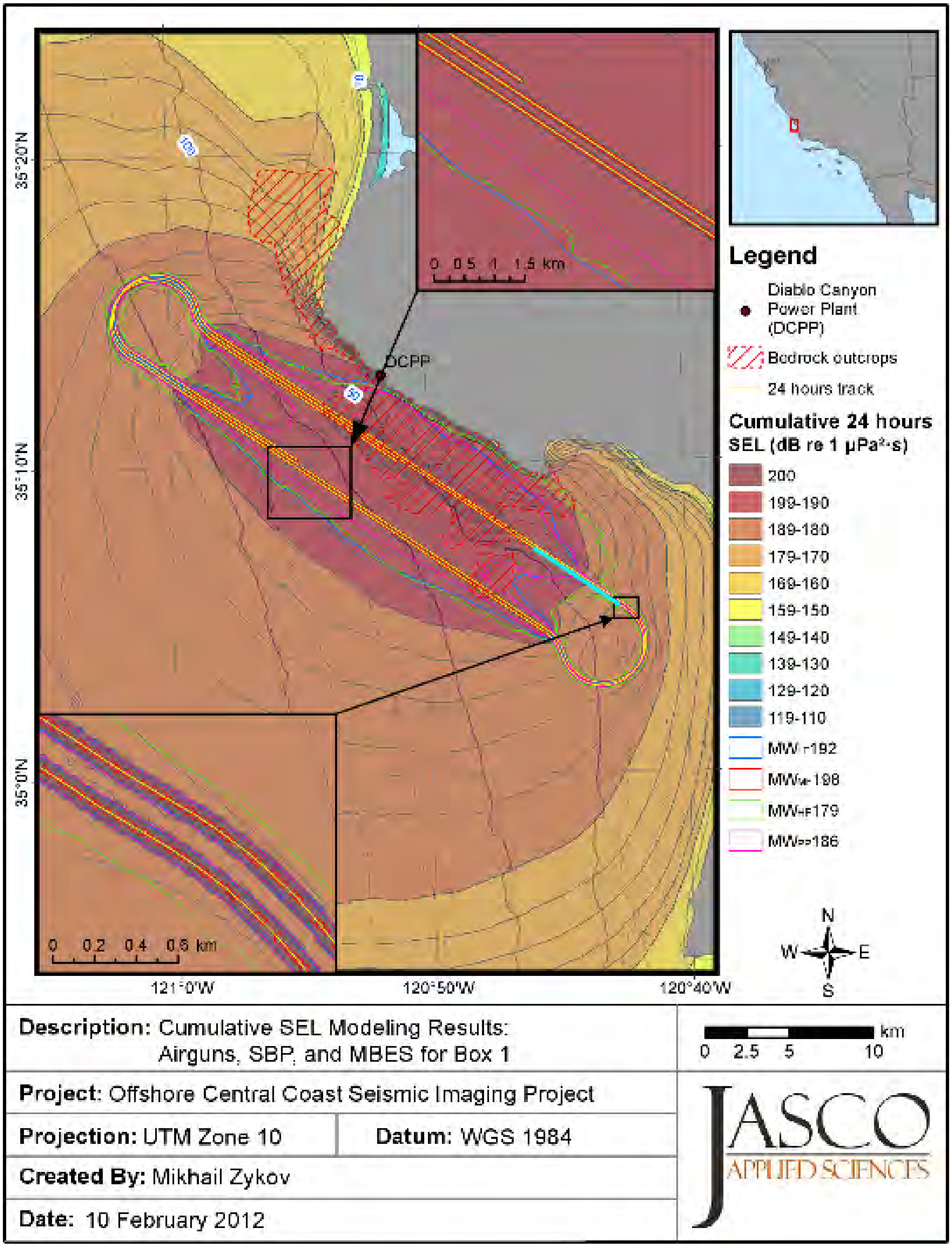
Figure 3.3 Application of the individual sites modeling results to the seismic tracklines relevant to Alternative 2.



Description: Cumulative SEL Modeling Results: Airguns, SBP, and MBES for Box 1

Project: Offshore Central Coast Seismic Imaging Project

Projection: UTM Zone 10 **Datum:** WGS 1984

Created By: Mikhail Zykov

Date: 10 February 2012

Figure 3.4 Cumulative SEL modeling results for Box 1 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

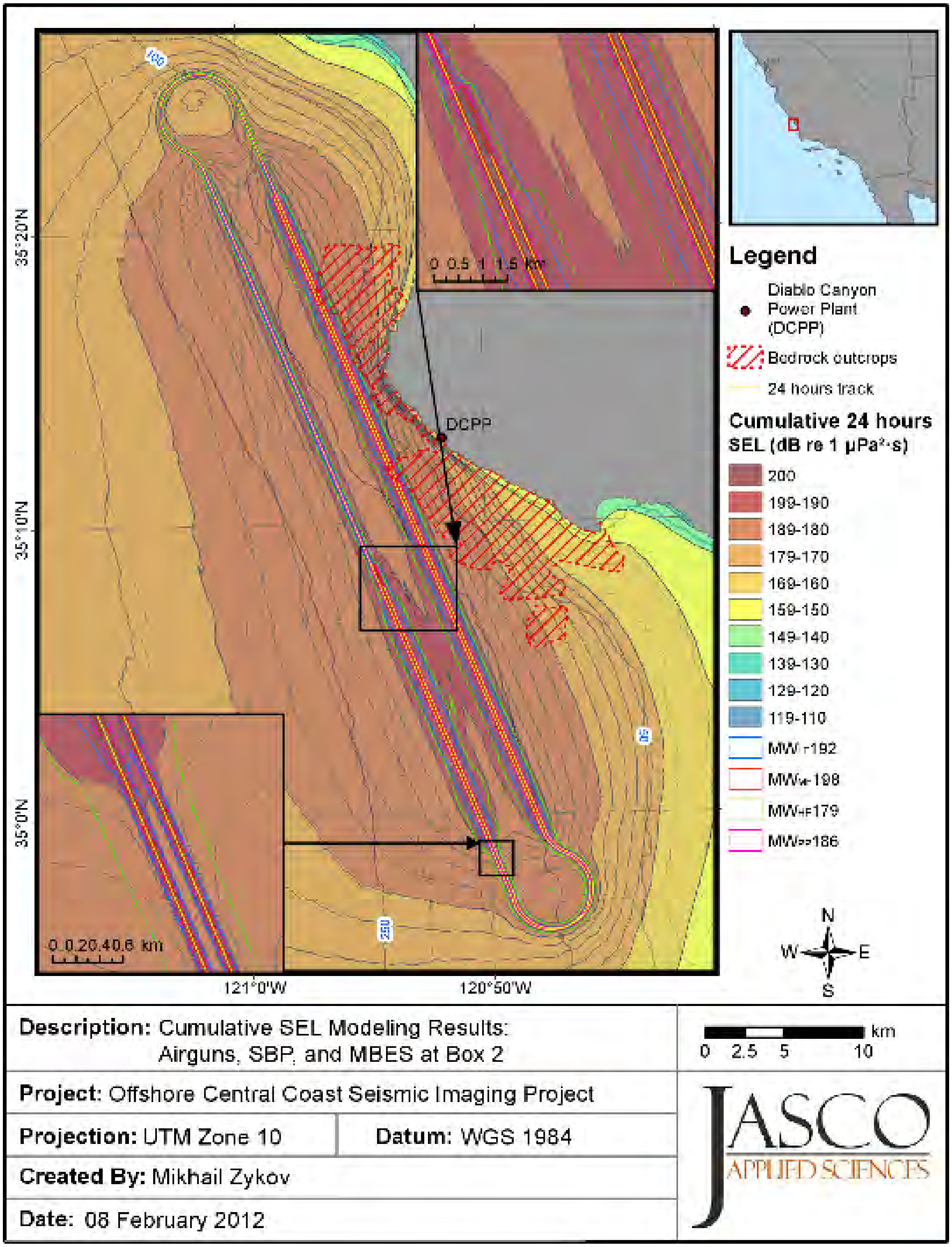


Figure 3.5 Cumulative SEL modeling results for Box 2 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

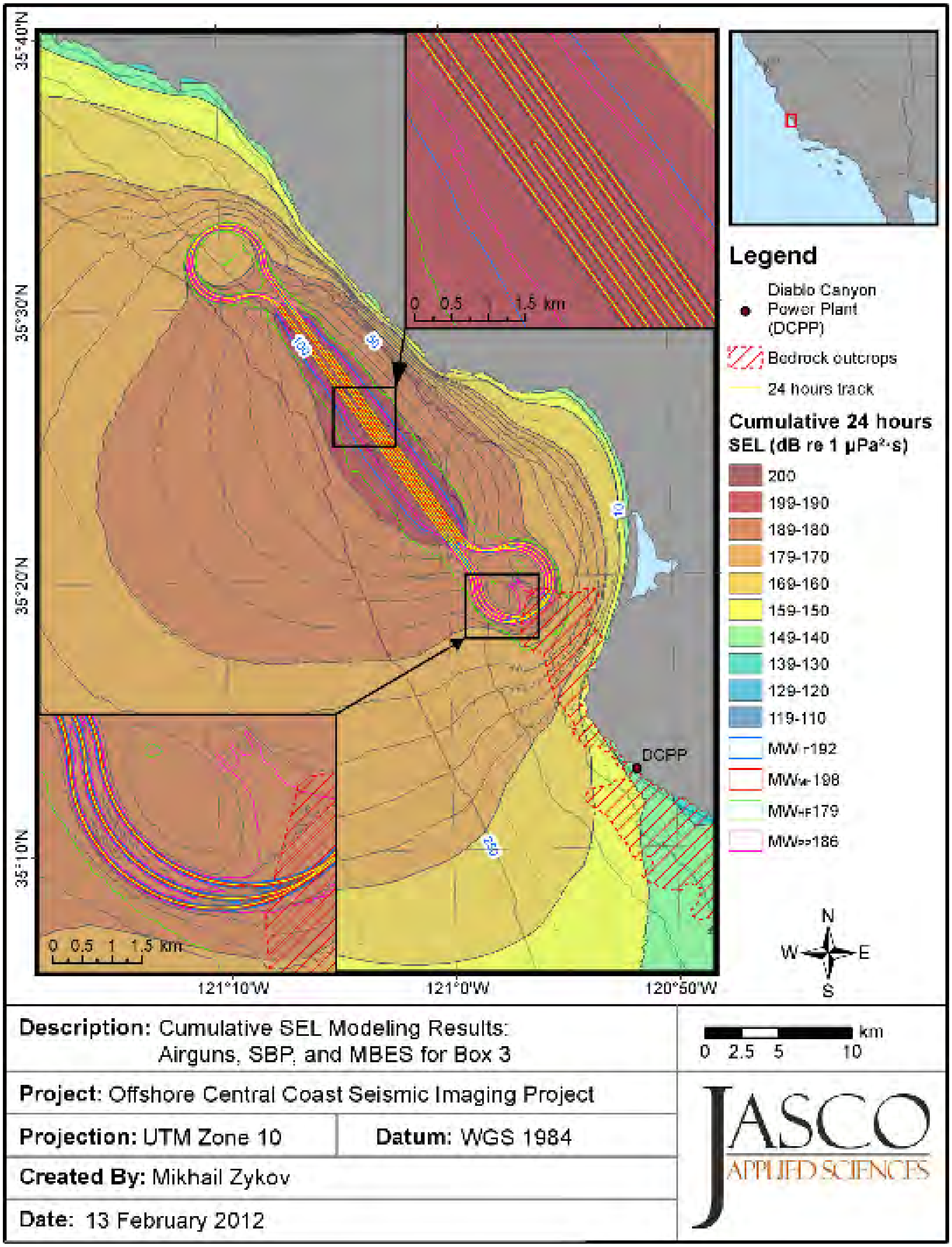
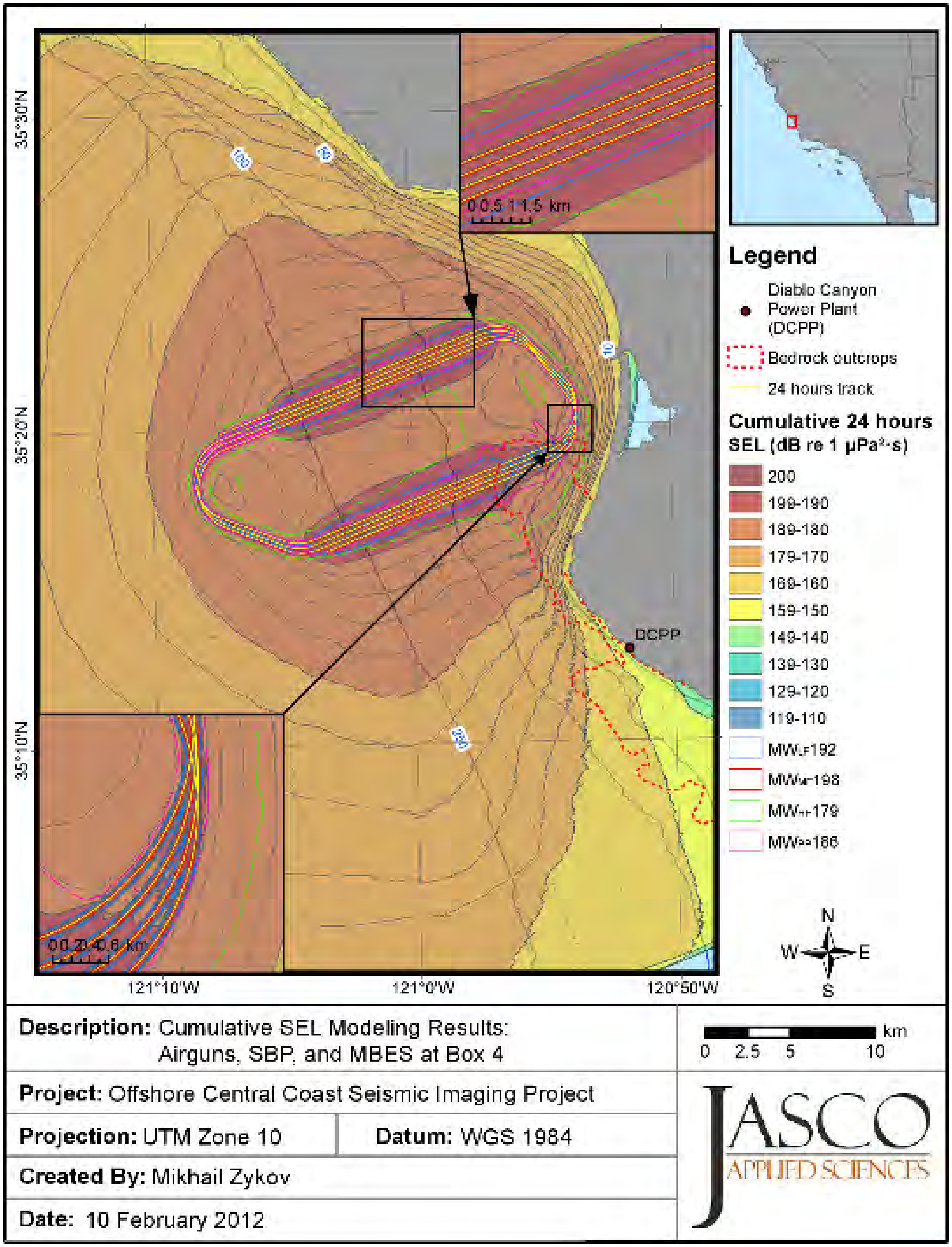


Figure 3.6 Cumulative SEL modeling results for Box 3 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $\mathrm{MW}_{LF,}$ 198 dB $\mathrm{MW}_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.



Description: Cumulative SEL Modeling Results: Airguns, SBP, and MBES at Box 4

Project: Offshore Central Coast Seismic Imaging Project

Projection: UTM Zone 10

Datum: WGS 1984

Created By: Mikhail Zykov

Date: 10 February 2012

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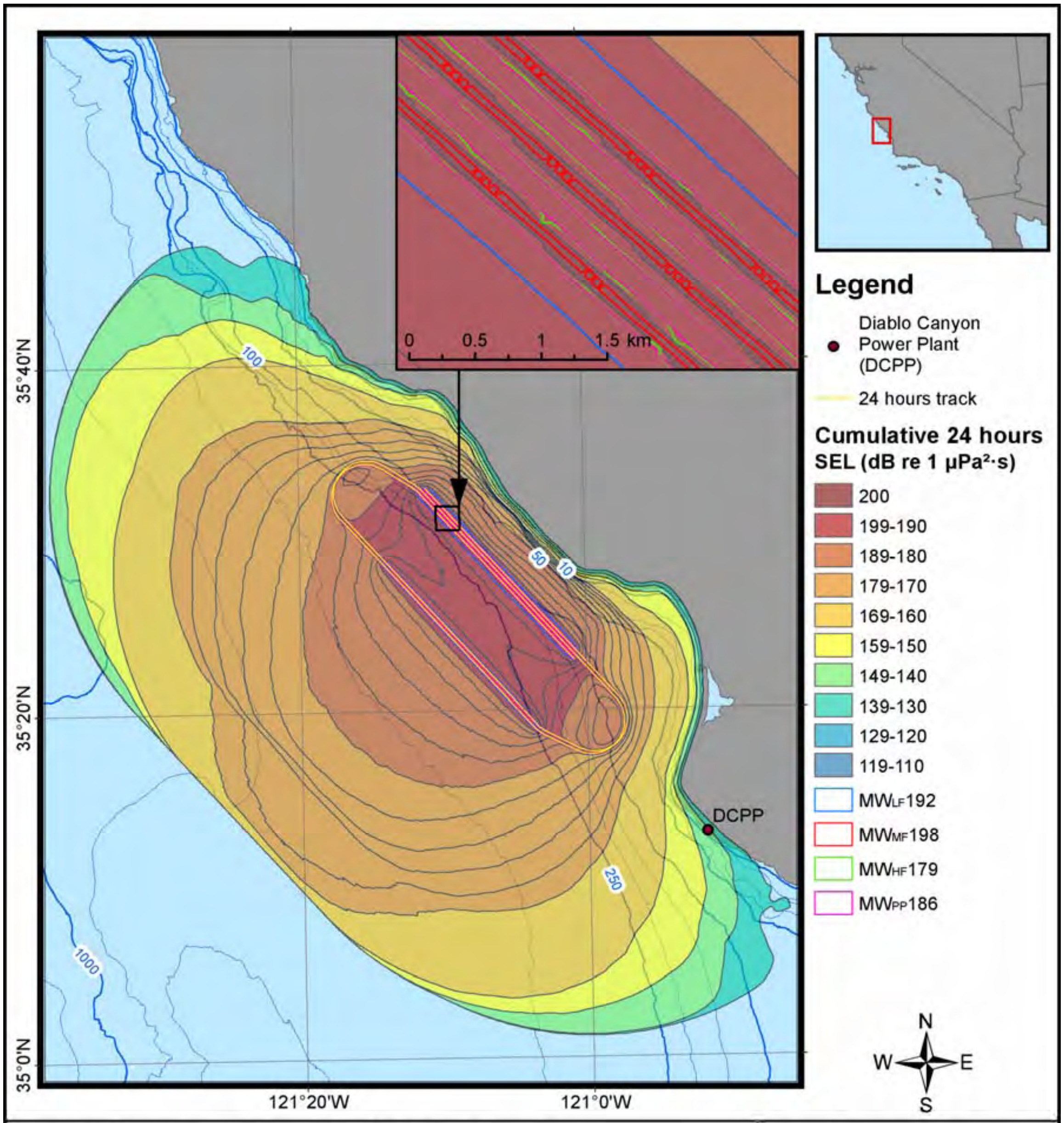
Figure 3.7 Cumulative SEL modeling results for Box 4 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.



Description: Cumulative SEL Modeling Results
Northern Area

0 5 10 20 km

Project: Offshore Central Coast Seismic Imaging Project

Projection: UTM Zone 10 **Datum:** WGS 1984

Created By: Mikhail Zykov

Date: 15 November 2011

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Figure 3.8 Cumulative SEL modeling results for Zone 1 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB MW_{LF}, 198 dB MW_{MF}, 179 dB MW_{HF}, and 186 dB MW_{PP}.

