Request by the U. S. Geological Survey For an Incidental Harassment Authorization, Under the Marine Mammal Protection Act, To Use A Small Airgun Near Marine Mammals In the Southern California Bight

Aerial view of the collapsed freeway interchange between I-5 and the Antelope Valley Freeway caused by the 1994, M 6.7 Northridge earthquake. Photo source: http://www.scecdc.scec.org/nri5.html

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Summary Request
The U.S. Geological Survey hereby requests an Incidental Harassment Authorization from the National Marine Fisheries Service to allow the incidental harassment of marine mammals that may occur while collecting marine seismic-reflection data offshore from southern California. Seismic data will be collected during June 1999, to support studies of the regional landslide and earthquake hazards and to understand how saltwater invades coastal aquifers.

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Introduction

The U. S. Geological Survey (USGS) proposes to conduct a high-resolution seismic survey offshore from Southern California. For two weeks during May and June 1999, the USGS would like to collect seismic-reflection data to investigate: 1) the hazards posed by landslides and potential earthquake faults in the nearshore region from Santa Barbara to San Diego; and 2) the invasion of seawater into freshwater aquifers that are critical to the water supply for people within the Los Angeles-San Pedro area. Both of these tasks are multiyear efforts that require using a small airgun.

Coastal Southern California is the most highly populated urban area along the U.S. Pacific coast. The primary objective of our research is to provide information to help mitigate the earthquake threat to this area. We emphasize that the goal is not to predict earthquakes but rather to help determine what steps might be taken to minimize the devastation should a large quake occur. The regional earthquake threat is known to be high, and a major earthquake could adversely affect the well being of a large number of people.

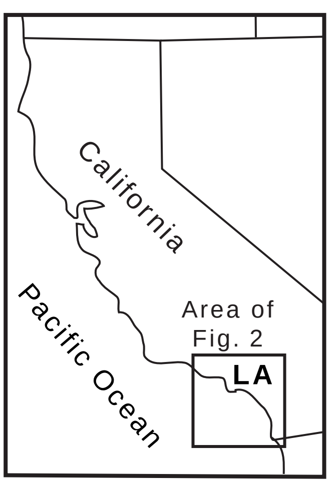

Figure 1. Index map of the study area.

Important geologic information that the USGS will derive from this project's seismic-reflection data concerns how earthquake deformation is distributed offshore, that is, where the active faults are and what the history of movement along them has been. This should improve our understanding of the shifting pattern of deformation that occurred over both the long term (approximately the last 100,000 years) and short term (the last few thousand years). We seek to identify actively deforming structures that may constitute significant earthquake threats.

We also propose to locate offshore landslides that might affect coastal areas. Major subsea landslides not only might affect the footings of coastal buildings but also very large slides can generate local tsunamis. Actually these large sea waves can be generated by seafloor movement that is produced either by landslides or by earthquakes. Knowing where large slides have occurred offshore will help locate areas susceptible to wave inundation.

Some faults that have produced earthquakes lie entirely offshore or extend into offshore areas where they can be studied using high-resolution seismic-reflection techniques. An example is the Rose Canyon fault, which extends through the San Diego area and is considered to be the primary earthquake threat. This fault extends northward from La Jolla, beneath the inner continental shelf, and appears again onshore in the Los Angeles area. This fault and others like it near shore could generate moderate (M5-6) to large (M6-7) earthquakes.

Knowing the location and geometry of fault systems is critical to estimating the location and severity of ground shaking. Therefore the results of this project will contribute to decisions involving land use, hazard zonation, insurance premiums, and building codes.

The proposed work is in collaboration with scientists at the Southern California Earthquake Center (SCEC), who analyze faults and earthquakes in onshore regions, and with scientists at the Scripps Institute of Oceanography, who measure strain (incremental movement) on offshore faults.

We also want to collect high-resolution seismic-reflection data to locate the sources and pathways of seawater that intrudes into freshwater aquifers below San Pedro. Ground water usage in the Los Angeles basin began in the mid-1800s. Today, more than 44,000 acre-feet of freshwater each year are extracted from the aquifers that underlie just the city of San Pedro. Extracting freshwater from coastal aquifers causes offshore salt water to flow toward areas of active pumping. To limit this salt-water intrusion, the Water Replenishment District and water purveyors in San Pedro are investing $2.7 million per year to inject freshwater underground to establish a zone of high water pressure in the aquifer. The resulting zone of high pressure will form a barrier between the invasive saltwater and the productive coastal aquifers.