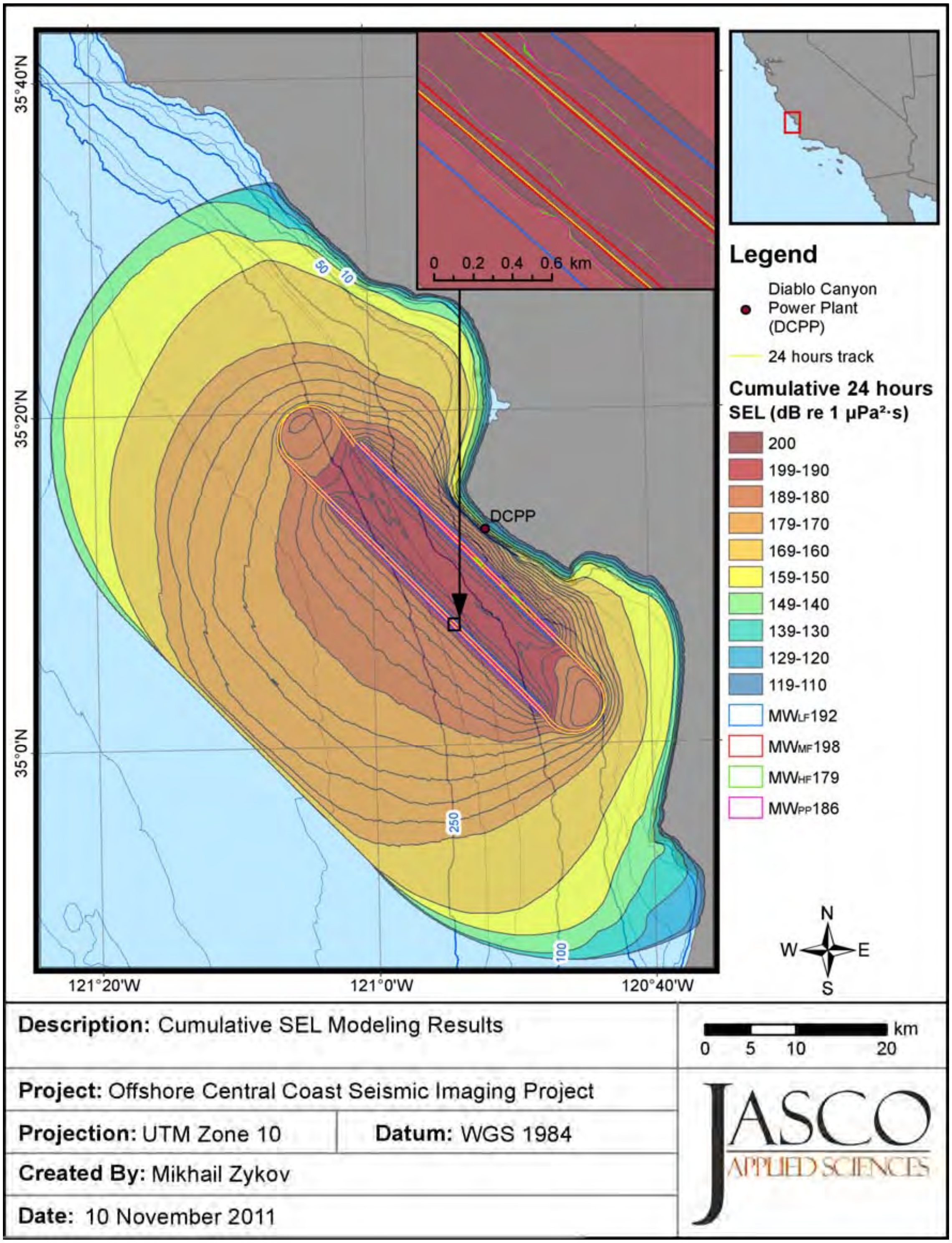

Figure 3.9 Cumulative SEL modeling results for Zone 2 showing contour lines for unweighted cumulative SEL as well as selected contours for different M-weighted marine mammal frequency group fields: 192 dB $MW_{LF,}$ 198 dB $MW_{MF,}$ 179 dB MW_{HF}, and 186 dB MW_{PP}.

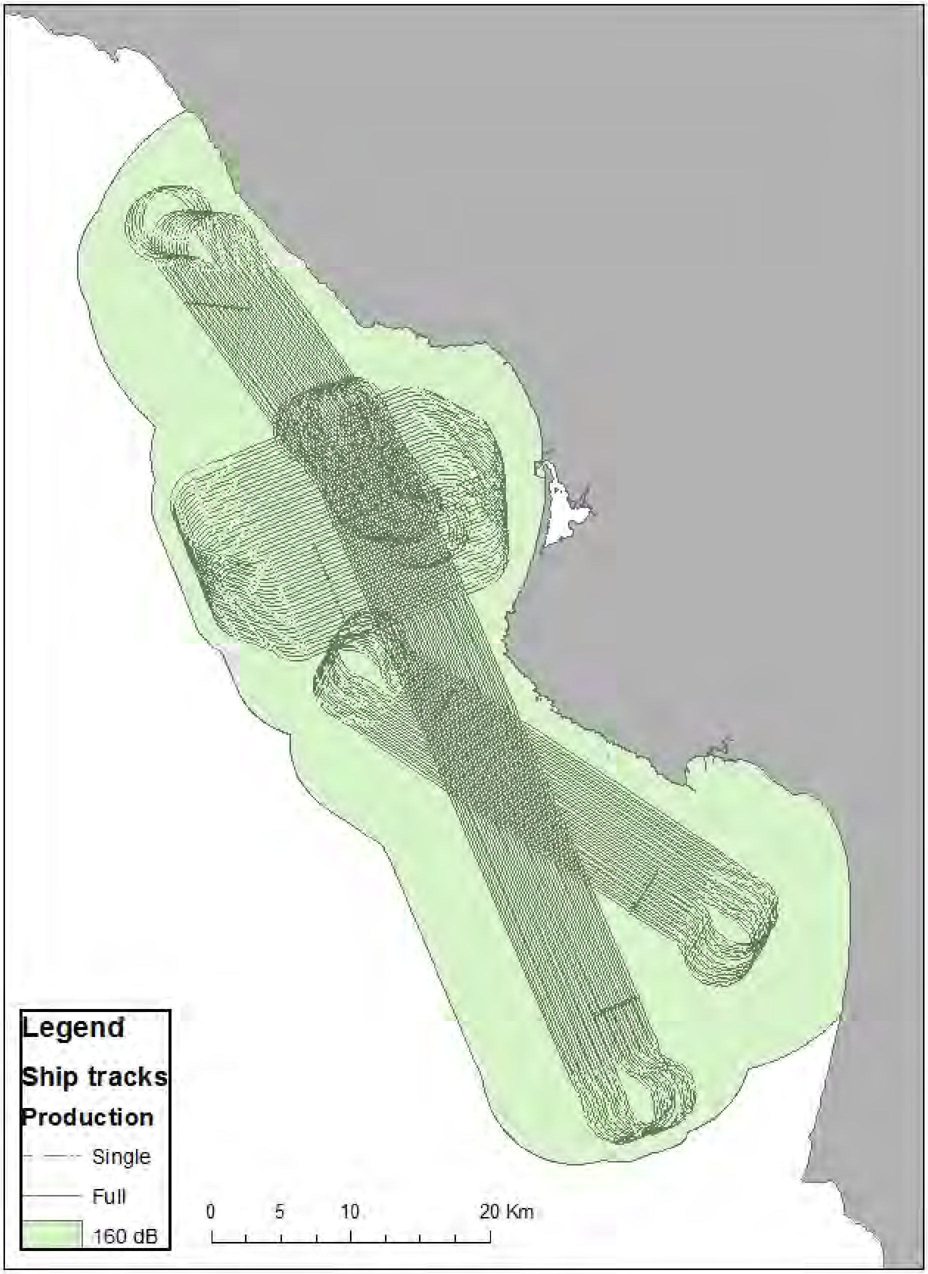

Figure 3.10 Area ensonified by all active acoustic sources combined during proposed Project survey after application of NMFS Level B threshold.

3.9.3. Proportion of mysticetes foraging versus migrating

Calculation of Level B takes using the Probabilistic Disturbance rms approach required an estimate of proportion of mysticetes migrating versus foraging. Appropriate data were available for blue whales. Bailey et al. (2010) provided satellite tag data from 56 blue whales tagged initially in the Santa Barbara basin to calculate the proportion of time animals spent in area-restricted search (ARS) or foraging versus time spent migrating. Values for each month were 0.421 for September, 0.346 for October and 0.313 for November (resulting seasonal average = 0.360). This seasonal average (36% of time) was used as an estimate of proportion of time spent by all mysticetes foraging.

3.9.4 Density variability scenarios

Three density scenarios were incorporated into the take estimates to explore the impact of variability on take assessments. The '**Base**' density was derived from the mean densities provided in Table 3.1. The '**Upper**' density estimate was derived from incorporating a correction factor based on the SERDP-SDSS upper 90% confidence intervals or one standard deviation based on reported CVs (Koski et al. 1998). A third density scenario was developed aiming to recognize some of the limitations of using a static density estimate based on large-scale habitat-predictions. For this '**Potential**' density estimate, a correction factor (2.3) was applied to the humpback whales SERDP-SDSS Model density, derived from validations undertaken by Barlow et al. (2009) to take into account SERDP-SDSS model underestimates (compared to line transect estimates) for the area. The Potential density estimate also applied a conservative species-related turnover factor, incorporated to take into account local area net positive immigration (new animals entering or passing through the ensonification area). Turnover rates for resident species (e.g., harbor porpoise and harbor seal) were assumed to be 1 (i.e., no turnover). Data from satellite tags deployed on 139 blue whales indicated mean time within a foraging patch as 21 days (Bailey et al. 2010). This represent an estimate of turnover rate of 2.5 times over the length of the survey and was applied to all mysticete species. Turnover is likely larger for some migrating species, but we have assumed this level of large scale movement is to a greater extent captured within the SERDP-SDSS density estimates. A conservative estimated turnover value of 1.25 was applied to the remaining species (Table 3.11).

3.9.5 Behavioral Avoidance Response (BAR)

Ramp-up has become a standard mitigation measure for seismic operations in many areas. This has occurred in recognition of the potential risk that immediate hearing damage could occur to a nearby marine mammal if a high-energy sound source, such as an airgun array, were turned on suddenly. The ramp-up procedure in this survey plans to ramp up to full operating levels starting with the smallest airgun and adding power at a rate of approximately 6 dB per 5 minute period (time period estimated to be 30 minutes). The assumption with this mitigation measure is that marine mammals will find the sound aversive and the ramp up period will give animals adequate time to move away before hearing damage or physiological effects occur (Richardson et al. 1995). However, the ramp-up procedure is currently implemented as a common sense approach, and there is little information on its efficacy in evoking an appropriate response from marine mammals. For example, Stone and Tasker (2006) noted no difference in the distance of cetaceans from seismic arrays when systems were ramping up (compared to periods when airguns were off or in full operation); though for both small odontocetes and mysticetes more animals were seen heading away from the vessel than any other direction. Clear movement away has been observed for some species, like Atlantic spotted dolphins, *Stenella frontalis.* In contrast, some species may avoid a disturbance vertically rather than horizontally; that is, by surfacing or diving, which may leave them more vulnerable to certain acoustic or other impacts (such as ship collision).

The assumption is also often made that operational airguns will also cause animals to move away and minimize the risk or chance of level A harassment. Stone and Tasker (2006) reported on observations undertaken during 201 seismic surveys in UK and adjacent waters and results demonstrate small odontocetes showed the strongest lateral spatial avoidance (extending at least as far as the limit of visual observation) in response to active airguns, while mysticetes and killer whales showed more localized spatial avoidance. Sections 2.0 and 3.6 highlight the large differences in behavioral sensitivity, highlighting the lower tolerance level of porpoise and beaked whales, as well as the importance of context (e.g., foraging or not).

While temporary avoidance of intense noise like air guns appears the most likely reaction, review of studies assessing the need to shut-down or power-down during a seismic survey indicate there are instances where an animal has not moved away and has or is about to enter the pre-determined noise exclusion zone (of a size related typically to the 180 dB re: 1 µPa (rms) level). Relevant information for species inhabiting California waters were compiled from observations during three USGS small scale seismic surveys. In summer 1998, during a 13 day cruise of the California Bight shut downs were made for 8 Common dolphins and 3 California sea lions. Headings of 27 of 129 sightings were observed moving towards the vessel (Calambokidis et al. 1998). During 19 days in summer 2000, also in the California Bight, shut downs were made for 29 Common dolphins, 3 Risso's Dolphins, 4 bottlenose dolphins, 3 California sea lions and 1 blue whale (Calambokidis and Chandler 2000). In summer 2002, during 14 days in the Santa Barbara channel, shut downs were made when using a high power source for 20 Common dolphins, 1 Risso's Dolphin, 10 Pacific white-sided dolphins, 2 California sea lions, 4 humpback whales and 1 blue whale (Calambokidis et al. 2002b). Stone and Tasker (2006) documented 6.8% of cetaceans were observed heading towards seismic survey vessel firing large arrays, of which ~75% were observed within 2km. Overall, complete avoidance of Level A levels of intense noise do not appear to occur consistently.

Based on the USGS shut-down data above , the review made in Sections 2.0 and 3.5 and harbor porpoise reactions observed by Brandt et al. (2011) to pulsed sounds, we applied a reasonable estimate for a behavioral response level of likelihood for avoiding the assumed 180 dB re: 1 µPa (rms) exclusion zone. Based on the aggregate scientific information that is available, a **behavioral avoidance response** (BAR) value of 0.99 was selected for porpoise and beaked whales (identified as particularly sensitive species by Southall et al. (2007), and a value of 0.90 selected for all other remaining species. Application of a behavioral avoidance response decreased the estimated number of Level A takes, but consequently Level B takes were increased accordingly. A coarse sensitivity analysis was undertaken assessing impact of lowering the BAR.

3.9.6 Effectiveness of Marine Mammal Observers and PAM (Level A only)

Marine Mammal Observers (MMOs) on the scout vessel and the survey vessel and initially on the aircraft would be used to monitor the exclusion zone. Passive acoustic monitoring (PAM) would also be in operation. A proportion of animals predicted to co-occur within the Level A radii should be detected, causing subsequent power down (or shut down) and reduction in the predicted take estimate.

The proportion of time MMOs are able to observe for will vary over the survey. We have assumed a 12 h. visual monitoring day on average (Civil twilight starts 6.38am, ends 6.28pm on October 20th in the Investigation area). Quantitative values for probability of detection if an animal is within the prescribed exclusion zone (an average of ~1km based on Greenridge and Jasco Applied Sciences models) are not available for most species, and where available, would depend upon sea conditions and visibility, among other factors. Estimates listed in Table 3.11 are qualitative estimates from experienced field biologists working on these species in many areas. Data was derived for an Environmental Assessment conducted in support of NMFS permit #14534 for biological and behavioral response studies in southern California. The estimates are based upon the size of the individual (the larger the animal, the more likely to detect), the size of the group (the larger the group, the more likely to detect), the frequency of surfacing, and the visibility of surface behavior. These estimates for the distance at which sensitive and hard-to-sight species (e.g., beaked whales) are detected also take monitoring for vocalizations into account. Daylight detection probabilities are considered maximums, taking into account the use of MMOs on two vessels and the proposed use of PAM (Table 3.11). Detection probabilities will likely decrease if the survey continues in poor weather, increasing Level A takes.

3.9.7 Sea otter takes

Assessment of potential takes on sea otters required an alternative technique, given their limited distribution and a review of potential stressors. Malme et al. (1984) did not find any disturbance response or change in foraging behavior in sea otters exposed to seismic airgun noise. Typical distance from the otters being observed and the sound source was 1.3 – 1.6 km. On one occasion this distance was as close at 900m. Nevertheless, an acoustic take was still computed using the 180 dB re: 1 µPa rms isopleths with the final take compared against the minimum population estimate as sea otter behavior (e.g., surface rafting) allows for minimization of acoustic injury. We used the maximum 180 dB re: 1 µPa rms radius from Jasco Applied Sciences (Appendix I) for production lines (856 m) and mitigation turns (46 m) to buffer the survey tracks. We also calculated a take level based on the potential disturbance effect from the physical presence of vessels on sea otters. Udevitz et al. (1995) compared detection probabilities of sea otters by boat based and land based observers within a 200 m (100 m either side of) swath of the boat's path. They report that 30% of the otters detected by land based observers were not seen by boat based observers. Of those 30% missed by boat observers, 53% were not detected because they left the transect segment while the rest either dove or evaded detection in another way. We therefore applied a conservative approach to otter disturbance due to vessel presence, namely that 30% of otters within 100 m of a vessel would be disturbed.

To estimate the number of otters disturbed in the above manners we utilized the USGS Western Ecological Research Center's Spring 2010 survey results. These GIS data present sea otter densities in polygons along the California coastline. These polygons are roughly 500 meters wide and stretch out to the 60 meter isobath and are further divided between those areas <30m and those >30m. Using ArcGIS 10 we overlaid the buffer areas for the acoustic and physical presence takes with the USGS otter density polygons. These areas were multiplied by the reported otter density in each polygon and summed to estimate the total number of otters that would be within 100m (for boat presence) and 856m for the airgun array of the seismic survey vessel. Thirty percent of the physical presence takes were assumed to be animals that were disturbed. Otter densities were also calculated within the area proposed for placement of offshore geophone lines as interactions with vessels undertaking this task will probably occur.

Table 3.11 Biological context and correction factors used in take analysis of candidate species. See text for details. Southall functional hearing groups as follows; LFC: low frequency cetaceans, MFC: mid frequency cetaceans, HFC: high frequency cetaceans, Pw: pinnipeds in water

Species	Minimum Population	Residual PBR	Depth dependent density cut offs	Upper density weighting factor	Noise behavioral avoidance response	MMO detection success	Turnover estimate for Potential density	Southall et al. (2007) functional hearing group
Fin whale	*2,624*	*15*	*0*	*1.44*	*0.9*	*0.9*	*2.5*	*LFC*
Humpback whale	*1,878*	*7.7*	*0*	*1.68*	*0.9*	*0.9*	*2.5*	*LFC*
Blue whale	*2,046*	*2.1*	*<80m*	*1.63*	*0.9*	*0.9*	*2.5*	*LFC*
Minke whale	202	2	0	1.59	0.9	0.9	2.5	LFC
Short-beaked common dolphin	343,990	3,376	0	1.53	0.9	0.9	1.25	MFC
Long-beaked common dolphin	17,127	151	0	2.91	0.9	0.9	1.25	MFC
Small beaked whale species	2,498	25	<100m	1.55	0.99	0.1	1.25	MFC
Harbor porpoise	1,478	15	>200m	2.26	0.99	0.5	1.0	HFC
Dall's Porpoise	32,106	257	<100m	1.68	0.99	0.5	1.25	HFC
Pacific white-sided dolphin	21,406	178	0	1.53	0.9	0.9	1.25	MFC
Risso's dolphin	4,913	39	0	1.95	0.9	0.9	1.25	MFC
Northern right whale dolphin	6,019	43.2	<100m	1.43	0.9	0.9	1.25	MFC
Bottlenose dolphin - California coastal	290	2.4	1 km offshore	1.43	0.9	0.9	1.25	MFC
Sperm whale	*751*	*1.5*	*<100m*	*1.59*	*0.9*	*0.9*	*1.25*	MFC
Harbor seal	26,667	1,569	0	1.94	0.9	0.5	1.0	Pw
California sea lion	153,337	8,766	0	1.25	0.9	0.5	1.25	Pw

4.0 Results

4.1. Level A acoustic takes

Level A acoustic takes were calculated using the dual-criteria thresholds and the methodologies described above (Injury SEL and NMFS Minimum and Maximum). Three density scenarios were modeled (Base, Upper and Potential). These represent mean densities (Base), mean densities weighted by 90% confidence limits or one Standard Deviation (Upper) and a potential density prediction (Potential) that also aims to reflect conservative animal turnover rates and applies correction factor specifically for humpback whales based on expert comments received in reviews of the SERDP-SDSS Model density estimates. Level A acoustic takes presented in Table 4.1 have also been modified to reflect species-specific water depth density cut-off criteria (Table 3.11), depth dependent density variability (for harbor porpoise), the estimated effectiveness of APMs (mainly detection rates by MMOs, Table 3.11) and an assumed species–specific behavioral avoidance response (Table 3.11) to avoid the zone within the Level A threshold. Gray whales are not included in the acoustic take tables as densities during the proposed time period are expected to be zero and therefore acoustic takes are expected to be close to zero.

Injury SEL takes (green cells, Table 4.1) for the proposed Project have been color-coded to depict magnitude level (based on a comparison with residual PBR). These levels were used in the impact assessment matrices (see Section 4.6) and the potential substantial impact species reviews and were preferentially weighted in the final population level assessment, as they include a time component factor and differences in hearing sensitivity. NMFS Minimum Level A takes for the proposed Project are presented in the blue cells in Table 4.1. NMFS Minimum Level A represents an estimate of the minimum number of individual Level A takes, based on the Project footprint area, with no account taken of any area ensonified more than once by the survey. NMFS Maximum Level A takes represent the total area ensonified, including areas that are ensonified more than once (i.e., including overlapping areas as the survey goes back and forth within the Project footprint). NMFS Maximum takes provide an indication of the potential scale for multiple (repeat) takes (under the assumption of static animals). The ratio of NMFS Maximum to Minimum represents a quantification of how ‘intense’ the survey is within the Project footprint over the entire course of the proposed survey and can be considered to largely reflect the amount of repeated or multiple exposures.

Tables 4.2-4.3 provide Level A takes for Alternatives 1-2. To assess differences between the proposed Project and the two Alternatives, takes were compared. For each Alternative, the percentage of the proposed Project take was calculated (Table 4.4). Reductions in take compared to the proposed Project are depicted by grey cells.

Table 4.1 **Proposed Project** (Boxes 1, 2, 3, 4) Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioral avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Gray whales not included in table as densities expected to be zero during proposed survey period.

		Methodology to calculate number of Level A takes							
Take method	**Residual PBR**	**Injury SEL**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*15*	2.5	3.6	8.9	0.5	0.8	1.9	5.2	9.9
Humpback whale	*7.7*	1.2	2.0	11.3	0.2	0.4	2.4	2.4	9.9
Blue whale	*2.1*	0.9	1.5	3.8	0.2	0.3	0.8	2.0	10.7
Minke whale	2	0.1	0.1	0.3	<0.1	<0.1	0.1	0.2	9.9
Short-beaked common dolphin	3,376	14.8	22.6	28.3	36.9	56.4	70.5	365.2	9.9
Long-beaked common dolphin	151	0.5	1.3	1.7	1.1	3.3	4.1	11.2	9.9
Small beaked whale species	25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	14.1
Harbor porpoise	15	22.8	51.6	51.6	3.3	7.5	7.5	35.3	10.7
Dall's porpoise	257	0.9	1.5	1.9	0.1	0.2	0.3	1.8	14.1
Pacific white-sided dolphin	178	1.6	2.4	3.0	3.9	6.0	7.5	38.7	9.9
Risso's dolphin	39	0.7	1.3	1.7	1.7	3.3	4.1	16.7	9.9
Northern right whale dolphin	43.2	0.6	0.8	1.0	1.3	1.9	2.4	18.8	14.1
Bottlenose dolphin – CA coastal	2.4	<0.1	<0.1	<0.1	0.6	0.9	1.1	2.7	4.4
Sperm whale	*1.5*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	14.1
Harbor seal	1,569	7.8	15.1	15.1	1.7	3.3	3.3	5.6	3.3
California sea lion	8,766	501.0	626.2	782.7	109.9	137.4	171.7	361.7	3.3

Table 4.2 **Alternative 1** (Boxes 1, 2, 4) Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioral avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint.

		Methodology to calculate number of Level A takes							
Take method	**Residual PBR**	**Injury SEL**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*15*	2.1	3.0	7.6	0.5	0.7	1.6	4.3	9.5
Humpback whale	*7.7*	1.0	1.7	9.6	0.2	0.4	2.1	2.0	9.5
Blue whale	*2.1*	0.8	1.2	3.1	0.2	0.3	0.7	1.7	10.0
Minke whale	2	0.1	0.1	0.3	<0.1	<0.1	0.1	0.1	9.5
Short-beaked common dolphin	3,376	12.2	18.7	23.3	32.0	48.8	61.0	304.6	9.5
Long-beaked common dolphin	151	0.4	1.1	1.4	1.0	2.9	3.6	9.4	9.5
Small beaked whale species	25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	13.2
Harbor porpoise	15	18.6	42.1	42.1	2.8	6.3	6.3	28.7	10.4
Dall's porpoise	257	0.7	1.2	1.5	0.1	0.2	0.2	1.5	13.2
Pacific white-sided dolphin	178	1.3	2.0	2.5	3.4	5.2	6.5	32.3	9.5
Risso's dolphin	39	0.6	1.1	1.4	1.5	2.9	3.6	13.9	9.5
Northern right whale dolphin	43.2	0.5	0.7	0.8	1.2	1.7	2.1	15.6	13.2
Bottlenose dolphin – CA coastal	2.4	<0.1	<0.1	<0.1	0.5	0.7	0.8	2.3	4.9
Sperm whale	*1.5*	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	13.2
Harbor seal	1,569	6.7	12.9	12.9	1.5	2.9	2.9	4.7	3.1
California sea lion	8,766	426.0	532.4	665.5	95.8	119.8	149.7	301.5	3.1

Table 4.3 **Alternative 2 (Zones 1 and 2)** Level A takes of special status species calculated using Injury SEL and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (>100%), orange highlight medium magnitude (50-100%) and yellow low magnitude (10-50%), based on percentage of Residual Potential Biological Removal (PBR). Endangered species are denoted in italics. Take estimates have been modified to take account of group-specific behavioral avoidance responses (range 90-99%) whereby animals avoid the area ensonified to the Level A threshold, as well as detection success of animals entering or within the exclusion zone using MMOs and PAM. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Notes: [1] Excluding Echosounder and Sub-bottom profiler

		Methodology to calculate number of Level A takes							
Take method	**Residual PBR**	**Injury SEL[1]**			**NMFS Minimum**			**NMFS Maximum [1]**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*15*	0.7	1.0	2.4	0.5	0.8	1.9	2.0	3.8
Humpback whale	*7.7*	0.3	0.5	3.1	0.2	0.4	2.4	0.9	3.8
Blue whale	*2.1*	0.3	0.5	1.3	0.2	0.4	1.0	0.9	3.9
Minke whale	2	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	3.8
Short-beaked common dolphin	3,376	7.6	11.6	14.5	36.6	55.9	69.8	140.9	3.8
Long-beaked common dolphin	151	0.2	0.7	0.9	1.1	3.3	4.1	4.3	3.8
Small beaked whale species	25	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	3.8
Harbor porpoise	15	1.1	2.5	2.5	1.8	4.0	4.0	7.1	4.0
Dall's porpoise	257	0.1	0.2	0.2	0.2	0.3	0.4	0.7	3.8
Pacific white-sided dolphin	178	0.8	1.2	1.5	3.9	5.9	7.4	14.9	3.8
Risso's dolphin	39	0.3	0.7	0.8	1.7	3.3	4.1	6.4	3.8
Northern right whale dolphin	43.2	0.4	0.5	0.7	1.8	2.6	3.2	6.9	3.8
Bottlenose dolphin – CA coastal	2.4	0	0	0	0	0	0	0.0	n/a
Sperm whale	*1.5*	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	3.8
Harbor seal	1,569	1.2	2.4	2.4	1.3	2.5	2.5	1.8	1.4
California sea lion	8,766	79.6	99.5	124.3	83.8	104.7	130.9	113.7	1.4

Table 4.4 Percent of each Alternative (A) Level A take compared with the proposed Project (P) Level A take, for Injury SEL, NMFS Minimum and NMFS Maximum methods. Cells color shaded in grey indicate a reduction in take compared to the proposed Project. Notes: [1] Excluding Echosounder and Sub-bottom profiler

Take method	**Injury SEL**		**NMFS Minimum**		**NMFS Maximum**	
Comparison	**P v A1**	**P v A2**[1]	**P v A1**	**P v A2**	**P v A1**	**P v A2**[1]
Species						
Fin whale	85	27	87	99	83	39
Humpback whale	85	27	87	99	83	39
Blue whale	81	33	88	126	82	45
Minke whale	85	27	87	99	83	39
Short-beaked common dolphin	82	51	87	99	83	39
Long-beaked common dolphin	82	51	87	99	83	39
Small beaked whale species	83	66	89	136	83	37
Harbor porpoise	82	5	84	53	81	20
Dall's porpoise	78	12	89	136	83	37
Pacific white-sided dolphin	82	51	87	99	83	39
Risso's dolphin	82	51	87	99	83	39
Northern right whale dolphin	83	66	89	136	83	37
Bottlenose dolphin - CA coastal	71	0	77	0	86	0
Sperm whale	83	66	89	136	83	37
Harbor seal	86	16	87	76	83	31
California sea lion	85	16	87	76	83	31
All species average	82	35	87	98	83	34

4.2 Level B acoustic takes

Level B acoustic takes were calculated using the dual-criteria thresholds and the methodologies described above (Probabilistic Disturbance rms NMFS Minimum and Maximum). Three density scenarios have been modeled (Base, Upper and Potential). These represent mean densities (Base), mean densities weighted by 90% confidence limits or one Standard Deviation (Upper) and a potential density prediction (Potential) that also aims to reflect conservative animal turnover rates and applies correction factor specifically for humpback whales based on expert comments received in reviews of the SERDP-SDSS Model density estimates. Level B acoustic takes presented in Table 4.5 have also been modified to reflect species-specific water depth density cut-off criteria (Table 3.11), depth dependent density variability (for harbor porpoise) and are increased to reflect assumed species–specific behavioral avoidance response to avoid the zone within the Level A threshold. Gray whales are not included in the acoustic take tables as densities during the proposed time period are expected to be zero and therefore acoustic takes are expected to be close to zero.

Probabilistic Disturbance rms takes (green cells, Table 4.5) for the proposed Project have been color-coded to depict magnitude level (based on a comparison with the minimum population estimate). These levels were used in the impact assessment matrices (see Section 4.4) and the potential substantial impact species reviews and were preferentially weighted in the final population level assessment, as they take into account context and variability in hearing and response sensitivity. NMFS Minimum Level B takes for the proposed Project are presented in the blue cells in Table 4.5. NMFS Minimum Level B represents an estimate of the minimum number of individual Level B takes, based on the Project footprint area, with no account taken of any area ensonified more than once by the survey. NMFS Maximum Level B takes represent the total area ensonified, including areas that are ensonified more than once (i.e., including overlapping areas as the survey goes back and forth within the Project footprint). NMFS Maximum takes provide an indication of the potential scale for multiple (repeat) takes (under the assumption of static animals). The ratio of NMFS Maximum to Minimum represents a quantification of how 'intense' the survey is within the Project footprint and can be considered to largely reflect the amount of repeated or multiple exposures.

Tables 4.6-4.7 provide Level B takes for Alternatives 1-2. To assess differences between the proposed Project and the two Alternatives, takes were compared. For each Alternative, the percentage of the proposed Project take was calculated (Table 4.8). Reductions in take compared to the proposed Project are depicted by grey cells.

Table 4.5 **Proposed Project** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioral avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint. Gray whales not included in table as densities expected to be zero during proposed survey period.

		Methodology to calculate number of Level B takes							
Take method	**Minimum population estimate**	**Probabilistic Disturbance rms**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*2,624*	77.6	112.1	280.4	14.4	20.8	51.9	484.4	33.7
Humpback whale	*1,878*	36.5	61.4	353.0	6.8	11.4	65.4	227.7	33.7
Blue whale	*2,046*	38.3	62.4	156.0	4.8	7.8	19.6	137.1	28.6
Minke whale	202	2.5	3.9	9.7	0.5	0.7	1.8	15.3	33.7
Short-beaked common dolphin	343,990	1047.1	1597.9	1997.4	1012.1	1544.5	1930.6	34116.8	33.7
Long-beaked common dolphin	17,127	32.2	93.8	117.2	31.1	90.6	113.3	1049.9	33.7
Small beaked whale species	2,498	50.9	78.8	98.4	2.9	4.4	5.6	61.9	21.6
Harbor porpoise	1,478	1438.6	3256.4	3256.4	734.1	1661.7	1661.7	19379.5	26.4
Dall's porpoise	32,106	270.4	454.4	568.0	26.8	45.0	56.2	577.1	21.6
Pacific white-sided dolphin	21,406	111.0	169.8	212.2	107.3	164.1	205.1	3616.6	33.7
Risso's dolphin	4,913	47.8	93.4	116.8	46.2	90.3	112.9	1557.5	33.7
Northern right whale dolphin	6,019	44.3	63.5	79.4	35.6	51.0	63.8	784.0	22.0
Bottlenose dolphin - CA coastal	290	19.8	28.3	35.4	41.4	59.2	74.1	1838.4	44.4
Sperm whale	*751*	0.8	1.2	1.5	0.6	1.0	1.2	13.3	22.0
Harbor seal	26,667	48.7	94.5	94.5	38.8	75.2	75.2	1279.8	33.0
California sea lion	153,337	3137.4	3921.8	4902.3	2496.0	3120.0	3900.0	82392.8	33.0

Table 4.6 **Alternative 1** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioral avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint.

		Methodology to calculate number of Level B takes							
Take method	**Minimum population estimate**	**Probabilistic Disturbance rms**			**NMFS Minimum**			**NMFS Maximum**	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*2,624*	72.9	105.3	263.3	12.9	18.6	46.6	337.9	26.2
Humpback whale	*1,878*	34.3	57.7	331.5	6.1	10.2	58.6	158.8	26.2
Blue whale	*2,046*	35.9	58.6	146.5	4.2	6.9	17.3	92.8	21.9
Minke whale	202	2.3	3.7	9.1	0.4	0.6	1.6	10.7	26.2
Short-beaked common dolphin	343,990	925.7	1412.7	1765.8	908.2	1385.9	1732.4	23798.4	26.2
Long-beaked common dolphin	17,127	28.5	82.9	103.6	27.9	81.3	101.7	732.4	26.2
Small beaked whale species	2,498	46.5	71.9	89.9	2.5	3.9	4.9	34.2	13.5
Harbor porpoise	1,478	1381.4	3127.0	3127.0	670.0	1516.7	1516.7	13240.1	19.8
Dall's porpoise	32,106	251.4	422.5	528.2	23.6	39.6	49.5	318.4	13.5
Pacific white-sided dolphin	21,406	98.1	150.1	187.6	96.3	147.3	184.1	2522.8	26.2
Risso's dolphin	4,913	42.3	82.6	103.2	41.5	81.0	101.3	1086.5	26.2
Northern right whale dolphin	6,019	39.2	56.2	70.3	31.4	44.9	56.2	449.5	14.3
Bottlenose dolphin - CA coastal	290	17.1	24.5	30.6	37.4	53.4	66.8	1420.2	38.0
Sperm whale	*751*	0.7	1.1	1.3	0.5	0.8	1.1	7.6	14.3
Harbor seal	26,667	43.5	84.3	84.3	34.8	67.4	67.4	1023.7	29.4
California sea lion	153,337	2798.5	3498.1	4372.6	2238.3	2797.9	3497.3	65904.2	29.4

Table 4.7 **Alternative 2** Level B takes of special status species calculated using Probabilistic Disturbance rms and NMFS rms thresholds under three density scenarios. Red cells highlight high magnitude (Listed species >2.5%, non-listed species >25%), orange highlight medium magnitude (Listed species 1.25-2.5%, non-listed species >15-25%) and yellow low magnitude (Listed species >1 individual, non-listed species 5-15%), based on percentage of minimum population estimate. Endangered species are denoted in italics. Take estimates have been modified to include group-specific behavioral avoidance responses whereby animals avoid the Level A threshold area. NMFS Maximum takes are provided for the Base density scenario and represent multiple (repeat) takes. The ratio of NMFS Maximum to Minimum quantifies the 'intensity' of the survey within the Project footprint.

		Methodology to calculate number of Level B takes							
Take method	**Minimum population estimate**	**Probabilistic Disturbance rms**			**NMFS Minimum**			**NMFS Maximum**^{1}	**Ratio of NMFS Maximum/ Minimum**
Density scenario		**Base**	**Upper**	**Potential**	**Base**	**Upper**	**Potential**	**Base**	
Species									
Fin whale	*2,624*	74.2	107.2	268.0	16.0	23.1	57.8	250.5	15.7
Humpback whale	*1,878*	34.9	58.7	337.4	7.5	12.6	72.7	117.7	15.7
Blue whale	*2,046*	36.9	60.2	150.6	6.3	10.3	25.7	94.4	15.0
Minke whale	202	2.3	3.7	9.3	0.5	0.8	2.0	7.9	15.8
Short-beaked common dolphin	343,990	927.2	1415.0	1768.8	1126.2	1718.6	2148.3	17,641.0	15.7
Long-beaked common dolphin	17,127	28.5	83.0	103.8	34.7	100.9	126.1	542.9	15.6
Small beaked whale species	2,498	49.9	77.2	96.5	3.9	6.1	7.6	51.1	13.1
Harbor porpoise	1,478	1303.3	2950.3	2950.3	595.5	1347.9	1347.9	5,386.0	9.0
Dall's porpoise	32,106	268.1	450.6	563.2	36.4	61.2	76.5	475.8	13.1
Pacific white-sided dolphin	21,406	98.3	150.4	188.0	119.4	182.6	228.3	1870.1	15.7
Risso's dolphin	4,913	42.3	82.7	103.4	51.4	100.5	125.6	805.4	15.7
Northern right whale dolphin	6,019	43.6	62.5	78.2	48.5	69.4	86.8	660.5	13.6
Bottlenose dolphin - CA coastal	290	13.5	19.2	24.0	32.8	46.9	58.6	335.8	10.2
Sperm whale	*751*	0.7	1.2	1.5	0.8	1.3	1.6	11.2	14.0
Harbor seal	26,667	45.5	88.3	88.3	43.6	84.6	84.6	663.6	15.2
California sea lion	153,337	2928.7	3660.9	4576.1	2808.8	3511.0	4388.8	42,719.0	15.2

1 Excludes Echosunder or Sub-bottom profiler

Table 4.8 Percent of each Alternative (A) Level B take compared with the proposed Project (P) Level B take, for Probabilistic Disturbance rms, NMFS Minimum and NMFS Maximum methods. Cells color shaded in grey indicate a reduction in take compared to the proposed Project. Notes: [1] Excluding Echosounder and Sub-bottom profiler

Take method	**Probabilistic Disturbance rms**		**NMFS Minimum**		**NMFS Maximum**	
Comparison	**P v A1**	**P v A2**	**P v A1**	**P v A2**	**P v A1**	**P v A2[1]**
Species						
Fin whale	94	96	90	111	70	52
Humpback whale	94	96	90	110	70	52
Blue whale	94	97	88	131	68	69
Minke whale	94	96	80	100	70	52
Short-beaked common dolphin	88	89	90	111	70	52
Long-beaked common dolphin	88	89	90	112	70	52
Small beaked whale species	91	98	86	134	55	83
Harbor porpoise	96	91	91	81	68	28
Dall's porpoise	93	99	88	136	55	82
Pacific white-sided dolphin	88	89	90	111	70	52
Risso's dolphin	88	89	90	111	70	52
Northern right whale dolphin	89	98	88	136	57	84
Bottlenose dolphin - CA coastal	87	68	90	79	77	18
Sperm whale	89	98	83	133	57	84
Harbor seal	89	93	90	112	80	52
California sea lion	89	93	90	113	80	52
All species average	**91**	**92**	**88**	**114**	**68**	**57**

4.3 Acoustic take overview

Take estimates varied across methodologies and density scenarios, particularly for Level B results. Takes were used to determine magnitude level for input into severity ratings.

4.3.1. Level A takes

Project Level A takes and resulting magnitude ratings were consistently higher for Injury SEL Level A for fin, humpback and blue whales, as well as harbor porpoise compared to NMFS Minimum takes. NMFS Minimum takes were higher for mid-frequency cetaceans (Table 4.1).

For the Project, under the assumed 99% avoidance response, harbor porpoise (23 to 52) exceeded the high magnitude criteria for Level A (>100% of residual PBR) for Injury SEL at all density scenarios, but remained at low magnitude using NMFS Minimum methods. Under the assumed 90% avoidance responses, both humpback (11) and blue (4) whale takes exceeded the high magnitude criteria for Injury SEL at the Potential density scenario. Both methods predicted high numbers of California sea lion Level A takes (Table 4.1), albeit a fraction of their residual PBR. For NMFS Minimum takes, no species exceeded low magnitude levels. NMFS Minimum takes of endangered mysticete were below 1 animal at Base densities and ~1-2 at Potential densities. NMFS Maximum levels were 9.9-14.1 times that of NMFS Minimum estimates for cetaceans and 3.3 times for pinnipeds (reflecting the higher Level A dB threshold criteria for pinnipeds). This ratio potentially can be considered to largely reflect the amount of repeated or multiple exposures, if animals remain within the area of ensonification throughout the survey and no new ones enter the area (Table 4.1). The Potential density scenario aims to incorporate a modest turnover of animals during the Project duration.

Sensitivity analyses on our noise BAR, and to a smaller extent, MMO detection success assumptions, (Table 3.11) especially influenced harbor porpoise takes. For example, high magnitude levels (>100% residual PBR) for NMFS Level A Minimum takes at Base density were exceeded for harbor porpoises if BAR was reduced from 0.99 to 0.95. Similarly, high magnitude was exceeded for Coastal bottlenose dolphin at BAR of 0.60. At low 0.50 BAR levels, endangered mysticete NMFS Level A takes were 1 animal for blue whale and humpback whale and 2.6 animals for fin whale, with 165 harbor porpoises estimated to be taken. Takes were less sensitive to changes in MMO detection success, with no high magnitude ratings reached if a 50% reduction in assumed detection success values was applied (Table 3.11). For Injury SEL takes at Base densities, a reduction to 0.5 BAR resulted in Level A takes of 5 blue whales (high magnitude), 6 humpback whales, 12 fin whales and 1139 harbor porpoise (high magnitude).

Level A magnitude ratings were close to identical for Alternative 1 (Table 4.2), despite takes being 82-87% of that of the Project (Table 4.4). No high magnitude ratings were found for Alternative 2 (Table 4.3), with only one moderate magnitude for Alternative 2 (blue whales at Potential densities). Injury SEL takes for Alternative 2 represented on average 35% of the Project take, with relatively large decreases in takes for porpoises, bottlenose dolphins and the pinnipeds. Injury SEL takes for Alternative 2 did not include the contribution for the echosounder and sub-bottom profiler, but this only explains a small part of the difference. Cumulative 24 hour SEL estimates (based on data from Box 1) using data for airguns only represented 99.7% of the combined active sources area for low frequency cetaceans, 91.4% for mid frequency cetaceans, 84.3% for high frequency cetaceans and 97.7% for pinnipeds. Importantly, correction of Alternative 2 Injury SEL takes to account for this level of additional SEL contribution of the echosounder and sub-bottom profiler made no changes to reported magnitude ratings. Differences in NMFS Minimum estimates between Alternative 2 and the Project varied by species with takes of deeper water restricted species increasing by 26-36% and porpoises, bottlenose dolphins and the pinnipeds decreasing. Results reflect differences in size and the location across surveys. NMFS maximum takes for Alternatives 2 were approximately one third that of the Project, highlighting the Projects relatively high number of tracks per km^2 compared to Alternative 2.