USGS scientists in San Diego are working with the Los Angeles County Department of Public Works and the Water Replenishment District to develop a ground-water simulation model to predict fluid flow below San Pedro and nearby parts of the Los Angeles Basin. Eventually this model will be used in managing water resources. The accuracy of the present model, however, is compromised by a paucity of information about aquifer geometry and about other geologic factors that might affect fluid flow. Data we collect will be used to improve 3-dimensional, fluid-flow models to aid management of water resources.

Fieldwork described here will be the third airgun survey that the USGS has conducted under close supervision by marine-mammal biologists. In March 1998, the USGS used a large (6500 in^3) airgun array in and around Puget Sound to study the regional earthquake hazard. We employed 12 biologists, who worked on two ships continuously to oversee airgun operations. On several occasions the USGS shut off the airguns when marine mammals entered safety zones that had been stipulated by NMFS, and when mammals left these zones, we gradually ramped up the array as required in our permit to avoid harming wildlife. Marine-mammal biologists reported that during the survey, no overt distress was evident among the dense marine-mammal population, and afterward no unexplained marine-mammal strandings occurred.

In August 1998 the USGS surveyed offshore from Southern California, using a small airgun (40 in^3). Two marine-mammal biologists oversaw this activity, and the

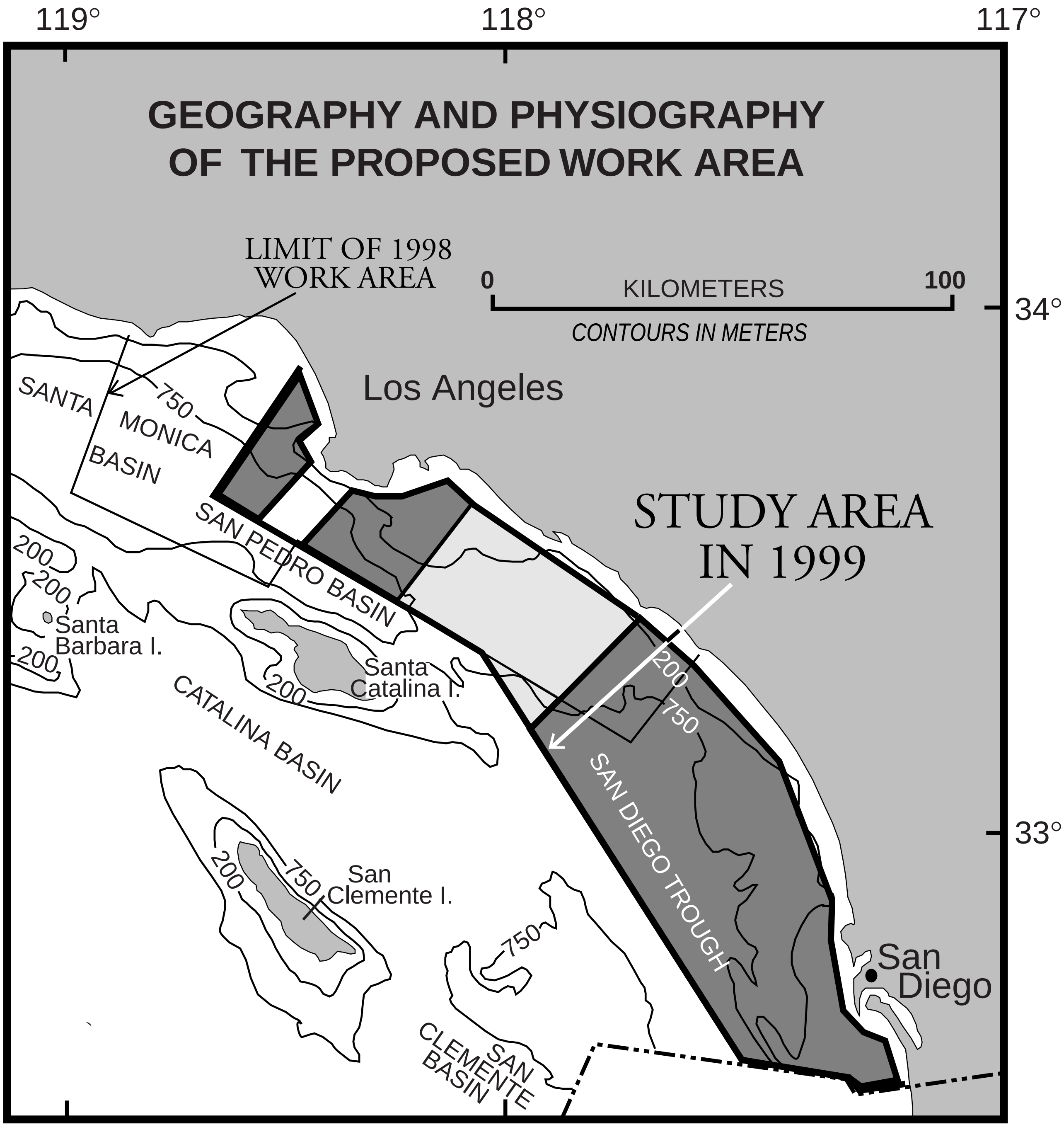

Figure 2. Area of the proposed airgun survey to study offshore earthquake and landslide hazards as well as aquifer quality near Los Angeles. Seismic refection data will be collected along a 2-km by 2-km grid in the offshore areas that are shaded with dark gray. The grid size will be 4 km by 4 km in the light-gray shaded area.

survey we propose here will be conducted with similar oversight.

We refer to these earlier surveys to show that the USGS has established a record of having operated airguns responsibly, in deference to the judgement of biologists and government agencies charged with protecting the marine environment.

Principal Earth-Science Investigators

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Principal Biologists

Biologists who oversaw our previous airgun surveys were affiliated with the Cascadia Research Collective in Olympia, Washington. Because of their experience with our operations we prefer to employ them again, but this decision is up to USGS contracting officers.

Experimental Design

Marine studies conducted by the USGS focus where natural hazards have their greatest potential impact on society. In Southern California, our studies will concern four chief areas. First in priority is the coastal zone and continental shelf between Los Angeles and San Diego, where much of the hazard appears to be associated with strike-slip faults such as the Newport-Inglewood and Palos Verdes faults. The second study area lies offshore, in the Santa Monica, San Pedro, and San Diego Trough deeps, where rapid sedimentation has left a more complete record, relative to shallow-water areas, that we can use to decipher earthquake history. The third area is the extension into the Santa Barbara Channel of major elements of onshore geology, including some large faults. The fourth area is the geologic boundary, marked generally by the Channel Islands, between the inner California Borderland (dominated by strike-slip faults) and the Santa Barbara Channel (dominated by compressional faults). The study proposed here focuses on the two highest priority areas, which lie near shore between Los Angeles and San Diego.

The seismic-reflection survey will last 14 days. From our experiences collecting seismic-reflection data in this general area during 1998, we decided to conduct the 1999 survey sometime within the May through July window. The basis for this decision is our desire to avoid the gray whale migrations and the peak arrival of other mysticetes during the later summer.

The USGS has not yet determined the exact tracklines for the survey, but we do know the areas where airgun use will be concentrated (Figure 2). Two of these areas are southwest and southeast of Los Angeles, and the third and largest one is west and northwest of San Diego. In these areas seismic-reflection data will be collected along a grid of lines that are about 2 km apart.

The USGS proposes to use a small airgun and 200-m long streamer to collect seismic-reflection data. The potential effect on marine mammals is from the airgun; mammals cannot become entangled in the streamer. The USGS also will use a low-powered, high-resolution seismic system to obtain detailed information about the very shallow geology. The seismic-reflection system will be aboard a vessel owned by a private contractor. Ocean-bottom seismometers will be deployed to measure the velocity of sound in shallow rocks to help unravel the recent history of fault motion. These seismometers are passive recorders and pose no threat to the environment.