4.3.2 Level B takes

Project Level B Probabilistic Disturbance rms takes and resulting magnitude levels were considerably higher than NMFS Minimum takes for endangered mysticete, however both methods resulted in high magnitudes for harbor porpoises (Table 4.5). Under assumed model conditions and responses, combined Probabilistic Disturbance rms take estimates exceeded the high magnitude criteria for harbor porpoise and all three endangered mysticete at Upper and Potential density scenarios and for fin whale alone at base density. Probabilistic Disturbance rms takes across density scenarios ranged from 77-280 for fin whales, 37-353 for humpback whales, 38-156 for blue whales and 438-3256 for harbor porpoises. These Probabilistic Disturbance rms estimates amounted to a 97-100+% of the porpoise population (minimum estimate), 3-11% of the fin whale population, 2-19% of the humpback whale population and 2-8% of the blue whale population (depending on the density scenario).

The Probabilistic Disturbance rms approach set a 10% probability of response for migrating mysticete at the M-weighted 120 dB re: 1 µPa (rms) isopleths. The resulting area amounted to 40-45% of the total take calculated for mysticete, as a predictable function of the large areas ensonified at these levels. The removal of this lower level isopleths for migrating mysticete from the takes still resulted in high magnitude at Potential densities, as well as Upper densities for fin whales. Similarly, this approach predicted that 50% of the particularly sensitive species group (porpoises and beaked whales) will be behaviorally disturbed at the M-weighted 120 dB re: 1 µPa (rms) isopleths. This ensonification area subsequently represented a large proportion of total takes for beaked whales (70%), Dall’s porpoise (72%) and harbor porpoise (30%). The removal of this lower level isopleths for harbor porpoise still results in high magnitude at all density scenarios. The assumption that a percentage of animals have behavioral reactions at relatively low threshold levels is a critical part of any comparison across methodologies.

Project take estimates for NMFS Minimum methods also exceeded high magnitude criteria for Level B for harbor porpoise under all density scenarios (ranging between 50-100+% of population). NMFS Minimum take estimates exceeded high magnitude criteria for Level B for humpback whales (3.9% of the population) only at Potential densities. Fin and blue whales were moderate magnitude in this Potential density scenario, i.e., <2.5% of population). Medium magnitude criteria were also reached for California Coastal bottlenose dolphin for Upper and high magnitude at Potential densities. Notably, for harbor porpoise Probabilistic Disturbance rms takes equate to 70-100+% of the best population estimate and NMFS Minimum Level B takes equate to 36-81% of the best population estimate in comparison.

NMFS Maximum takes levels for the Project were ~22-34 times that of NMFS Minimum take estimates for all species except bottlenose dolphin (for which the ratio was 44). This ratio highlights the intensity of the repetitive shooting within the proposed survey and the large overlap across production runs. It also includes the 25% contingency factor for reshot production lines. Repeat exposure levels are considered a greatest concern for resident species, such as harbor porpoise and harbor seal.

The Proposed Project and Alternative 1 have relatively larger areas over hard bottom substrate, leading to an increase in noise transmission and increased radii for tracks within this area. The Proposed Project extends furthest along the coast. However, Alternative 2 had the largest NMFS Level B footprint. As a result, Probabilistic Disturbance rms takes for Alternative 1 and 2 averaged 91% and 92% of the Project. NMFS Minimum takes averaged 88% for Alternative 1, but averaged 114% for Alternative 2. In Alternative 2 however, harbor porpoise and bottlenose dolphin takes were reduced compared to the Project (reflecting the more offshore nature of these surveys). NMFS Maximum takes were highest for the Project and least for Alternative 2 (Table 4.8). Despite these differences, magnitude ratings were similar across the Project and the Alternatives. Harbor porpoises remained high magnitude across all methods and Alternatives. Fin, blue and humpback whale were high magnitude at Upper and Potential densities using Probabilistic Disturbance rms methods. Blue whales reduced to moderate magnitude at Probabilistic Disturbance rms Base densities for Alternative 2. NMFS maximum to Minimum ratios were between 9-16 for Alternative 2, illustrating the reduced intensity of this Alternatives compared to the Project.

The inclusion of threshold radii calculated for the echosounder and the sub-bottom profiler typically occurred when the single airgun was in use, but varied by threshold and marine mammal frequency group. In general the MBES was loudest at close distances with the single airgun becoming relatively louder at greater distances. This is due to the louder source level of the MBES and higher frequency content (12 kHz) compared to the single airgun (most energy <1 kHz). Frequency dependent absorption increases with frequency such that the MBES sound is attenuated at a faster rate than the single airgun. Therefore at a certain distance the single airgun sound becomes relatively louder than the MBES even though the MBES started out louder at the source. Under certain depth scenarios and frequency weighting (HFC and pinnipeds in water) the SBP was louder than the single airgun or MBES. This is likely due to the wide frequencies used by the SBP (3.5, 12, 200 kHz).

Using the maximum radius from all active sound sources rather than the airguns alone was assessed for Level B takes in Alternative 2. No changes in the level of magnitude were found. Inclusion of non-airgun sources resulted in small positive increases for NMFS Minimum take estimates, approximately <0.5% across all species. For Probabilistic Disturbance rms, moderate increases were seen for mid-frequency cetaceans (8-9%) excluding porpoises and beaked whales for which increases were <0.1%. The combined Probabilistic Disturbance rms take estimate for pinnipeds increased by 5-6%, and increased by 0.3-0.4% for mysticetes.

4.3.3 Sea otter take analyses

Assessment of NMFS Level B~~A~~ Minimum take and boat disturbance to sea otters resulted in values of 62 and 12 individuals respectively for the proposed Project (Table 4.9). The boat disturbance estimates are for one vessel only. If more vessels will be used for mitigation, then the numbers for boat disturbance should be increased proportionate to the number of vessels present and their proximity to otter habitat. The majority of takes occurred in Buchon Point vicinity, but overlap with the highest density areas of less than 30m depth in this region were relatively small (Figure 4.1). Alternative 1 resulted in a small reduction, but Alternative 2 resulted in larger reductions due to tracklines positioned further away from the coastal fringe where otters reside. For acoustic disturbance, Project and Alternative 1 magnitude ratings were considered Moderate, while Alternative 2 was considered low magnitude.

Approximately 32 km of geophone cables will be laid from a vessel off the DCPP. This area has a high density otters, especially near shore. The total otter habitat encompassed by these geophone cables is roughly 81 km^2 containing an estimated 173 animals. With a total of five lines to be laid, a moderate magnitude (equivalent of 1.25-2.5% of ESA-listed regional population) rating was appropriate for this stressor.

Table 4.9 Estimates of otter take from Level B~~A~~ acoustic disturbance from acoustic survey (NMFS 180 dB re: 1 µPa rms) and from vessel proximity (30% at 100 m per Udevitz 1995).

Assessment Level	**Project**	**Alternative 1**	**Alternative 2**
Level A NMFS Minimum	61.9	56.3	7.5
Boat at 100m	11.9	11.4	1.4

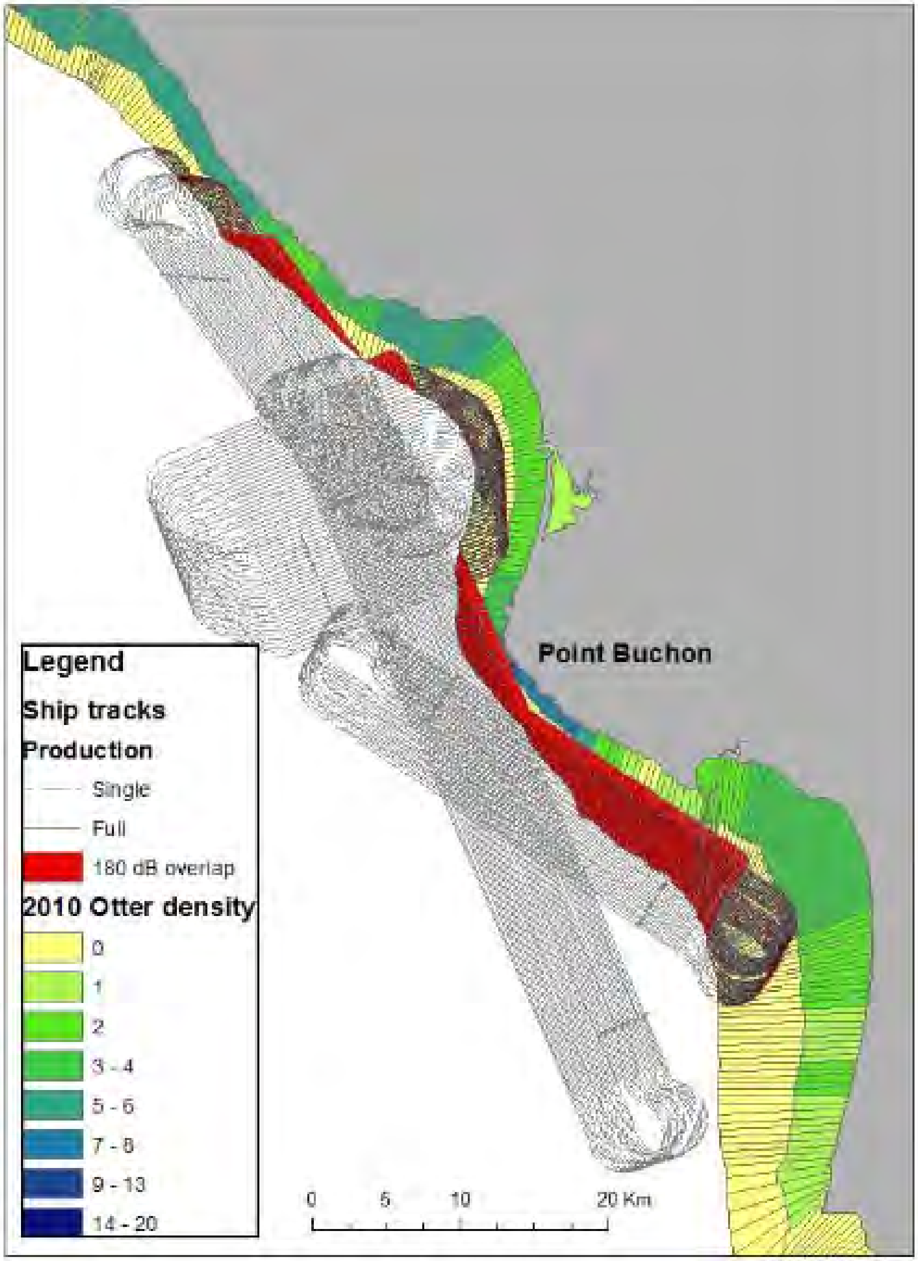

Figure 4.1 Distribution of overlap of sea otter distribution and NMFS Level A thresholds for the Proposed Project. Darker areas represent higher densities of sea otters.

4.4 Impact Analysis

4.4.1 Significance criteria a (NMFS NOAA rms Level B individual takes)

The proposed Project has the potential to affect at least 15 cetacean species, 4 pinnipeds and 1 mustelid using significance criteria a - level A or B harassment takes using NOAA-NMFS (rms) thresholds. Gray whales are considered to have the potential for a level B takes only if the project continues beyond mid-December (i.e. zero density during proposed Project time period). In addition to the candidate species, NMFS Level B takes are predicted to occur at Base densities for striped dolphins, killer whales, elephant seals and northern fur seals.

4.4.2. Significance criteria b-e (substantial adverse effects)

No universally adopted method is available to assess stressor impacts on populations of marine mammals. This report describes the development of a simple matrix assessment approach which aims to identify the potential effects of identified stressors based on the available scientific understanding of these kinds of impacts. Impact ratings were developed for the key stressors identified in Table 3.6 and following the matrix methodology described in Section 3.3. Acoustic takes for the airgun array, single mitigation gun, the MBES echosounder and the sub-bottom profiler were combined in determining magnitude (one of the components required to determine severity). Three density scenarios were assessed for these acoustic take (termed Base, Upper and Potential), largely as a means to highlight the potential impact of data limitations (including inter-annual variability and methodological assumptions). Matrixes were collapsed where species or groups of species were assessed as having identical determinations (i.e., were consistent for a particular impact rating). Severity and impact assessment methodology aimed to be precautionary, to highlight the repetitive nature of the survey and anticipated responses (avoidance) at close ranges, and draw attention to any identified stressors that exceeded set criteria for a potential population impact. Stressor impact ratings are together reviewed in a species by species substantial adverse effects overview that aims to synthesize data from impact ratings with biologically relevant information, such as capacity to withstand habitat loss (Section 4.5). Where substantial impacts are determined, mitigation methods are proposed to minimize the potential effect (Section 5.0).

4.4.2.1 Impact rating matrices for key stressors

To determine final impact ratings, severity ratings were combined with Likelihood predictions to determine Impact ratings for the population. Impact ratings are ranked from most severe to least. Each stressor is defined as acoustic or non-acoustic and partitioned across direct and indirect effects. Information on whether further specific mitigation (MIT) is believed required at a minimum is specified in each matrix. High impact rating is denoted in red and is considered to exceed report criteria for a less than significant population effect.

4.4.2.2 Acoustic impacts of combined active sources (airguns, echosounder and sub-bottom profiler) – Level A

Level A extent was considered local, with moderate duration, intermittent temporal frequency and a high likelihood of occurrence. The reported direct Level A impacts of active acoustic sources used in this survey exceeded negligible (at the population level) for 7 species. High Project impact ratings were determined only for harbor porpoise and at Potential densities for blue and humpback whales using Injury SEL methods. Using NMFS Minimum methods, no candidate species exceeded moderate impact, irrespective of density scenario. All impact ratings resulted from low magnitude take levels (Table 4.10). NMFS Minimum Project impact ratings for harbor porpoise, blue whale and bottlenose dolphins increased under BAR sensitivity analyses. Acoustic impacts of the Project and Alternative 1 to Southern sea otters were considered moderate.

Stressor	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Likelihood
Acoustic Combined	Level A Direct	Local	Tables 4.1-4.3	Moderate	Intermittent	High

Table 4.10 Severity Rating (SR) and final Impact Rating (IR) for Level A (Injury SEL and NMFS Minimum) takes for the proposed Project and Alternatives 1-2. High Impact Ratings are depicted in red and denote potential substantial effects. M denotes medium severity rating based on moderate magnitude level, while M* denotes medium severity rating based on a low magnitude. Empty cells represent negligible ratings.

		Project				Alternative 1				Alternative 2				MIT
	Method	**Injury SEL**		**NMFS Minimum**		**Injury SEL**		**NMFS Minimum**		**Injury SEL**		**NMFS Minimum**		
Species	**Density Scenario**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	
Harbor porpoise	Base	H	H	M*	M	H	H	M*	M			M*	M	Y
	Upper	H	H	M*	M	H	H	M*	M	M*	M	M*	M	Y
	Potential	H	H	M*	M	H	H	M*	M	M*	M	M*	M	Y
Blue whale	Base	M*	M			M*	M			M*	M	M*	M	N
	Upper	M	M	M*	M	M	M	M*	M	M*	M	M*	M	N
	Potential	H	H	M*	M	H	H	M*	M	M	M	M*	M	Y
Fin whale	Base	M*	M			M*	M							N
	Upper	M*	M			M*	M							N
	Potential	M	M	M*	M	M	M	M*	M	M*	M	M*	M	N
Humpback whale	Base	M*	M			M*	M							N
	Upper	M*	M			M*	M							N
	Potential	H	H	M*	M	H	H	M*	M	M*	M	M*	M	Y
Bottlenose dolphin	Base			M*	M			M*	M					N
	Upper			M*	M			M*	M					N
	Potential			M*	M			M*	M					N
Risso's dolphin	Base													N
	Upper													N
	Potential			M*	M							M*	M	N
Minke whale	Base													N
	Upper													N
	Potential	M*	M			M*	M							N
Remainder Species	All													N

4.4.2.3 Acoustic impacts of combined active sources (airguns, echosounder and sub-bottom profiler) – Level B

Level B extent was considered regional, with moderate duration, continuous temporal frequency and a high likelihood of occurrence. The reported direct Level B impacts of active acoustic sources used in the Project survey exceeded negligible (at the population level) for 6 species (Table 4.11). Probabilistic Disturbance rms Level B impacts were consistently high across the Project and all Alternatives for harbor porpoise, blue whale, fin whale and humpback whale. NMFS Minimum Level B takes were consistently high across the Project and all Alternatives for harbor porpoise, as well as fin whale and humpback whale under Potential densities. High impact ratings were determined for Alternative 2 only for blue whales at Potential densities and for the Project and Alternatives 1 and 2 for bottlenose dolphins at Upper and Potential densities.

Stressor	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Likelihood
Acoustic Combined	Level B Indirect	Regional	Tables 4.5-4.7	Moderate	Continuous	High

Table 4.11 Severity Rating (SR) and final Impact Rating (IR) for Level B (Probabilistic Disturbance rms and NMFS Minimum) takes for the proposed Project and Alternatives 1-2. High Impact Ratings are depicted in red and denote potential substantial effects. H denotes high severity rating based on high magnitude level, while H* denotes high severity rating based on a moderate magnitude. M* denotes medium severity rating based on a low magnitude. Empty cells represent negligible ratings.

		Project				**Alternative 1**				**Alternative 2**				**MIT**
	Method	**Probabilistic Disturbance rms**		**NMFS Minimum**		**Probabilistic Disturbance rms**		**NMFS Minimum**		**Probabilistic Disturbance rms**		**NMFS Minimum**		
Species	**Density Scenario**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	**SR**	**IR**	
Harbor porpoise	Base	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
	Upper	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
	Potential	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
Blue whale	Base	H*	**H**	M*	M	H*	**H**	M*	M	H*	**H**	M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Potential	H	**H**	M*	M	H	**H**	M*	M	H	**H**	H*	**H**	Y
Fin whale	Base	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Potential	H	**H**	H*	**H**	H	**H**	H*	**H**	H	**H**	H*	**H**	Y
Humpback whale	Base	H*	**H**	M*	M	H*	**H**	M*	M	H*	**H**	M*	M	Y
	Upper	H	**H**	M*	M	H	**H**	M*	M	H	**H**	M*	M	Y
	Potential	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	H	**H**	Y
Bottlenose Dolphin	Base	M*	M	M*	M	M*	M	M*	M			M*	M	N
	Upper	M*	M	H*	**H**	M*	M	H*	**H**	M	M	H*	**H**	Y
	Potential	M*	M	H	**H**	M*	M	H	**H**	M	M	H*	**H**	Y
Sperm whale	Base													N
	Upper	M*	M	M*	M	M*	M			M*	M	M*	M	N
	Potential	M*	M	M*	M	M*	M	M*	M	M*	M	M*	M	N
Remainder Species	All													N

4.4.2.4 Acoustic impacts of airguns – Secondary prey effects (indirect)

Acoustic effects on fish and invertebrates has the potential to indirectly impact marine mammals through loss of prey resources. The use of seismic air guns during survey operations could disturb or displace adult fish that may occur in the Project area. It is expected that adult fish exposed to seismic sound sources will elicit a behavioral response that will result in either movement away from the approaching sound source (see Appendix I Noise Technical Report), or by hiding within benthic cover (e.g., rocky outcroppings, kelp holdfast structures, or sediment dwellings). Population effects on fish and invertebrates are considered less than significant. Any impacts on marine mammals are likely highest for resident species consuming fish prey (e.g., harbor porpoise and harbor seal).

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
Harbor porpoise, harbor seal	Indirect	Local	Moderate	Moderate	Intermittent	Medium	Medium	Moderate	N
Remainder	Indirect	Local	Low	Moderate	Intermittent	Medium	Medium	Moderate	N

4.4.2.5 Acoustic effect of vessel noise – Level B harassment (Indirect)

More than 4,000 large vessels travel along the central California coast every year, most within 15 miles (24 km) of the shoreline of San Luis Obispo County. The majority of them are fishing and recreational vessels that operate out of Morro Bay and to a lesser extent, Port San Luis. Indirect acoustic effects from vessel noise have the potential to affect marine mammals in two ways, either by disturbing their prey or masking their communications. De Robertis and Wilson (2011) present data demonstrating a larger disturbance on fish from a non-quieted oceanographic survey vessel compared to a quieted but comparable vessel. Ship noise is concentrated at frequencies below 1000 Hz and varies with ship design, maintenance and speed (Richardson et al. 1995; Fischer and Brown 2005). Averson and Vendittis (2000) report source levels for a representative 173 m merchant ship that vary from 178 dB re 1µPa at vessel speeds of 8 knots to 192 dB re 1µPa at 16 knots. Given that the R/V Langseth is smaller in size, designed to be quiet for surveys, and will be operating at speeds lower than 8 knots, the source level from the R/V Langseth during this survey is likely to be lower than 178 dB re 1µPa, and thus much lower than the levels produced by the airguns themselves. However the ship will produce sound continuously while underway, whilst the airguns will fire once every ~11 seconds. It is assumed two other smaller vessels will also be operating continuously in the area. Given the frequency overlap between mysticete and vessel noise there may be moderate reductions in effective communication space for these species (Clark et al. 2009). Low magnitude ratings equate to the disturbance of at least one ESA-listed species and hence, fin, humpback and blue whales are ranked at this level. For all other species, this impact is considered negligible (i.e., < 5% of the population).

Species or species group	**Pathway**	**Extent**	**Maximum magnitude**	**Duration**	**Temporal Frequency**	**Severity Rating**	**Likelihood**	**Impact Rating**	MIT
Fin, Humpback and Blue whale	Indirect	Local	Low	Moderate	Continuous	Medium	High	Moderate	N
Remainder	Indirect	Local	Negligible	Moderate	Continuous	Negligible	High	Negligible	N

4.4.2.6 Acoustic effect of survey aircraft – Level B harassment (Indirect)

Aircraft can generate significant airborne sound which can be prolonged if surveying a confined area. However, due to the impedance mismatch between air and water, little acoustic energy is transferred across this boundary layer. Most airborne sound that hits the ocean surface at angles >13^{o} from vertical is reflected off the interface back into the air (Richardson et al. 1995). Generally an aircraft must be overhead for the sound to penetrate into the ocean. This limits the amount of sound that enters the water and the duration that sound is present for. The loudest frequency components of aircraft sound are usually below 500 Hz (Richardson et al. 1995). Observations of aircraft impacts on hauled out pinnipeds is mostly anecdotal, but involves increased alertness and potentially a rush into the water. No Elephant seal haul-outs or rookeries exist within the Investigation area, but relatively large California sea lion and harbor seal haul-outs are present in multiple locations. We have assumed survey aircraft will not fly near enough over pinniped haul outs to cause large scale disturbance. Reactions of cetaceans to aircraft over-flight are also mostly anecdotal but can include hasty dives, and other changes in behavior. Response, as per response to purely acoustic stressors, seems to vary depending on behavioral context and location of the individual (Richardson et al. 1995). Due to their ESA status and overlap in frequency between airplane noise and mysticete whale calls, we have listed fin, humpback and blue whales with a higher magnitude for this stressor than all other species. However, given the short duration and isolated temporal frequency of this stressor, the impact rating from this stressor on all species in negligible.

Species or species group	**Pathway**	**Extent**	**Maximum magnitude**	**Duration**	**Temporal Frequency**	**Severity Rating**	**Likelihood**	**Impact Rating**	MIT
Fin, Humpback and Blue whale	Indirect	Local	Low	Short	Isolated	Low	Low	Negligible	N
Remainder	Indirect	Local	Negligible	Short	Isolated	Low	Low	Negligible	N

4.4.2.7 Entanglement in airgun or hydrophone strings – Injury/Mortality (direct)

Entanglement in various human made structures can cause injury and death in marine mammals. Porpoises and other small cetaceans suffer from by catch in gillnet fisheries (Tregenza et al. 1997) and mysticete whales also get entangled in lines and other fishing gear (Cassoff et al. 2011). For example, Allen and Angliss (2011) estimate there are at minimum 3.3 gray whale mortalities along the west coast of North America due to entanglement in fishing gear per year. We are not aware of any records of marine mammals being entangled in cables behind a seismic survey vessel. Given that the air-guns and hydrophone cables will be under tension as they are pulled through the water, it is unlikely that a marine mammal would get entangled in the cables even though they extend 6 km behind the vessel. However, given their size fin, humpback and blue whales have been given a slightly higher likelihood of entanglement, and because of their low PBR the magnitude of the effect is also higher than other species. All species nevertheless are deemed to be at low or negligible impact due to entanglement in airgun or hydrophone cables.

Species or species group	**Pathway**	**Extent**	**Maximum magnitude**	**Duration**	**Temporal Frequency**	**Severity Rating**	**Likelihood**	**Impact Rating**	MIT
Fin, Humpback and Blue whale	Direct	Local	Low	Moderate	Isolated	Medium	Low	Low	N
Remainder	Direct	Local	Negligible	Moderate	Isolated	Negligible	Very Low	Negligible	N

4.4.2.8 Entanglement in geophone strings – Injury/Mortality (direct)

Cables laid along the sea floor are likely to only pose a risk of entanglement to species diving to the sea floor to forage. Approximately 32 km of geophone cables will be deployed in five different lines running from the shore to offshore locations. Sea otters and harbor seals may come into proximity or contact with the geophone cables during foraging dives, but given their relative size and dexterity it is very unlikely that either species would become entangled in the geophone cable. The only other marine mammal that might potentially forage inshore on the sea floor is the gray whale. In some locations they will forage for benthic amphipods in the substrate on the sea floor (Stelle et al. 2008). This might pose an entanglement risk, however the timing of the survey is such that gray whales will not be present (unless survey is delayed), and should they be present they are in the process of migrating rather than foraging. Thus all species will have a negligible impact from this stressor.

Species or species group	Pathway	Extent	Maximum magnitude	Duration	Temporal Frequency	Severity Rating	Likelihood	Impact Rating	MIT
All	Direct	Local	Negligible	Short	Isolated	Negligible	Very Low	Negligible	N

4.4.2.9 Oil contamination – Injury/Mortality (direct) and Life function effects (indirect)

The likelihood and potential magnitude of oil spills will be reduced by the Oil Spill Contingency plan. The plan states ‘All vessels will be USCG-inspected and will have the appropriate spill response equipment onboard’ and ‘PG&E will maintain an approved oil spill response plan and the appropriate spill response equipment on all vessels. Response drills will be in accordance with federal and state requirements. Contracts with off-site spill response companies will be in-place and will provide additional containment and clean-up resources as needed’. It is unknown whether off-site spill companies are locally based and have the appropriate equipment (like booms) on stand-by. The *R/V Langseth* can carry up to 353,760 gallons of marine gas oil (marine diesel) and has a range of 25,000 km. The vessel will be refueled once during the survey, so there will be two periods when the vessel will be holding near its fuel capacity. At other periods the fuel load will diminish with time. To evaluate the consequences of oil spills on wildlife it is important to understand the properties and chemistry of crude oils and petroleum products. Oil, depending upon its form and chemistry, causes a range of physiological and toxic effects. Volatile components of oil can burn eyes, burn skin, irritate or damage sensitive membranes in the nose, eyes and mouth. Hydrocarbons can trigger pneumonia if it enters lungs. Light hydrocarbons of oil and fuels if inhaled, are transferred rapidly to the bloodstream from the lungs and can damage red blood cells, suppress immune systems, strain the liver, spleen and kidneys and even interfere with the reproductive system. In general, refined petroleum products tend to be more toxic to organisms but less persistent in the environment. Crude oils and heavy fuel oils like bunker fuels tend to be less toxic but are more persistent and more likely to have physical impacts on wildlife e.g., coating fur and skin. Vessels in this study are assumed to carry the latter type. This compositional variation of oil also governs its behavior, weathering and fate after being spilt in the marine environment. Ambient wind and water conditions can modify the impact of oil on wildlife. For example, on a warmer sea and in high winds, evaporation may remove the lighter aromatic compounds. As a result they do not dissolve into the water column and affect marine life and are therefore not incorporated into the food chain. The discharge of petroleum products may have both direct injury or mortality effects and indirect life function effects (e.g., immuno-suppression). Spill potential effects will also vary across species, with sea otters considered most at risk (due to thermoregulation and direct ingestion/inhalation effects – Garrott et al. 1993). Surface feeding mysticete whales may be more impacted by oil ingestion/mysticete fouling than odontocetes. Pinnipeds can be impacted via toxicity from ingestion (both directly and indirectly if contaminated prey is consumed), thermoregulatory issues if the pelage is covered for fur seals, irritation of membranes especially the eyes and respiratory difficulties (Geraci and St Aubin 1990 cited in PG&E 2011). In terms of magnitude of direct effect, we have placed sea otters in high magnitude given their susceptibility to oil spills and the possibility that >8 animals (>100% of PBR) could be affected. Harbor porpoise are also strongly resident species with low PBR and were also listed as high magnitude. Blue whales are also listed as moderate magnitude given low PBR levels and potential surface feeding behavior increasing exposure. Fin, humpback, minke whales, bottlenose dolphin and Risso's dolphin are listed as low magnitude due to lower relative PBR criteria. The remainder of species were placed in negligible magnitude. Severity ratings were high for sea otters and harbor porpoises and moderate for blue whales. The additional indirect long-term effects of an oil spill are poorly understood for marine mammals. We have placed all species in low magnitude but with low confidence (final row of table below). Given the mainly low speeds of the operational vessels, the assumed quality and diligence of the operational and the contingency plans in place, we have assumed there is a very low likelihood of an oil spill. This results in low or negligible impact ratings from oil contamination.

Species or species group	**Pathway**	**Extent**	**Maximum magnitude**	**Duration**	**Temporal Frequency**	**Severity Rating**	**Likelihood**	**Impact Rating**	MIT
Sea otter, Harbor porpoise	Direct	Regional	High	Short	Isolated	High	Very Low	Low	N
Blue whale	Direct	Regional	Moderate	Short	Isolated	Medium	Very Low	Low	N
Fin, Humpback, Minke whale, Bottlenose, Risso's dolphin	Direct	Regional	Low	Short	Isolated	Medium	Very Low	Low	N
Remainder	Direct	Regional	Negligible	Short	Isolated	Negligible	Very Low	Negligible	N
All	Indirect	Regional	Low	Long	Isolated	Medium	Very Low	Low	N

4.4.2.10 Vessel interaction – Injury/Mortality (direct) and non-acoustic disturbance (indirect)

Vessel interaction includes direct impact leading to death or injury to the individual or indirect disturbance caused by the vessel presence. Ships collide with a number of different marine mammals, especially mysticete whales (Laist et al. 2001; Jensen and Silber 2004). It is estimated that 1.2 gray whale and 1 blue whale are killed every year on the west coast of North America from ship strikes with a record of four blue whales reported in 2007 (Allen and Angliss 2011; Carretta et al. 2011). Ships strikes of smaller cetaceans and pinnipeds are much less common, presumably due to their more agile nature. General mitigation strategies are to slow vessel speed (strike leading to mortality or significant injury believed reduced) and to post observers. However, mitigation through reduced speed is not always successful. On October 19, 2009 an oceanographic survey vessel travelling at 5.5 knots approximately 1.3 nautical miles offshore of Fort Bragg California struck and killed a blue whale (http://www.nauticalcharts.noaa.gov/staff/headline-whalestrike.htm). There was not a marine mammal observer during this cruise as one was not required by permits (it was mapping the local bathymetry, not conducting a seismic survey). This is the only known instance of a slow moving oceanographic survey vessel striking a whale. This suggests that this occurrence is unlikely and in suitable daytime conditions can likely be mediated by visual observers. In addition, the noise from the seismic survey is also more likely to cause whales to move away from the survey vessel (e.g., assumed at 90% at 180 dB re: 1 µPa rms), however perhaps not from the chase boat. Vessels will also travel to a from the Investigation area at least 5 times. Blue whales in the study area are known to forage nearer to the surface at night time as they follow the daily vertical migration of krill (Fiedler et al. 1998). We have therefore listed blue whales as having a moderate magnitude from ship strike because of their low PBR and proclivity to spend more time feeding near the surface at night when visual observers will not be able to see them. Likelihood ratings for blue whales were also increased to Medium (possible occurrence) to reflect the increased risk. Fin and humpback whales are listed at low magnitude due to their higher PBR levels than blue whales, but still concern given that mysticete whales are most likely to be struck by ships. The remaining species are listed at negligible magnitude. Therefore, other than blue whales (moderate impact), and fin and humpback whale (low impact), the impact rating is considered negligible.

In terms of indirect non-acoustic effects from vessels, vessel presence can alter the behavior of marine mammals (Lusseau et al. 2009; Williams et al. 2002; Lusseau 2005). For most cetaceans and pinnipeds, the impact from vessel presence is very likely subsumed under the acoustic impacts of the seismic survey. However, given the apparent lack of sensitivity of sea otters to seismic noise, but their known reaction to the presence of vessels (Malme et al. 1984; Udevitz et al. 1995) it is appropriate to consider the impact of vessel presence as a stressor for this species. Based on our estimates of the seismic survey overlap with sea otter densities, less than two otters are likely to be disturbed by the R/V Langseth. However, this number is likely treble that given other support vessel movements. We have assigned sea otters a low magnitude for the seismic survey stressor with a resulting low impact rating. In addition to the seismic survey itself, approximately 32 km of geophone cables will be laid from a vessel off the DCPP. This area has a high density otters, especially near shore. The otter habitat encompassed by these geophone cables is roughly 81 km^2 with an estimate of 173 animals. With a vessel working to deploy and then retrieve these geophones and cables in this area we have listed sea otters as having a moderate magnitude (equivalent of

1.25-2.5% of ESA-listed regional population) for non-acoustic vessel disturbance which leads to a moderate impact rating from this stressor on sea otters. All other species have a negligible magnitude and impact rating.

Species or species group	**Pathway**	**Extent**	**Maximum magnitude**	**Duration**	**Temporal Frequency**	**Severity Rating**	**Likelihood**	**Impact Rating**	MIT
Blue whale	Direct	Local	Moderate	Short	Isolated	Medium	Medium	Moderate	Y
Fin and Humpback whale	Direct	Local	Low	Short	Isolated	Low	Low	Low	N
Remainder	Direct	Local	Negligible	Short	Isolated	Negligible	Very Low	Negligible	N
Sea Otter: geophone placement – retrieval	Indirect	Local	Moderate	Short	Isolated	Medium	Medium	Moderate	N
Sea Otter: seismic survey	Indirect	Local	Low	Moderate	Intermittent	Low	Medium	Low	N
Remainder	Indirect	Local	Negligible	Moderate	Intermittent	Negligible	Very Low	Negligible	N

4.5 Impact rating and substantial adverse effects overview.

Marine mammals are wide-ranging, occupying numerous habitats with distinct bathymetric features. Escarpments, characterized by upwelling and vigorous food production, are particularly attractive to many marine mammal species. The Investigation area is considered a productive coastal slope environment, with a local fishing and whale watching industry, and a diverse and often abundant variety of marine mammals. Three species of endangered cetacean (fin, humpback and blue whale) are considered seasonally present with fluctuating temporal abundance, with large concentrations of humpback and blue whales sometimes reported within the Investigation area. Sightings of the endangered sperm whale are considered rare (none reported within the Investigation area, Koski et al. 1998) and extremely remote for both sei and North Pacific right whale. The Investigation area is located between two notable marine mammal hotspots, the Santa Barbara Basin and the Monterrey Canyon system. During the time period of the Project, it is a known migration route for blue, humpback and gray whales (southward predominantly), as well as male and sub-adult California sea lions (northward predominantly). Large schools of many wide-ranging odontocetes (mainly delphinids) can be observed in coastal waters. Two species of pinnipeds (Guadalupe fur seal and Steller sea lion) are considered threatened, but sightings within the Investigation area are considered rare. Resident harbor porpoise (Morro Bay stock), harbor seal and the threatened southern sea otter occur within the Investigation area year-round.

The primary concern of the proposed Project to marine mammals was considered to be the repetitive nature and high source levels of operational noise from the airguns. The contribution of the echosounder and sub-bottom profiler was negligible for low frequency cetaceans (e.g., mysticete), but may increase cumulative SEL-based estimates by ~9% for mid frequency cetaceans, ~19% for high frequency cetaceans (porpoises). The Project may potentially have adverse effects of various types and durations on at least 15 cetacean species, 4 pinnipeds and 1 mustelid using CLSC significance criteria a - level B take using NOAA fisheries thresholds. Based on our simple behavioral avoidance reaction assumptions, Level A harassment (combined active acoustic sources) predicted using the Injury SEL criteria at Base densities was 1-3 individuals of the endangered mysticete species, 23 harbor porpoises (the only species exceeding 100% residual PBR) and 501 California sea lion. At Potential densities, Level A takes exceeded 100% of residual PBR for humpback whales (11 individuals), blue whales (4 individuals) and again harbor porpoise (52 individuals). No species exceeded low magnitude using NMFS Minimum threshold methods (combined active acoustic sources); therefore no high impact ratings were reached for Level A for any candidate species. NMFS Minimum Level A takes of fin (<2), humpback (<3) and blue (<1) whales were low, though exposure was predicted to repeatedly occur up to ~10 times over the course of the survey (based on NMFS Maximum predictions). Level A impact ratings for Alternative 1 were similar, but reduced no high impacts were determined for Alternative 2.

In contrast to Level A takes, high impact ratings from Project Level B takes (combined active acoustic sources) were predicted for the Morro Bay stock of harbor porpoise across all methods, all density scenarios and all Alternatives. Probabilistic Disturbance rms Level B takes of harbor porpoise at Base density amounted to 97% of the minimum population estimate (and 70% of the best population estimate). NMFS Minimum Level B takes amounted to 50% of the minimum population estimate. Thus, using a variety of assessment methodologies and assumptions, the conclusion is that the proposed operations would have a high likelihood of impacting this stock. Similarly, high impact ratings were consistently determined for all three endangered mysticete whale species using Probabilistic Disturbance rms methodology. In contrast, high impacts were determined for humpback and fin whales using NMFS Minimum only at Potential densities. The California Coastal stock of bottlenose dolphin was also rated at high impact using NMFS Minimum methods at Upper and Potential densities only. The likelihood of these higher density levels occurring for the Coastal stock of Bottlenose dolphins is considered small, unless warm water incursions occur (or after an El Nino event, Koski et al. 1988), nor does this population does not appear to have strong fidelity to any particular area (Carretta et al. 2011).

Acoustic effects on fish and invertebrates have the potential to indirectly impact marine mammals through loss of prey resources. The use of seismic air guns during survey operations could disturb or displace adult fish that may occur in the Project area. It is expected that adult fish exposed to seismic sound sources will elicit a behavioral response that will result in either movement away from the approaching sound source, or by hiding within benthic cover. Population effects on fish and invertebrates are considered less than significant. Impacts on marine mammals are likely highest for resident species consuming fish prey and were determined as moderate.

The Investigation area co-occurs with the core habitat of the increasing Morro Bay Stock of harbor porpoises. Considered resident with limited opportunity for emigration and very sensitive to anthropogenic noise effects, there is a high likelihood of potential for substantial interference in movement and reduction in habitat. Mitigation for Level B harassment to porpoises is unlikely to effective.

The California Current Ecosystem fluctuates both temporally and geographically between September and December, and the timing and location of high density foraging opportunities for mysticete whales are hard to predict, but have in the past occurred within the Investigation area (e.g. 2002). Typical movement by blue and humpback whales northward from Southern California occurs in the mid-summer; with a southward migration then occurring in late fall through November. Transit routes during both periods are likely to co-occur with Investigation area. Noise effects may exceed 200 km downslope (off-shelf) and considerably less coastally. If suitable prey resource concentrations occur within the Investigation area, they are potentially made inaccessible due to noise disturbance or avoidance reactions. In some years, this may result in the loss of a key foraging hotspot (i.e., habitat reduction). The Potential density estimates aim to reflect an increased prey resource concentration within the area, leading to increased predator densities. Given the unpredictability of such an event, a key mitigation method would be to undertake a pre-survey to ensure these conditions were not occurring in an area where the start off the survey was planned.

Overall, with one exception, all non-acoustic stressors were predicted to have low or negligible impacts and non-substantial adverse direct effects, assuming APMs and Contingency plans are fully adopted. Vessel interactions with blue whales were considered a moderate impact based on Medium severity rating and a medium (possible) likelihood rating. Geophone placement and retrieval in the near shore area in front of the DCPP were also considered to result in a moderate impact rating for sea otters due to a medium severity rating and a medium likelihood. Moderate levels of short-term disturbance may also occur to sea otters from the 3D survey, but tracklines and estimated zones of disturbance show only small areas of overlap with high density (shallow water) sea otter areas.