Ship navigation will be accomplished using satellites of the Global Positioning System. The survey ship will be able to report accurate positions, which is important to mitigating the airgun's effect on marine mammals and to analyzing what impact, if any, airgun operations had on the environment.

The Seismic Sound Sources

During this survey the USGS will operate two sound sources—an airgun and a high-resolution, Huntec ™ system. The main sound source will be a single small airgun of special type called a generator-injector, or GI-gun (trademark of Seismic Systems, Inc., Houston, TX). This type of airgun consists of two small airguns within a single steel body. The two small airguns are fired sequentially, with the precise timing required to stifle the bubble oscillations that typify sound pulses from a single airgun of common type (Figure 3). These oscillations impede detailed analysis of fault and aquifer structure. For arrays consisting of many airguns, bubble oscillations are cancelled by careful selection of airgun sizes. The GI gun is a mini-array that is carefully adjusted to achieve the desired bubble cancellation. Airguns and GI guns with similar chamber sizes have similar peak output pressures (Figure 3).

The GI gun for this survey has two

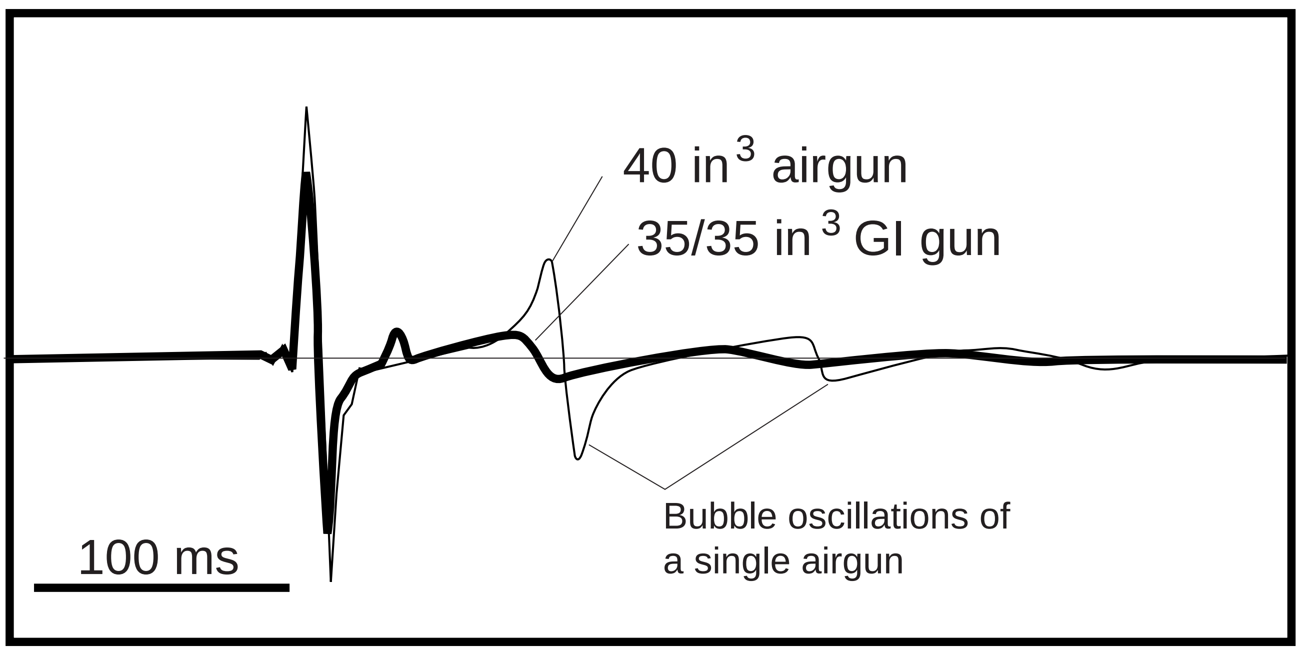

Figure 3. Comparison of the source signatures for a small airgun and a GI gun of equivalent strength. The GI gun has smaller bubble oscillations, which provides clearer images of subsurface geology.

chambers of equal size—35 in^3—and the gun will be fired every 12 seconds. Compressed air delivered to the GI gun will have a pressure of about 3000 psi. The gun will be towed 12 meters behind the vessel and suspended from a float to maintain a depth of about 1 m.