4.5.1 Potential adverse effects summary by species

4.5.1.1 Gray whale

The Investigation Area co-occurs with the migration route for majority of Eastern North Pacific Stock of gray whales, a population numbering up to 19,126. Southward transit through investigation area is estimated to start mid-December (15th) and peaks mid-January (15th). Small numbers may migrate through area prior to predicted start of migration. The majority of population likely to travel within 3 nautical miles of coast and pass through study area in <24 h. with limited feeding expected to take place. Based on likely sensitivity and (somewhat limited) use of low frequency sounds, gray whales may be more likely than odontocete cetaceans to be affected by seismic noise and they have been shown to exhibit localized avoidance to seismic exploration sound (Malme et al. 1984). However, there is no strong evidence suggesting gray whales are particularly sensitive to seismic or other low frequency noises and responses are expected to be limited and temporary avoidance behavior. Assuming survey is completed prior to the middle of December, then project impacts considered insignificant. Impacts of survey scale to the degree of delay beyond December 15th. High and medium magnitude impact considered Level B harassment to 25% (n=4504) and 15% (2703) of minimum population, may occur approximately 23 and 18 days after predicted migration start (January 2-6th), Direct effects up to day 23, including potential Level A takes, highly unlikely to exceed residual PBR of 233 animals, given responses to noise, typically inshore travel patterns and low likelihood of potential entanglement and oil contamination. May affect and may have substantial adverse effects assessment if survey delayed beyond January 2th. *Special mitigation monitoring recommend (initiated only if delayed surveys continue beyond 15th December) to confirm non-blocking avoidance reaction and study prediction of migration transit timing and rate.*

4.5.1.2 Fin whale

Highest density for ESA-listed strategic mysticete species within the Investigation area. Seasonally present from continental slope to offshore, but seasonal movements unclear and assumed lower density in winter. Inter-annual density variability documented (Peterson et al. 2006), reflecting fluctuating prey recruitment and search patterns that appear to concentrate on high density patches. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Low predicted numbers of Injury SEL Level A takes (3-9) result in up to moderate (<60% of PBR, non-substantial) direct impact ratings. There are no direct measurements of responses of fin whales to seismic noise, but based on responses in gray and humpback whales localized and temporary avoidance behavior are most likely and may be affected by the behavioral state of animals during exposure. Combined source Probabilistic Disturbance rms takes considered high impact (78-280 individuals), especially in scenarios that reflect increased density above average SERDP-SDSS habitat model predictions (range 3-11% of population affected, of which 40% from using the 120 dB re: 1 µPa rms M-weighted isopleth). In comparison, NMFS Minimum Level A (<2 individuals) and Level B takes (14-60 individuals) were lower. NMFS Level B based Maximum estimates predict individual animals may be exposed up to 34 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Lower than average densities (as well as the higher density scenarios modeled here) of fin whale may occur in some years. However, if suitable prey resource concentrations occur within or near the Investigation area, they are potentially made less accessible or inaccessible due to noise disturbance and/or avoidance reactions for as much as ~2 months. Noise effects on prey may vary between krill and forage fish, but it is assumed that reduced densities of both may occur during and for a short period after the survey. Energetic effort consequently required to locate alternate high value foraging patches, and potentially increase competition for these alternate resources. The project *may affect and may have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects.* Under the assumption that densities of fin whales exceed Upper level densities when the survey is about to start, acoustic effects from seismic operations *likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Pre-survey assessment of density is considered necessary to provide increased resolution of density and resulting level of potential impact.*

4.5.1.3 Humpback whale

ESA-listed strategic mysticete known to frequent Investigation area, in some years at relatively high densities (September/October, Calambokidis et al. 2002a). Densities considered low by mid-November. Investigation area encompasses known migration route during the survey period, especially southwards movement in late fall. Migration route uses more inshore areas than blue whales, increasing risk of impact. Species known to target both krill and forage fish patches (notably sardine and anchovy) that fluctuate temporally and geographically. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Low to moderate predicted numbers of Injury SEL takes (1-11 individuals) result in up to high (<147% of PBR) direct impact ratings. Humpback whales have been demonstrated to have variable responses to seismic noise, including limited local avoidance and, in some cases, attraction to seismic pulses among possible for male individuals (McCauley et al. 1998). Behavioral responses of little to moderate severity may be expected. Combined source Probabilistic Disturbance rms takes considered high impact (37-353 individuals), especially in scenarios that reflect increased density above average SERDP-SDSS habitat model predictions (range 2-19% of population affected, of which 40% from using the 120 dB re: 1 µPa rms M-weighed isopleth). In comparison, NMFS Minimum Level A (<2 individuals) and Level B takes (7-65 individuals) were lower. NMFS Level B based Maximum estimates predict individual animals may be exposed up to 34 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Local concentrations of humpback whales were observed in September/October 2002, 2006 and 2008. Lower than average density concentrations of humpback whale may also occur in some years. If suitable prey resource concentrations occur within or near the Investigation area, they are potentially made less accessible or inaccessible due to noise disturbance and/or avoidance reactions for as much as ~2 months. Noise effects on prey may vary between krill and forage fish, but it is assumed that reduced densities of both may occur during and for a short period after the survey. Energetic effort consequently required to locate alternate high value foraging patches, and potentially increase competition for these alternate resources. The project *may affect and may have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects.* Under the assumption that densities of humpback whales exceed Upper level densities when the survey is about to start, acoustic effects from seismic operations *likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Pre-survey assessment of* *density is considered necessary to provide increased resolution of density and resulting level of potential impact.*

4.5.1.4 Blue whale

ESA-listed strategic mysticete known to frequent Investigation area, in some years at relatively high densities (September/October, Calambokidis et al 2002a). Investigation area encompasses known migration route during the survey period, especially southwards movement in late fall. Densities considered low by mid-November and decrease from summer peak from September onwards. Species targets mainly krill patches and prefers waters deeper than ~80m locally, with a preference for waters ~200m deep. While concentrations occur mostly in summer, high numbers have also been observed in fall, notably 2000 through 2003. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Low predicted numbers of Injury SEL takes (1-4) result in up to high (<190% of PBR) direct impact rating. There are no direct measurements of responses of blue whales to seismic noise, but based on responses in gray and humpback whales localized and temporary avoidance behavior are most likely and may be affected by the behavioral state of animals during exposure. Combined source Probabilistic Disturbance rms takes were considered high impact (38-156 individuals), especially in scenarios that reflect increased density above average SERDP-SDSS habitat model predictions (range 2-8% of population affected, of which 45% from using the 120 dB re: 1 µPa rms M-weighed isopleth). In comparison, NMFS Minimum Level A (<1 individual) and Level B takes (5-20 individuals) were lower. NMFS Level B based Maximum estimates predict individual animals may be exposed up to 29 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects were rated as low to negligible impact (non-substantial), given proposed APMs and Contingency plans, except for vessel interactions which were predicted as moderate impact. Lethal collisions even with slow moving survey boats have occurred in the region recently and risk may increase at night when surface feeding rates increase, from the use of chase boats and during periods when the seismic noise is curtailed and when MMOs are not or less effective. If suitable prey resource concentrations occur within or near the Investigation area, they are potentially made less accessible or inaccessible due to noise disturbance and/or avoidance reactions for as much as ~2 months. Noise effects on krill largely unknown, but it is assumed that reduced densities may occur during and for a short period after the survey. Energetic effort consequently required to locate alternate high value foraging patches, and potentially increase competition for these alternate resources. The project *may affect and may have a substantial adverse effect through habitat modifications/reduction, combined direct and indirect acoustic effects and risk of vessel interactions.* Under the assumption that densities of blue whales exceed Upper level densities when the 3-D survey is started, acoustic effects from seismic operations *likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Pre-survey assessment of density is considered necessary to provide increased resolution of density and resulting level of potential impact.*

4.5.1.5 Minke whale

Minke whales are considered uncommon in the area but may be occasionally present. Until recently considered a strategic stock, they are found primarily over the continental shelf. Take assumptions have assumed similar behavior and detection rates to blue whales, but animals may be resident to particular home ranges (Koski et al 1998) and are not easily sighted. Assumed low frequency hearing sensitivity and selected thresholds of mysticete results in largest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. There are no direct measurements of responses of minke whales to seismic noise, but based on responses in gray and humpback whales localized and temporary avoidance behavior are most likely and may be affected by the behavioral state of animals during exposure. Predictions of Injury SEL takes was 0 individual and predictions of combined Probabilistic Disturbance rms takes ranged between 3-10 individuals (1.5-4.8% of population), resulting in negligible impact ratings. In comparison, NMFS Minimum Level A (0 individuals) were similar and Level B takes (<2 individuals) were lower. SERDP-SDSS model predictions considered underestimates based on NOAA unpublished survey data and so takes estimates are likely underestimated. However, population estimates are likely also underestimated and we have assumed takes as a proportion of the population are unlikely to change notably. Furthermore, there is no clear evidence that the Investigation area represent above average habitat to minke whales. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. The Project *may affect, but is unlikely to have a substantial adverse effect on minke whales.*

4.5.1.6 Short-beaked common dolphin

Short-beaked common dolphins are the most abundant cetacean in the area and occur from the coast out to at least 500 km offshore, mostly seaward of 200m. Recent population estimates have shown an increase in abundance in California, with large seasonal changes in distribution documented. Occur in large groups (100s or even 1000s), and are likely present in higher numbers in September and October than later in the season (Koski et al 1998). Confirmed multiple occurrences of common dolphins entering safety zone of seismic surveys (Calambokidis et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was up to 28 individuals (<1% of PBR) and predictions of combined Probabilistic Disturbance rms takes ranged between 1047-1997 individuals (0.3-0.6% of population), resulting in negligible impact ratings (non-substantial). NMFS Minimum Level A (37-71 individuals) takes were higher and level B (1012-1931 individuals) takes similar, resulting in negligible impact ratings. All Level A takes may be underestimated if a large school approached the survey vessel. There are no direct measurements of responses of short-beaked common dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Short-beaked common dolphins are very abundant, range widely, with optimal habitat considered seaward of 200m. They are able to prey upon a variety of fish and cephalopod species and consequently considered generalist feeders, with flexible foraging strategy. Good capacity to withstand Level B disturbance. Project *may affect, but is unlikely to have a substantial adverse effect on Short-beaked common dolphins.*

4.5.1.7 Long-beaked common dolphin

Long-beaked common dolphins occur mostly off southern California and Baja California generally within about 90 km of the coast. Occur in large groups (100s), including sightings made within the Investigation area. Confirmed multiple occurrences of common dolphins entering safety zone of seismic surveys

(Calambokidis et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes were <2 individual (<2% of PBR) and predictions of combined Probabilistic Disturbance rms takes ranged between 32-117 individuals (0.2-0.7% of population), resulting in negligible impact ratings (non-substantial). Minimum NMFS Level A (1-4) takes were higher and level B (31-113) takes similar, resulting in negligible impact ratings. All Level A takes may be underestimated if a large school approached the survey vessel. There are no direct measurements of responses of long-beaked common dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects also rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Long-beaked common dolphins are relatively abundant and range widely. They are able to prey upon a variety of fish and cephalopod species and consequently considered generalist feeders, with flexible foraging strategy. Good capacity to withstand Level B disturbance. Project *may affect, but is unlikely to have a substantial adverse effect on Long-beaked common dolphins.*

4.5.1.8 Small beaked whale species

Due to the rarity of sightings, species of beaked whales in the study area have been grouped. Baird's beaked whales are distributed along continental slopes and throughout deep waters of the North Pacific while Cuvier's beaked whale is the most commonly sighted beaked whale in US West Coast waters (Carretta et al. 2011). Mesoplodont beaked whales are five different species which are distributed along continental slopes and throughout deep waters in the North Pacific Ocean (Koski et al. 1998). Typically seen in small groups. Beaked whales considered to have high sensitivity to anthropogenic sound (Southall et al. 2007, D'AMico et al. 2009, Tyack et al. 2011), are cryptic with long dive times and these factors are reflected in our take estimates. Predictions of Injury SEL Level A takes was 0 individuals, while predictions of Probabilistic Disturbance rms takes ranged between 51-98 individuals (2.0-3.9% of population), resulting in negligible impact ratings (non-substantial). The majority of Probabilistic Disturbance rms take (70%) is based on behavioral disturbance at levels at the 120 dB re: 1 µPa rms M-weighted isopleths, and considered unlikely to cause injurious disruption to diving, as observed in intense mid-frequency sonar exposures. Minimum NMFS Level B takes were considerably lower at <6 individuals. The multiple narrow canyons located ~30 nm south of the Investigation area (off Vandenberg) are considered above average potential habitat for beaked whales, but neither the 140 or 120 dB re: 1 µPa rms isopleths co-occur with this area. While behavioral responses to seismic noise have not been directly measured in beaked whales, based on their apparent sensitivity to sounds of various types, which may be a function of their social and group configurations, there is likely a greater potential for avoidance behavior at greater ranges, even given the low frequency nature of seismic airguns. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the habitat within or near the Investigation area is not considered important to Beaked whales. Project *may affect, but is unlikely to have a substantial adverse effect on Beaked whales.*

4.5.1.9 Harbor porpoise (Morro Bay stock)

The Investigation area co-occurs with the core habitat of the increasing Morro Bay Stock of harbor porpoises. Considered a resident population (best estimate 2044 individuals, minimum 1478 individuals), with very limited opportunity for emigration, as this stock are not encountered south of Point Conception and the coastal areas north of the Investigation area are considered sub-optimal habitat, with relatively low sighting rates in NOAA surveys. Restricted movement into deeper water (>200m) also unlikely based on strong coastal habitat preferences (mainly <91m water depth). Time period of survey is post the summer calving period and overlaps with the presumed fall breeding season and therefore considered a sensitive period. Species considered very sensitive to anthropogenic noise effects on hearing (Lucke et al. 2009) and on behavior from a wide range of laboratory and field studies (see Southall et al., 2007). Behavioral responses to seismic noise have been infrequently observed in harbor porpoises (Lucke et al. 2009), and based on their apparent sensitivity to seismic noise in this study and also sounds of various types, there is likely a greater potential for avoidance behavior at large ranges, even given the low frequency nature of seismic airguns. Injury SEL takes (23-52 individuals) resulted in up to high direct impact ratings. Level A takes increase dramatically if assumed behavioral avoidance responses to high intensity noise were reduced, but significantly decreased responses are considered unlikely. Both Probabilistic Disturbance rms and NMFS Level B takes were considered high impact, in all 6 scenarios tested (i.e., both methods at all density scenarios). Probabilistic Disturbance rms takes of 1439-3256 individuals equate to 97-100+% of the minimum population estimate. NMFS Minimum Level B takes were lower (734-1662 individuals), but still equate to 50-100+% of the minimum population. A proportion of the Probabilistic Disturbance rms take (30%) were based on behavioral disturbance at the 120 dB re: 1 µPa rms M-weighted isopleths, but habitat avoidance at these intensity levels is predicted to occur. Probabilistic Disturbance rms takes equate to 70-100+% of the best population estimate (NMFS Minimum Level B takes equate to 36-88%). NMFS Level B based Maximum estimates predict individual animals may be exposed up to 26 times over the course of the survey, if animals are assumed not to leave the area. Non-acoustic effects rated as low to negligible and non-substantial, given proposed APMs and Contingency plans. High potential severity rating was noted for oil contamination. The porpoise population is considered at high risk to potential for short-term acoustic-related prey disturbances due to residency. Overall, prediction of substantial interference in movement and reduction in core habitat. A large proportion of the population is likely to be affected. The project *may affect and likely have a substantial adverse effect through habitat modifications/reduction and combined direct and indirect acoustic effects. Mitigation: Impacts to porpoise are believed largely through Level B harassments which are considered very difficult to mitigate given the ranges over which they occur. Sighting and acoustic detections are typically short-range and are unlikely to extend beyond the exclusion zone. Thus even with mitigation measures proposed the Project likely has a substantial adverse effect on harbor porpoise.*

4.5.1.10 Dall’s porpoise

Overall density distribution of Dall’s porpoise is widespread over the shelf, slope, and deep ocean habitats (mainly >100m). The distribution of Dall’s porpoise is highly variable among years/seasons and appears to be affected by oceanographic conditions, however, they are considered to be present locally within the study period. Take estimates have assumed acoustic effect behavior of Dall’s porpoise similar to harbor porpoise. Predictions of Injury SEL Level A takes was <2 individuals, while predictions of Probabilistic Disturbance rms takes ranged between 270-568 individuals (0.8-1.8% of population), resulting in negligible impact ratings (non-substantial). The majority of Probabilistic Disturbance rms take (72%) is based on behavioral disturbance at levels using the 120 dB re: 1 µPa rms M-weighted isopleths. Using sensitivity levels of harbor porpoises for Dall’s porpoise is considered precautionary. NMFS Minimum level B takes were far lower with 27-56 individuals. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, flexible in foraging strategy and prefers deep ocean habitat. Consequently, this species may be considered to have a good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Dall's porpoise.*

4.5.1.11 Pacific white-sided dolphin

Pacific white-sided dolphins are found in cold, temperate waters of the North Pacific Ocean from North America to Asia. They become most abundant in shelf waters off southern California from November to April and then off Oregon and Washington in May. Population may be migrating seasonally from the south to the north in the eastern North Pacific. Generally found in deeper/more offshore water, but can be seen fairly close to shore (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was <3 individuals, while predictions of Probabilistic Disturbance rms take ranged between 111-212 individuals (0.5-1.0% of population), resulting in negligible impact ratings (non-substantial). NMFS Minimum level A takes were higher (4-8) but still considered negligible magnitude. NMFS Minimum Level B takes and predicted impacts were similar with 107-205 individuals (0.5-1.0% of population). There are no direct measurements of responses of white-sided dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, flexible in foraging strategy and prefers deeper habitat. Consequently, this species may be considered to have a good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Pacific white-sided dolphins*

4.5.1.12 Risso's dolphin

The distribution of Risso's dolphin is highly variable, apparently in response to seasonal and interannual oceanographic changes (Forney and Barlow, 1998). Dolphins found off California during colder water months are thought to shift northward into Oregon and Washington as water temperatures increase in late spring and summer. Near-shore year-round species locally and most often sighted cetacean by Padre (2011) with 364 sightings. Feed mainly on squid (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was <2 individual, while predictions of combined Probabilistic Disturbance rms takes ranged between 48-117 individuals (1.0-2.4% of population), resulting in negligible impact ratings (non-substantial). NMFS level A takes were higher (2-4) but still considered negligible magnitude. NMFS Minimum Level B takes and predicted impacts were similar with 46-113 individuals (0.9-2.3% of population). There are no direct measurements of responses of Risso's dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, with a selective foraging strategy. Consequently, this species may be considered to have a moderate to good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Risso's Dolphin.*

4.5.1.13 Northern right whale dolphin

Species generally considered to occur offshore, but in also regionally seen fairly close to shore, with Padre (2011) reporting 10 sightings. Northern right whale dolphin, Risso's and Pacific white-sided dolphin often seen together in groups. Most groups between 1-300 and feed on squid, lanternfish and mesopelagic fish (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL Level A takes was <1 individual, while predictions of Probabilistic Disturbance rms takes ranged between 44-79 individuals (0.7-1.3% of population), resulting in negligible impact ratings (non-substantial). NMFS level A takes were higher (1-2) but still considered negligible magnitude. NMFS Minimum Level B takes and predicted impacts were very similar with 36-64 individuals (0.6-1.1% of population). There are no direct measurements of responses of Northern right whale dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered wide-ranging, and prefers deeper habitat. Consequently, this species may be considered to have a good capacity to withstand Level B disturbance in one region. Project *may affect, but is unlikely to have a substantial adverse effect on Northern right whale dolphin.*

4.5.1.14 Bottlenose dolphin – California coastal stock

The small population of the coastal stock ranges from northern Baja California to Central California. Core habitat mostly off southern California and into Mexican waters, but moves northward into central California during warm-water periods (Carretta et al. 2011). The Investigation area is considered within the northern part of the range. Found largely within 1km of shore (Carretta et al. 1998) and groups of 13+ animals were recorded in the Investigation area (NCCOS 2007). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL takes was 0 individual and NMFS Minimum Level A take was <1 individual, while predictions of Probabilistic Disturbance rms takes ranged between 20-35 individuals (7-12% of the population), resulting in low impact ratings (non-substantial). NMFS Minimum Level B takes were higher with 41-74 individuals (14-26% of population), resulting in low through to high magnitude ratings. There are no direct measurements of responses of bottlenose dolphins to seismic noise, but based on responses in other odontocete cetaceans localized and temporary avoidance behavior could occur over some limited range and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered to range moderately with a very strong preference for near-shore areas, but the population does not appear to have strong fidelity to any particular area (Carretta et al. 2011). Above Base densities potentially occur only when warm water incursions occur in Central California therefore the Project *may affect, but is unlikely to have a substantial adverse effect on California Coastal bottlenose dolphin.* In the event of a strong El Nino year or a substantial warm water incursion the Project may have a substantial adverse effect, but this presently appears unlikely (see NOAA Monthly Climate Bulletin for January 2012 at http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/index.shtml).

4.5.1.15 Sperm whale

The sperm whale is the only ESA listed odontocete at sufficient density in the Investigation area to require a take analysis. Population trends are unknown. Sperm whales have been reported year-round off California, with peak numbers appearing from April through mid-June and from the end of August into mid-November. Off California, sperm whales frequent deep offshore waters, although they sometimes venture into shallow water and one group of 6 or more animals was sighted less than 25 nm off Buchon Point (Koski et al. 1998). Mid frequency hearing sensitivity and selected thresholds of odontocetes results in the smallest potential areas for Injury SEL (Level A equivalent) and Probabilistic Disturbance rms (Level B equivalent) take estimates. Predictions of Injury SEL takes was 0 individual and maximum predictions of both level B methods of <2 individuals, resulting in negligible and low impact ratings. Responses of sperm whales to relatively low level seismic noise have been measured (Miller et al. 2009). Results indicate minor changes in foraging behavior in the presence of seismic airguns at moderate ranges, but responses at moderate to higher levels of airgun noise has not been measured. Considering this species' preference for deep offshore water, the chances of it appearing at or near the Investigation area are remote. Non-acoustic effects rated as low to negligible impact and consequently non-substantial. The Investigation area is not considered optimal habitat for sperm whales. Therefore, the Project *may affect, but is not likely to adversely affect, Sperm whales.*

4.5.1.16 Pacific Harbor seal

Pacific Harbor seals are a widely distributed coastal species. They are considered resident to area with foraging typically near shore on fish and cephalopods. Pupping generally occurs March – June and molting generally occurs May – July. Haul-outs with high counts (~50-300 individuals) were recorded in the vicinity of Cayucos Point, Diablo Canyon, Estero Point, China Harbor, Morro Bay Estuary, Fossil Point, South Point, Point San Luis, and Point Buchon. Based on NOAA aerial surveys, total study area population likely >3000 individuals (assuming an at-sea correction factor of 1.65, Lowry et al. 2008). Predictions of Injury SEL Level A takes was 8-15 individuals, while predictions of Probabilistic Disturbance rms takes ranged between 49-95 individuals (0.2-0.4% of stock population), resulting in negligible impact ratings (non-substantial). NMFS Level A and B takes were slightly lower. Comparing level B takes with the local population estimate (based on aerial surveys), ~3% may be disturbed, but repeated Level B exposures of up to 33 times may occur through the survey if animals do not leave the area. Morro Bay lagoon was assumed not to be ensonified above 160 dB re: 1 µPa rms isopleths. Mating courtship will not occur during the proposed time window for the CCCSIP Project and pups will be several months old and somewhat independent of their mothers. There are no direct measurements of the responses of harbor seals to seismic noise, but based on responses in other pinniped, localized and temporary avoidance behavior could occur over limited ranges and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered abundant and widely distributed, but with the local population that is resident and has a strong preference for near-shore areas. *Project may affect, but not likely to have a substantial adverse effect on Pacific harbor seals.*

4.5.1.17 California sea lion

Large population for US stock with seasonal abundance in central California linked to fall post-breeding typically northward migration of mainly males and sub-adults. Animals typically forage within 20 nmi of shore and was species with maximum number of sightings by Padre (2011). A NOAA aerial survey in September 2008 counted 2,385 animals at 7 locations between Point Sal and San Simeon, with 870 animals counted at Lion Rock, near Point Buchon. Predictions of Injury SEL takes was 501-787 individuals (6-9% of PBR), while predictions of Probabilistic Disturbance rms takes ranged between 3137-4902 individuals (2-3% of population), resulting in negligible impact ratings (non-substantial). Minimum NMFS Level A (110-172 individuals) and Level B (2496-3900) take estimates were lower. Comparing level B takes with the local population estimate, suggest high degree of repeated disturbance to the local population, but overall this population represents just a small fraction of the total stock and thus does not exceed criteria for high impact. Number of individual takes may be higher assuming high turnover rates occur during migration period. Density estimates may also vary due to El Nino. There are no direct measurements of the responses of sea lions to seismic noise, but based on responses in other pinniped, localized and temporary avoidance behavior could occur over limited ranges and may be affected by the behavioral state of animals during exposure. Non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Overall, the species is considered very abundant and widely distributed, with very flexible foraging strategy. Considered to have a good capacity to withstand Level B disturbance in one region. *Project may affect, but not likely to have a substantial adverse effect on California sea lion.*

4.5.1.18 Southern sea otter

Southern sea otters range extends from about Half Moon Bay in the north to Santa Barbara in the south. They are resident to the Investigation area where they inhabit the near shore waters, and the highest density within the Point Buchon area. In 2010, the coast from San Simeon to Point Sal contained 874 sea otters, approximately 30.5% of the total stock population. They breed in both June-July and October-November. Invertebrates form majority of diet and typically, dive depths of females <30m and males <40m (USGS 2010). Sea otters appear insensitive to seismic noise (Malme et al. 1984) at ranges >900m, but can be disturbed by close approaches by boats. The NMFS Level A threshold overlaps with sea otter habitat (including in the vicinity of Point Buchon), however, much of the overlap is in waters deeper than 30m (i.e., out of the female and pup core areas). Overall, the overlap area was estimated to contain 61 animals (2.2% of population) and was considered to represent an area of disturbance rather than injury, resulting in a moderate magnitude. Duration of the survey in high density habitat is considered short-term. There is limited available data on responses of sea otters to seismic airguns, as well as their hearing abilities, but the ability to raft without immersing their heads and ears is considered enough to preclude injury. Response may occur to any vessel participating in the survey, particularly during the shooting of near-shore lines. The assessment of disturbance by the survey vessel within 100m estimated 12 individuals may be disturbed. This value could double if the scout boat does not follow a similar route. In addition, the placement and recovery of the geophone lines off Point Buchon is likely to cause additional negative interactions with boats. The entire area encompassing the geophones was estimated to have 173 animals, but only a portion of this total is likely to be disturbed. This vessel disturbance is assumed to be very short term and isolated in placing and removing the lines and overall moderate (non-substantial) impact. Remaining non-acoustic effects rated as low to negligible impact and consequently non-substantial, given proposed APMs and Contingency plans. Notably, oil contamination of sea otters had a high potential magnitude rating. We have assumed that seismic acoustic effects on the species of invertebrates that sea otters rely upon is negligible. *Project may affect, but not likely to have a substantial adverse effect on sea otters.* Given the scarcity of information with regards to disturbance by seismic surveys on otters, additional mitigation is warranted. Undertaking near-shore surveys in the vicinity of Point Buchon during daylight hours would reduce the likelihood of disturbing large concentrations of animals.

4.6 Potential adverse effects summary for Alternatives.

Alternative 1 excludes Box 3. Reductions in Level A takes amount to 9-12%. Reductions in Level B takes amount to 13-18% (Tables 4.4 and 4.8). Active acoustic source impact ratings however remain near identical compared to the Project. Non-acoustic stressor impact ratings are also considered identical to the Project. No changes are considered warranted in species adverse effects conclusions.

Alternative 2 (Zone 1 and 2) varies significantly from the Project and Alternative 1 in that there are less tracklines in near-shore areas and more in deeper waters (>200m). Alternative 2 has the largest noise footprint, but the distance between tracklines is larger and the total length of trackline is also considerably less, so ‘intensity’ per area is less than the Project. Reductions in Level A takes amount to >60% for Injury SEL methods, but varied by species using NMFS Minimum methods (increases for deeper water species and large reductions for the coastal species, harbor porpoise, bottlenose dolphins and sea otters, Tables 4.4 and 4.9). Reductions in Level B takes amount to ~8% for Probabilistic Disturbance rms methods, but NMFS Minimum takes saw 10-36% increases for all species, except harbor porpoises (reduced 19%) and Bottlenose dolphins (reduced 21%). NMFS results reflect the increased footprint of Alternative 2 into deeper water (Table 4.8). Non-acoustic stressor impact ratings are considered identical to the Project. No changes are considered warranted in the species adverse effects conclusions.

5.0 Mitigation

Various mitigation strategies can help decrease the impact of the stressors discussed above. Mitigation strategies fall into three general groupings; equipment selection/modification, timing of operations, and distance between operations and animals. Equipment can be improved to reduce impacts on marine mammals; by for example decreasing or better focusing the amplitude of noise the airguns create to image the earth’s crust or changing the nature of signals used in imaging geophysical features. While such equipment improvement is a necessary long term goal of the seismic imaging industry, it may be difficult to implement within the time period of a specific project. Rather the best that can be done during a project is to ensure that equipment is well maintained and properly functioning. Using equipment that improves detection of marine mammals can however be successfully implemented during projects. The timing of a survey or timing of activities during the survey can greatly reduce the impacts of various stressors. For example conducting a survey at a time of year when species of concern are not present or at lower densities is one of the most effective mitigation strategies and has been incorporated into the proposed schedule of the Project. Increasing the distance between survey activities and exposed animals can also help decrease the impact of stressors. Generally the more distance between the stressor and the animal, the lower the impact. Thus using larger buffers or avoiding unique areas of concern can help mitigate the impact of stressors, but if those areas are difficult to observe they may lead to a false sense of lesser impact. While the 24/7 survey schedule reduces the detection rates of MMOs (and consequently may reduce the distance from the stressor) for many of the operational periods, it completes the survey at a faster rate and also does not offer long breaks in operations where animals may return to areas only to be again displaced by operations. Below are mitigation strategies to help mitigate the stressors discussed above.

Mitigation is partitioned into sections related to specific goals.

5.1 Decreasing effects on ESA-listed fin, humpback and blue whales during high densities occurrences

Mysticete whale density can vary a great deal from year to year and are difficult to predict with any confidence. Temporally sporadic high concentrations may occur within the acoustic effect zone of the survey. Our analysis indicates that substantial adverse effects are most likely to occur if high concentrations of mysticetes occur in the Investigation area or the near vicinity. Likelihood of relatively high concentrations occurring were rated as possible, depending on prevailing oceanic conditions. Surveys to assess density should therefore be undertaken prior to the survey and throughout the survey (ideally prior to switching between boxes). It is proposed that consultation with NMFS is undertaken to decide the density threshold for the various mitigation options proposed.

Mitigation 1: Pre-survey of Investigation area and vicinity to 14 km (twice the maximum 160 db rms isopleth) for mysticetes. The survey is best undertaken ~10 days prior to the start of the survey. An intensive multi-day sighting survey is proposed to specifically assess mysticete density and location of any major concentrations.

Options depending on results would be to proceed, selecting the box with the lowest density or to delay the survey until non-critical densities were detected. It is predicted that high concentrations of mysticetes are unlikely to occur for long periods of time (less than 2 weeks) at this time period. Thus reassessment of densities could occur and the survey proceeds later in the season, unless length of resulted survey would result in substantial effects on gray whales (i.e., into January). However, if high concentrations were to remain in the Project area then options include delaying the survey into the following year. This decision would need to be offset with concerns of multi-year stressors then being placed on resident species such as harbor porpoise.

Mitigation 2: Weekly aerial survey of Investigation area and vicinity to 14 km (twice the maximum 160 dB re: 1 µPa rms isopleths) for mysticetes. These surveys aim to ensure no large concentrations of mysticetes are occurring within the larger acoustic effects area or in the next box to be undertaken. High concentrations would lead to survey delays as per Mitigation 1.

Mitigation 3: Adaptive management for the occurrence of multiple shut-downs. More than three shut-downs for mysticete whales results in an immediate project review. Requires real-time data transfer to regulators.

5.2 Decreasing effects on resident species, especially harbor porpoise

Potential effects on harbor porpoise are mainly due to Level B harassment, which are hard to mitigate effectively. Level A harassment of porpoises was considered high magnitude and levels increase if BAR assumptions are lower than predicted.

Mitigation 4: Time the inshore tracks so they coincide with maximum amount of daylight. This potential mitigation option recognizes that many resident species will have high densities in inshore areas (including harbor porpoise, sea otters, bottlenose dolphins and harbor seals). Daylight surveys aim to reduce the likelihood of Level A takes, by increasing detection success by MMOs.

Research recommendation: Aerial surveys are not considered to have sufficient temporal resolution to assess the potential effects of the survey on harbor porpoise. It is proposed that multiple porpoise passive acoustic autonomous click detectors (e.g., Chelonia Ltd. C-PODs) are deployed before, during and after the survey as well as within and outside the Investigation area to assess the effects of the survey on porpoise presence. It is suggested that the design of this study be formulated with the consultation of NMFS. In broad strokes, the study would require three deployments and retrievals of 12+ C-PODS from a small vessel at multiple sites inside and outside of the Project area.

Mitigation 5: Ensure aerial surveys avoid local pinniped haul-outs or occur at high altitude when passing local pinniped haul-outs.

5.3 Decreasing numbers of Level A acoustic takes for all species

A number of strategies exist to reduce the likelihood of Level A acoustic takes and are presented in order of likely effectiveness.

Mitigation 6: Increase the size of the exclusion zone. Realistically, this measure is likely most effective if applied to mysticetes (whose hearing sensitivity overlaps the greatest with seismic airgun signals), Sperm whales and if large groups of marine mammals are observed. Given the maximum 180 dB re: 1 μPa (un-weighted, soft sediment) radius modeled by Jasco Applied Sciences of 856 m, the exclusion zone is likely to be ~1 km. It is proposed that the exclusion zone for large whales and large groups (>20 individuals) of marine mammals be increased to 2 km. MMOs would be able to monitor a 2 km exclusion zone effectively for large whales and large groups of odontocetes, however would not be able to do so for small groups of odontocetes or pinnipeds. Thus the 1 km exclusion zone may be more appropriate for these scenarios.

Mitigation 7: Increase number of scout boats to maximize ability to cover exclusion zone effectively. It is proposed that two scout boats be used with MMOs to increase detection rates within the exclusion zone. These boats would maintain a distance of half the exclusion zone on either side of the survey vessel. During surveying near shore, these scout boats would reorient so as to maintain a minimum of 2 km distance from shore to avoid additional otter disturbance. Additional scout vessels may increase the risk of ship strikes, but this is considered to be more than offset by the additional detections by more dispersed MMOs.

Mitigation 8: Use PAM to localize cetacean detections within or close to the exclusion zone, allowing power-down to occur in poor sighting conditions or at night. Presently, PAM is assumed to be used only to alert MMOs of an acoustic detection.

Mitigation 9: Use of additional equipment and personnel to increase day (big-eye binoculars, additional MMOs, reduction in time of MMOs on shift) and night detection rates (advanced infrared equipment, sodium lighting and millimeter waves radar). There should be a minimum of 3 MMOs per vessel (survey vessel and two scout boats) with 2 MMOs on watch at a time. The third would rest and then rotate with other MMOs to ensure vigilance during watch times.

Mitigation 10: Increase length of pre ramp-up scan period to 45 minutes, especially in poor sighting conditions. Some species have long dive times and only spend short periods of time at the surface between dives. Other species are hard to sight at long range or in poor conditions. Increasing the pre ramp-up scan period increases the chances of sighting these individuals. Similarly, an increase in the time period of exclusion zone observation following power-down or shut-down is proposed.

Mitigation 11: Daylight surveys for production lines near to Church Rock. Church Rock appears to be a hotspot for humpback whales and other cetaceans. Undertaking seismic operations during the daytime in the vicinity of Church Rock would increase chance of detection. Location of Church Rock is N35º 20.675 W120º 59.049. This would affect boxes 2, 3 and 4 since Church Rock is at the confluence of all three of these boxes.

Mitigation 12: Ensure all MMOs are independent and have had considerable experience sighting local species and using PAM.

5.4 Decreasing potential of Level A takes for all species

Mitigation 13: Ensure sufficient 'major' oil spill response equipment for immediate containment is available locally.

Mitigation 14: During transits increase distance to be maintained away from whales to 500m in order to reduce chance of collision.

Special Mitigation 15: The airguns will be shut down if a North Pacific right whale is sighted at any distance from the vessel.

6.0 References

Allen, B. M., & Angliss, R. P. (2011). Alaska Marine Mammal Stock Assessments, 2010. NOAA Technical Memorandum NMFS-AFSC-233: U.S. Department of Commerce.

Angliss, R. P., & Outlaw, R. B. (2007). *Alaska Marine Mammal Stock Assessments , 2006. NOAA Technical Memorandum NMFS-AFSC-168. Fisheries (Bethesda)* (p. 1291).

Arveson, P., & Vendittis, D. (2000). Radiated noise characteristics of a modern cargo ship. *The Journal of the Acoustical Society of America*, *107*(1), 118-29.

Au, W. W. L., & Moore, P. W. B. (1990). Critical ratio and critical bandwidth for the Atlantic bottlenose dolphin. *The Journal of the Acoustical Society of America*, *88*(3), 1635-1638.

Bailey, H., Mate, B., Palacios, D., Irvine, L., Bograd, S., & Costa, D. (2010). Behavioural estimation of blue whale movements in the Northeast Pacific from state-space model analysis of satellite tracks. *Endangered Species Research*, *10*, 93-106.

Bain, D. E., & Williams, R. (2006). Long-range effects of airgun noise on marine mammals: responses as a function of received sound level and distance. *International Whaling Commission Working Paper SC/58/E35*.

Barlow, Jay, Forney, K. A., Hill, P. S., Brownell, R. L., Carretta, J. V., Demaster, D. P., Julian, F., et al. (1997). *U.S. Pacific Marine Mammal Stock Assessments: 1996. NOAA-TM-NMFS-SWFSC-248* (p. 229).

Barlow, Jay, Ferguson, M. C., Becker, E. A., Redfern, J. V., Forney, K. A., Vilchis, I. L., Fielder, P. C., et al. (2009). Predictive modeling of cetacean densities in the eastern Pacific Ocean. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-444: U.S. Department of Commerce.

Benson, Scott R, Croll, D. A., Marinovic, B. B., Chavez, F. P., & Harvey, J. T. (2002). Changes in the cetacean assemblage of a coastal upwelling ecosystem during El Nino 1997 – 98 and La Nina 1999. *Progress in Oceanography*, *54*, 279-291.

Brandt, M. J., Diederichs, A., Betke, K., & Nehls, G. (2011). Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea. *Marine Ecology Progress Series*, *421*, 205–216.

Calambokidis, John, & Osmek, S. D. (1998). *Marine Mammal Research and Mitigation in Conjunction with Air Gun Operation for the USGS “SHIPS” Seismic Surveys in 1998. Final Report* (p. 46).

Calambokidis, John, Schlender, L., & Quan, J. (1998). *Marine Mammal Observations and Mitigation Associated with USGS Seismic Surveys in the Southern California Bight in 1998. Final Report* (p. 14).

Calambokidis, John, & Chandler, T. (2000). *Marine Mammal Observations and Mitigation Associated with USGS Seismic Surveys in the Southern California Bight in 2000. Final Report* (p. 13).

Calambokidis, John, Chandler, T., Schlender, L., Rasmussen, K., & Steiger, G. (2002a). *Research on Humpback and Blue Whales off California, Orgegon and Washington in 2001. Final Report* (p. 50).

Calambokidis, J., Chandler, T., & Douglas, A. (2002b). *Marine mammal observations and mitigation associated with USGS seismic-reflection surveys in the Santa Barbara Channel 2002* (p. 30).

Calambokidis, J., Chandler, T., Schlender, L., Steiger, G. H., & Douglas, A. (2003). *Research on humpback and blue whale off California, Oregon and Washington in 2002: Final Report* (p. 47).

Calambokidis, John, Chandler, T., Faclone, E., & Douglas, A. (2004). *Research on larger whales off California, Oregon, and Washington in 2003, Annual report for 2003 to the Southwest Fisheries Science Center* (p. 48).

Calambokidis, John, Falcone, E. A., Quinn, T. J., Burdin, A. M., Clapham, P. J., Ford, J. K. B., Gabriele, C. M., et al. (2008). *SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final Report* (p. 57).

Calambokidis, John, Falcone, E., Douglas, A., Schlender, L., & Huggins, J. (2009). *Photographic identification of humpback and blue whales off the US West Coast : Results and updated abundance estimates from 2008 field season. Final Contract Report to Southwest Fisheries Science Center* (p. 18).

Carretta, J., Forney, K., & Laake, J. (1998). Abundance of southern California coastal bottlenose dolphins estimated from tandem aerial surveys. *Marine Mammal Science*, *14*(4), 655–675.

Carretta, J.V., Forney, K. A., & Benson, S. R. (2009). Preliminary estimates of harbor porpoise abundance in California waters from 2002 to 2007. NOAA Technical Memorandum, NOAA-TM-NMFSSWFSC-435: U.S. Department of Commerce.

Carretta, James V, Forney, K. A., Oleson, E., Martien, K., Muto, M. M., Lowry, M. S., Barlow, J., et al. (2011). *U.S. Pacific Marine Mammal Stock Assessments: 2010* (p. 357).

Carstensen, J., Henriksen, O., & Teilmann, J. (2006). Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors (T-PODs). *Marine Ecology Progress Series*, *321*, 295–308.

Cassoff, R., Moore, K., McLellan, W., Barco, S., Rotstein, D., & Moore, M. (2011). Lethal entanglement in baleen whales. *Diseases of Aquatic Organisms*, *96*(3), 175-185.

Clark, Christopher W, & Gagnon, G. C. (2006). Considering the temporal and spatial scales of noise exposures from seismic surveys on baleen whales. *International Whaling Commission Working Paper SC58/ E9*.

Clark, Christopher W, Ellison, W., Southall, B. L., Hatch, L., Van Parijs, S. M., Frankel, A., & Ponirakis, D. (2009). Acoustic masking in marine ecosystems: intuitions, analysis, and implication. *Marine Ecology Progress Series*, *395*, 201-222.

Cox, T. M., Ragen, T., Read, A., Vos, E., Baird, R., Balcomb, K., Barlow, J., et al. (2006). Understanding the impacts of anthropogenic sound on beaked whales. *Journal of Cetacean Research and Management*, *7*(3), 177–187.

De Robertis, A., & Wilson, C. D. (2011). Silent ships do not always encounter more fish (revisited): comparison of acoustic backscatter from walleye pollock recorded by a noise-reduced and a conventional research vessel in the eastern Bering Sea. *ICES Journal of Marine Science*, *68*(10), 2229-2239.

Di Iorio, L., & Clark, C. W. (2009). Exposure to seismic survey alters blue whale acoustic communication. *Biology Letters*, *6*(3), 334-335.

D’Amico, A., Gisiner, R. C., Ketten, D. R., Hammock, J. a., Johnson, C., Tyack, P. L., & Mead, J. (2009). Beaked Whale Strandings and Naval Exercises. *Aquatic Mammals*, *35*(4), 452-472.

Ellison, W. T., Southall, B. L., Clark, C. W., & Frankel, A. S. (2011). A New Context-Based Approach to Assess Marine Mammal Behavioral Responses to Anthropogenic Sounds. *Conservation Biology*, *26*(1), 21-28.

Erbe, C. (2008). Critical ratios of beluga whales (Delphinapterus leucas) and masked signal duration. *The Journal of the Acoustical Society of America*, *124*(4), 2216-23.

Fernández, A., Edwards, J. F., Rodríguez, F., Espinosa de los Monteros, A., Herráez, P., Castro, P., Jaber, J. R., et al. (2005). “Gas and fat embolic syndrome” involving a mass stranding of beaked whales (family Ziphiidae) exposed to anthropogenic sonar signals. *Veterinary Pathology*, *42*(4), 446-57.

Fiedler, P. C., Reilly, S. B., Hewitt, R. P., Demer, D., Philbrick, V. A., Smith, S., Armstrong, W., et al. (1998). Blue whale habitat and prey in the California Channel Islands. *Deep-Sea Research Part II*, *45*(8-9), 1781–1801. Elsevier.