The manufacturer's literature indicates that a GI gun of the size we will use has a sound-pressure level (SPL) of about 220 dB re 1 μPa-m. In comparison, a 40 in^3 airgun has an SPL of 216 dB re 1 μPa-m (Richardson et al. 1995; p. 137). The GI-gun's output sound pulse has a duration of about 10 ms. The amplitude spectrum of this pulse, as shown by the manufacturer's data, indicates that most of the sound energy is at frequencies below 500 Hz (Figure 4). Field measurements by USGS personnel indicates that the GI gun outputs low sound amplitudes at frequencies above 500 Hz (Figure 5). Thus high-amplitude sound from this source is at frequencies that are outside the main hearing band of odontocetes and pinnipeds (Richardson et al. 1995, p. 205-240).

The high-resolution Huntec ™ system uses an electrically powered sound source. In operation the sound producing and recording hardware are towed behind the ship near the seabottom. The unit emits sound about every 0.5 s. This system provides highly detailed information about stratified sediment, so that dates obtained from fossils in sediment samples can be correlated with episodes of fault offset. The

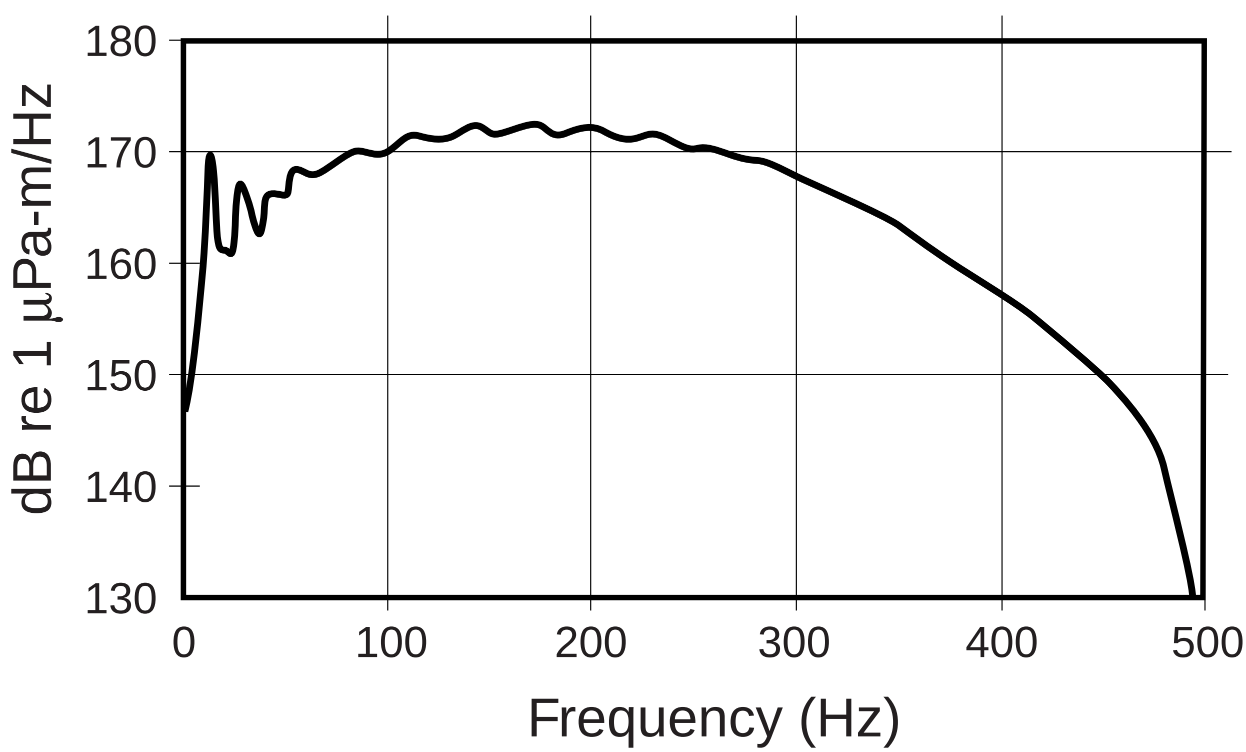

Figure 4. Frequency spectrun of a GI gun shows that most of the high amplitudes are at frequencies below 500 Hz. This information is from the manufacturer's specifications.