Finneran, James J., Schlundt, C. E., Dear, R., Carder, D. a., & Ridgway, S. H. (2002). Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *The Journal of the Acoustical Society of America*, *111*(6), 2929.

Finneran, James J, & Schlundt, C. E. (2004). Effects of Intense Pure Tones on the Behavior of Trained Odontocetes. SPAWAR Systems Center Technical Report 1913.

Finneran, James J, Carder, D. a, Schlundt, C. E., & Dear, R. L. (2010a). Temporary threshold shift in a bottlenose dolphin (Tursiops truncatus) exposed to intermittent tones. *The Journal of the Acoustical Society of America*, *127*(5), 3267-72.

Finneran, James J, & Schlundt, C. E. (2010b). Frequency-dependent and longitudinal changes in noise-induced hearing loss in a bottlenose dolphin (Tursiops truncatus). *The Journal of the Acoustical Society of America*, *128*(2), 567-70.

Fischer, R. W., & Brown, N. A. (2005). Factors Affecting the Underwater Noise of Commercial Vessels Operating in Environmentally Sensitive Areas. *OCEANS*, *3*, 1982-1988.

Forney, K. a., & Barlow, J. (1998). Seasonal Patterns in the Abundance and Distribution of California Cetaceans, 1991–1992. *Marine Mammal Science*, *14*(3), 460-489.

Frankel, AS. (2005). Gray whales hear and respond to a 21–25 kHz high-frequency whale-finding sonar. *Proceedings of the16th Biennial Conference on the Biology of Marine Mammals* (pp. 12–16).

Garrott, R. A., Eberhardt, L. L., & Burn, D. M. (1993). Mortality of Sea Otters in Prince William Sound Following the Exxon Valdez Oil Spill. *Marine Mammal Science*, *9*(4), 343-359.

Gedamke, J., Gales, N., & Frydman, S. (2011). Assessing risk of baleen whale hearing loss from seismic surveys: The effect of uncertainty and individual variation. *The Journal of the Acoustical Society of America*, *129*(1), 496-506.

Goold, J. C., & Fish, P. J. (1998). Broadband spectra of seismic survey air-gun emissions, with reference to dolphin auditory thresholds. *The Journal of the Acoustical Society of America*, *103*(4), 2177-84.

Gordon, Jonathan, Gillespie, D., Potter, J., Frantzis, A., Simmonds, M. P., Swift, R., & Thompson, D. (2004). A Review of the Effects of Seismic Surveys on Marine Mammals. *Marine Technology Society Journal*, *37*(4), 16-34.

Gotz, T., Hastie, G., Hatch, L., Raustein, O., Southall, B., Tasker, M., Thomsen, F., et al. (2009). Overview of the impacts of anthropogenic underwater sound in the marine environment. OPSAR Commission.

Haley, B., & Koski, W. R. (2004). *Marine Mammal Monitoring During Lamont-Doherty Earth Observatory's ADWBC Seismic Program in the Northwest Atlantic Ocean July - August 2004: LGL Report TA2822-27* (p. 92).

Harris, R. E., Miller, G. W., & Richardson, W. J. (2001). Seal Responses to Airgun Sounds During Summer Seismic Surveys in the Alaskan Beaufort Sea. *Marine Mammal Science*, *17*(4), 795-812.

Hastie, G. D. (2007). Using active sonar to detect marine animals around marine energy devices: behavioural responses by porpoises to sonar signals. SMRU Ltd.

Hastie, G. D., & Janik, V. M. (2007). Using active sonar to detect marine animals around marine energy devices: behavioural responses by grey seals to sonar signals. SMRU Ltd.

Henderson, D., & Hamernik, R. P. (1986). Impulse noise: critical review. *The Journal of the Acoustical Society of America*, *80*(2), 569-84.

High Energy Seismic Survey Team. (1999). High Energy Seismic Survey Review Process and Interim Operational Guidelines for Marine Surveys Offshore Southern California. The California State Lands Commission and The United States Minerals Management Service.

Holst, M., Smultea, M. A., Koski, W. R., & Haley, B. (2005). *Marine Mammal and Sea Turtle Monitoring During Lamont-Doherty Earth Observatory's Marine Seismic Program off the Northern Yucatan Penninsula in the Southern Gulf of Mexico, January - February 2005: LGL Report TA 2822-31* (p. 110).

Holt, M. M., Noren, D. P., Veirs, V., Emmons, C. K., & Veirs, S. (2009). Speaking up: Killer whales (Orcinus orca) increase their call amplitude in response to vessel noise. *The Journal of the Acoustical Society of America*, *125*(1), EL27-32.

Jensen, A. S., & Silber, G. K. (2004). Large whale ship strike database. NOAA Technical Memorandum NMFS-OPR-25: U.S. Department of Commerce.

Jochens, A., Biggs, D., Benoit-Bird, K., Engelhaupt, D., Gordon, J., Hu, C., Jaquet, N., et al. (2008). *Sperm Whale Seismic Study in the Gulf of Mexico: Synthesis Report. OCS Study MMS 2008-006* (p. 341).

Johnson, C. S. (1991). Hearing thresholds for periodic 60-kHz tone pulses in the beluga whale. *The Journal of the Acoustical Society of America*, *89*(6), 2996-3001.

Johnson, C.S., McManus, M., & Skaar, D. (1989). Masked tonal hearing thresholds in the beluga whale. *The Journal of the Acoustical Society of America*, *85*(6), 2651-2654.

Johnston, Dave W. (2002). The effect of acoustic harassment devices on harbour porpoises (Phocoena phocoena) in the Bay of Fundy, Canada. *Biological Conservation*, *108*(1), 113-118.

Kastak, D., Southall, B. L., Schusterman, R. J., & Kastak, C. R. (2005). Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration. *The Journal of the Acoustical Society of America*, *118*(5), 3154-3163.

Kastelein, R A, Jennings, N., Verboom, W. C., de Haan, D., & Schooneman, N. M. (2006). Differences in the response of a striped dolphin (Stenella coeruleoalba) and a harbour porpoise (Phocoena phocoena) to an acoustic alarm. *Marine Environmental Research*, *61*(3), 363-78.

Kastelein, Ronald A, Hoek, L., Wensveen, P. J., Terhune, J. M., & de Jong, C. a F. (2010). The effect of signal duration on the underwater hearing thresholds of two harbor seals (Phoca vitulina) for single tonal signals between 0.2 and 40 kHz. *The Journal of the Acoustical Society of America*, *127*(2), 1135-45.

Koski, W. R., Lawson, J. W., Thomson, D. H., & Richardson, W. J. (1998). *Point Mugu Sea Range, marine mammal technical report* (p. 280). King City, Ontario, Canada.

Kremser, U., Klemm, P., & Kötz, W.-D. (2005). Estimating the risk of temporary acoustic threshold shift, caused by hydroacoustic devices, in whales in the Southern Ocean. *Antarctic Science*, *17*(1), 3-10.

Kryter, K. D., Ward, W. D., Miller, J. D., & Eldredge, D. H. (1966). Hazardous exposure to intermittent and steady-state noise. *Journal of the Acoustical Society of America*, *39*(3), 451-464.

Kujawa, S. G., & Liberman, M. C. (2009). Adding insult to injury: cochlear nerve degeneration after “temporary” noise-induced hearing loss. *The Journal of Neuroscience*, *29*(45), 14077-85.

LGL. (2009). *Environmental Assessment of a Marine Geophysical Survey by the R/V Marcus G . Langseth in the Northeast Pacific Ocean , August – September 2009* (p. 218).

Laist, D., Knowlton, A., & Mead, J. (2001). Collisions between ships and whales. *Marine Mammal Science*, *17*(1), 35-75.

Ljungblad, D. K., Moore, S. E., Clarke, J. T., & Bennett, J. C. (1988). Distribution, Abundance, Behavior and Bioacoustics of Endangered Whales in the Western Beaufort and Northeastern Chukchi Seas, 1979-1987. MMS OCS Study MMS-87-0122: U.S. Department of the Interior.

Lowry, M. S., Carretta, J. V., & Forney, K. A. (2008). Pacific Harbor Seal Census in California During May-July 2002 and 2004. *California Fish and Game*, *94*(4), 180-193.

Lucke, Klaus, Siebert, U., Lepper, P. a, & Blanchet, M.-A. (2009). Temporary shift in masked hearing thresholds in a harbor porpoise (Phocoena phocoena) after exposure to seismic airgun stimuli. *The Journal of the Acoustical Society of America*, *125*(6), 4060-70.

Lurton, X., & DeRuiter, S. (2011). Sound radiation of seafloor-mapping echosounders in the water column, in relation to the risks posed to marine mammals. *International Hydrographic Review*, (November), 7-17.

Lusseau, D. (2005). Residency pattern of bottlenose dolphins Tursiops spp. in Milford Sound, New Zealand, is related to boat traffic. *Marine Ecology Progress Series*, *295*, 265-272.

Lusseau, David, Bain, D., Williams, R., & Smith, J. (2009). Vessel traffic disrupts the foraging behavior of southern resident killer whales Orcinus orca. *Endangered Species Research*, *6*(3), 211–221.

Madsen, P T, Payne, R., Kristiansen, N. U., Wahlberg, M., Kerr, I., & Møhl, B. (2002). Sperm whale sound production studied with ultrasound time/depth-recording tags. *The Journal of Experimental Biology*, *205*, 1899-906.

Madsen, P. T., Johnson, M., Miller, P. J. O., Aguilar Soto, N., Lynch, J., & Tyack, P. (2006a). Quantitative measures of air-gun pulses recorded on sperm whales (Physeter macrocephalus) using acoustic tags during controlled exposure experiments. *The Journal of the Acoustical Society of America*, *120*(4), 2366.

Madsen, P., Wahlberg, M., Tougaard, J., Lucke, K., & Tyack, P. (2006b). Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series*, *309*, 279-295.

Malme, C. I., Miles, P. R., Clark, C. W., Tyak, P., & Bird, J. E. (1983). Investigations of the Potential Effects of Underwater Noise from Petroleum Industry Activities on Migrating Gray Whale Behavior. MMS Report No. 5366: U.S. Department of the Interior.

Malme, C. I., Miles, P. R., Clark, C. W., Tyak, P., & Bird, J. E. (1984). Investigation of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior. MMS Report No. 5586: U.S. Department of the Interior.

Manly, B., Moulton, V., Elliott, R., Miller, G., & Richardson, W. (2007). Analysis of covariance of fall migrations of bowhead whales in relation to human activities and environmental factors, Alaskan Beaufort Sea: Phase I, 1996-1998. MMS OCS Study MMS-2005-033: U.S. Department of Commerce.

Mate, B. R., Stafford, K. M., & Ljungblad, D. K. (1994). A change in sperm whale (Physeter macrocephalus) distribution correlated to seismic surveys in the Gulf of Mexico. *Journal of the Acoustical Society of America*, *96*(5), 3268-3269.

McCarthy, E., Moretti, D., Thomas, L., DiMarzio, N., Morrissey, R., Jarvis, S., Ward, J., et al. (2011). Changes in spatial and temporal distribution and vocal behavior of Blainville’s beaked whales (Mesoplodon densirostris) during multiship exercises with mid-frequency sonar. *Marine Mammal Science*, *27*(3), E206-E226.

McCauley, R. D., Jenner, M.-N., Jenner, C., McCabe, K. A., & Murdoch, J. (1998). The response of humpback whales (Megaptera novaeangliae) to offshore seismic survey noise: Preliminary results of observations about a working seismic vessel and experimental exposures. *APPEA Journal*, *38*, 692-707.

Miller, P.J.O., Biassoni, N., Samuels, A., & Tyack, P. L. (2000). Whale songs lengthen in response to sonar. *Nature*, *405*(6789), 903.

Miller, G., Moulton, V., Davis, R., Holst, M., Millman, P., MacGillivray, A., & Hannay, D. (2005). Monitoring seismic effects on marine mammals - southeastern Beaufort Sea. 2001-2002. In S. Armsworthy, P. Cranford, & K. Lee (Eds.), *Offshore oil and gas environmental effects monitoring/approaches and technologies.* (pp. 511-542). Columbus, OH: Battelle Press.

Miller, Patrick J O, Johnson, M., Madsen, P. T., Biassoni, N., Quero, M., & Tyack, P. L. (2009). Using at-sea experiments to study the effects of airguns on the foraging behavior of sperm whales in the Gulf of Mexico. *Deep Sea Research Part I: Oceanographic Research Papers*, *56*(7), 1168-1181.

Mooney, T. A., Nachtigall, P. E., & Vlachos, S. (2009a). Sonar-induced temporary hearing loss in dolphins. *Biology letters*, *5*(4), 565-7.

Mooney, T. A., Nachtigall, P. E., Breese, M., Vlachos, S., & Au, W. W. L. (2009b). Predicting temporary threshold shifts in a bottlenose dolphin (Tursiops truncatus): the effects of noise level and duration. *The Journal of the Acoustical Society of America*, *125*(3), 1816-26.

Moors, H., & Terhune, J. M. (2004). Repetition patterns in Weddell seal (Leptonychotes weddellii) underwater multiple element calls. *The Journal of the Acoustical Society of America*, *116*(2), 1261-1270.

NCCOS. (2007). *A Biogeographic Assessment off North / Central California : In Support of the National Marine Sanctuaries of Cordell Bank , Gulf of the Farallones and Monterey Bay. Phase II - Environmental Settings and Update to Marine Birds and Mammals. Ocean Science* (p. 306). Silver Spring, MD.

National Oceanic and Atmospheric Administration. (2009). Taking and Importing Marine Mammals: U.S. Navy Training in the Hawaii Range Complex; Final Rule. *Federal Register*, *74*(7), 1456-1491.

National Oceanic and Atmospheric Administration. (2009). Taking and Importing Marine Mammals; U.S. Navy’s Atlantic Fleet Active Sonar Training (AFAST) Final Rule. *Federal Register*, *74*(16), 4844-4855.

National Research Council. (2005). *Marine mammal populations and ocean noise: Determining when noise causes biologically significant effects* (p. 142). Washington, DC: The National Academies Press.

National Science Foundation. (2011). Environmental Impact Statement/ Overseas Environmental Impact Statement for Marine Seismic Research Funded by the National Science Foundation or Conducted by the U.S. Geological Survey.

Nowacek, Douglas P., Thorne, L. H., Johnston, D. W., & Tyack, P. L. (2007). Responses of cetaceans to anthropogenic noise. *Mammal Review*, *37*(2), 81-115.

Olesiuk, P. F., Nichol, L. M., Sowden, M. J., & Ford, J. K. B. (2002). Effect of the Sound Generated By an Acoustic Harassment Device on the Relative Abundance and Distribution of Harbor Porpoises (Phocoena phocoena) in Retreat Passage, British Columbia. *Marine Mammal Science*, *18*(4), 843-862.

PG&E. (2011). *Central Coastal California Seismic Imaging Project Permit Application*.

Padre Associates. (2011). *Marine Wildlife Monitoring Report PG&E Geophysical Surveys Offshore Point Buchon for the Survey Period: December 2010 to February 2011* (p. 19).

Parks, Susan E, Clark, C. W., & Tyack, P. L. (2007). Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. *The Journal of the Acoustical Society of America*, *122*(6), 3725-31.

Peterson, B., Emmett, R., Goericke, R., Venrick, E., Mantyla, A., Bograd, S. J., Shwing, F. B., et al. (2006). The state of the California Current, 2005 – 2006 : warm in the north, cool in the south. *CalCOFI*, *47*, 30-74.

Richardson, W J, Würsig, B., & Greene Jr, C. R. (1986). Reactions of bowhead whales, Balaena mysticetus, to seismic exploration in the Canadian Beaufort Sea. *The Journal of the Acoustical Society of America*, *79*(4), 1117-28.

Richardson, W John, Wursig, B., & Greene, C. R. (1990). Reactions of Bowhead Whales , Balaena mysticetus, to Drilling and Dredging Noise in the Canadian Beaufort Sea. *Marine Environmental Research*, *29*, 135-160.

Richardson, W. John, Greene Jr, C. R., Malme, C. I., & Thomson, D. H. (1995). *Marine mammals and noise* (p. 576). San Diego: Academic Press.

Richardson, W., Miller, G., & Greene Jr, C. R. (1999). Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. *Journal of the Acoustical Society of America*, *106*(4), 2281.

Rolland, R. M., Parks, S. E., Hunt, K. E., Castellote, M., Corkeron, P. J., Nowacek, D. P., Wasser, S. K., et al. (2012). Evidence that ship noise increases stress in right whales. *Proceedings of the Royal Society B: Biological Sciences*.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., Carder, D. A., et al. (2004). Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. *Canadian Journal of Fisheries and Aquatic Sciences*, *61*(7), 1124–1134.

Rugh, D. J., Muto, M. M., & DeMaster, D. P. (1999). Status review of the eastern North Pacific stock of gray whales. NOAA Technical Memorandum NMFS-AFSC-103: U.S. Department of Commerce.

Rugh, D. J., Shelden, K. E. W., & Schulman-Janiger, A. (2001). Timing of the gray whale southbound migration. *Journal of Cetacean Research and Management*, *3*(1), 31–39.

Schlundt, C E, Finneran, J. J., Carder, D. a, & Ridgway, S. H. (2000). Temporary shift in masked hearing thresholds of bottlenose dolphins, Tursiops truncatus, and white whales, Delphinapterus leucas, after exposure to intense tones. *The Journal of the Acoustical Society of America*, *107*(6), 3496-508.

Smultea, M. A., Holst, M., & Koski, W. R. (2004). *Marine Mammal Monitoring During Lamont-Doherty Earth Observatory's Seismic Program in the Southeast Caribbean Sea and Adjacent Atlantic Ocean, April - June 2004: LGL Report TA2822-26* (p. 120).

Southall, Brandon L., Schusterman, R. J., & Kastak, D. (2003). Auditory masking in three pinnipeds: aerial critical ratios and direct critical bandwidth measurements. *The Journal of the Acoustical Society of America*, *114*(3), 1660.

Southall, Brandon L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., et al. (2007). Marine mammal noise exposure criteria: Initial scientific recommendations. *Aquatic Mammals*, *33*(4), 411-521.

Stafford, K. M., Chapp, E., Bohnenstiel, D. R., & Tolstoy, M. (2011). Seasonal detection of three types of “pygmy” blue whale calls in the Indian Ocean. *Marine Mammal Science*, *27*(4), 828-840.

Stelle, L. L., Megill, W. M., & Kinzel, M. R. (2008). Activity budget and diving behavior of gray whales (Eschrichtius robustus) in feeding grounds off coastal British Columbia. *Marine Mammal Science*, *24*(3), 462-478.

Stone, C. J. (2003). The effects of seismic activity on marine mammals in UK waters, 1998-2000. JNCC Report No. 323.

Stone, C., & Tasker, M. (2006). The effects of seismic airguns on cetaceans in UK waters. *Cetacean Research and Management*, *8*(3), 255-263.

Tinker, M. T., Estes, J. A., Ralls, K., Williams, T. M., Jessup, D., & Costa, D. P. (2006). *Population Dynamics and Biology of the California Sea Otter (Enhydra lutris nereis) at the Southern End of its Range: Final Study Report MMS 2006-007* (p. 253).

Tregenza, N., Berrow, S., Hammond, P., & Leaper, R. (1997). Harbour porpoise (Phocoena phocoena L.) by-catch in set gillnets in the Celtic Sea. *ICES Journal of Marine Science*, *54*, 896–904.

Tyack, Peter L, Zimmer, W. M. X., Moretti, D., Southall, B. L., Claridge, D. E., Durban, J. W., Clark, C. W., et al. (2011). Beaked whales respond to simulated and actual navy sonar. *PloS One*, *6*(3), e17009.

U.S. Department of the Navy. (2008). Final Atlantic Fleet Active Sonar Training Range environmental impact statement (EIS)/Overseas environmental impact statement (OEIS), December 2008.

U.S. Geological Survey. (2010). California Sea Otter Survey Data: Spring 2010. Retrieved December 2011, from http://www.werc.usgs.gov/ProjectSubWebPage.aspx?SubWebPageID=4&ProjectID=91

Udevitz, M. S., Bodkin, J. L., & Costa, D. P. (1995). Detection of sea otters in boat-based surveys of Prince William Sound, Alaska. *Marine Mammal Science*, *11*(1), 59–71.

Wade, P., De Robertis, A., Hough, K., Booth, R., Kennedy, A., LeDuc, R., Munger, L., et al. (2011). Rare detections of North Pacific right whales in the Gulf of Alaska, with observations of their potential prey. *Endangered Species Research*, *13*(2), 99-109.

Wartzok, D., & Ketten, D. R. (1999). Marine mammal sensory systems. In R. E. Reynolds & S. A. Rommel (Eds.), *Biology of marine mammals* (pp. 117-175). Washington, DC: Smithsonian Institute Press.

Wartzok, Douglas, Popper, A. N., Gordon, J., & Merrill, J. (2003). Factors Affecting the Responses of Marine Mammals to Acoustic Disturbance. *Marine Technology Society Journal*, *37*(4), 6-15.

Williams, Rob, Trites, A. W., & Bain, D. E. (2002). Behavioural responses of killer whales (Orcinus orca) to whale-watching boats: opportunistic observations and experimental approaches. *Journal of Zoology*, *256*(2), 255–270.

Wright, A. J., & Kuczaj, S. (2007). Noise-related stress and marine mammals: An introduction. *International Journal of Comparative Psychology*, *20*(2-3), III-VIII.