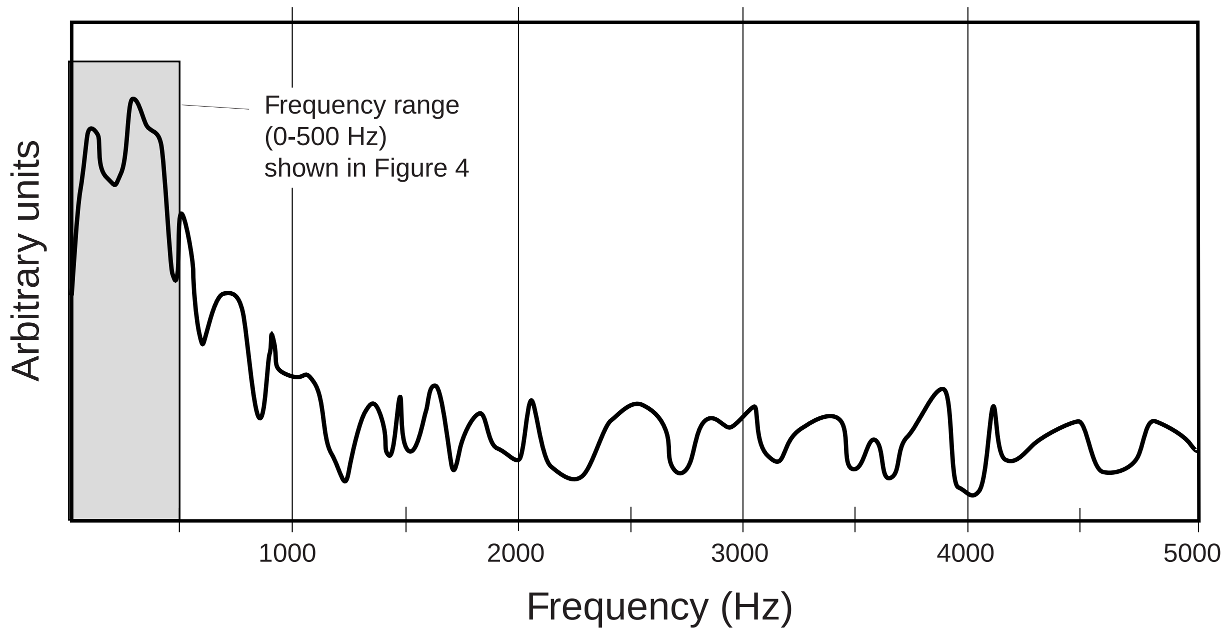

Figure 5. Frequency spectrum of the GI gun, measured by USGS scientists, shows that amplitudes are low at frequenies above 500 Hz. Measurement was made with an uncalibrated hydrophone, which is why amplitude is shown in arbitrary units. This information indicates that the main sound energy is outside the sensitive hearing band of odontocetes and pinnipeds.

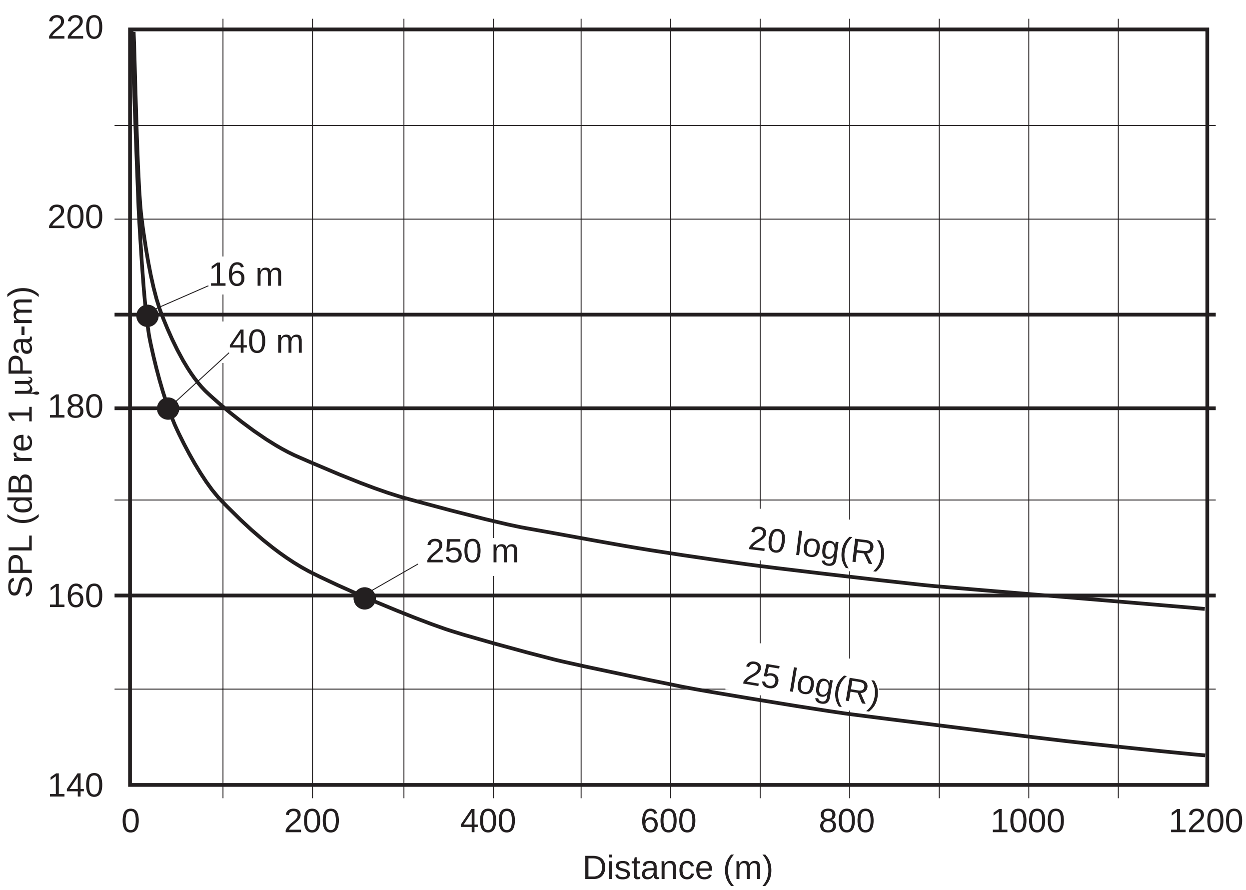

Figure 6. Safe distances for the main types of marine mammals from the GI-gun, which has an SPL of 220 dB re 1 μPa-m. The procedure used to calculate safe distance is described in the text.

SPL for this unit is 210 dB re 1 μPa-m. The output-sound bandwidth is 0.5 kHz to 8 kHz, with the main peak at 4.5 kHz.

Maximum Sound-Exposure Levels for Marine Mammals

We lack detailed measurement of sound-transmission loss for the southern California offshore. Instead we estimated how SPL varies with distance from the GI-gun by assuming that sound decays according to 25log(R). The coefficient 25 accounts approximately for the attenuation that is caused by sound's interacting with the seabottom (Fig. 6). Figure 6 is based on the 220 dB SPL produced by the GI gun, the larger of the two sound sources we plan to use.

Loud continuous sounds can damage the hearing of marine mammals. However, the adverse effects of sound on mammals have been documented for exposure times that last for tens of seconds or minutes, but effects have not been documented for the brief pulses typical of the GI gun (10 ms) and the Huntec system (typically 0.3 ms). NMFS considers that the maximum SPLs to which marine mammals can be exposed are 180 dB re 1 μPa-m RMS for mysticetes and sperm whales, and 190 dB re 1 μPa-m RMS for odontocetes and pinnipeds.

The zone of influence for the GI gun is defined to be the circle whose radius is the distance from the gun where the sound pressure level reduces to 160 dB re 1μPa-m. For the assumed 25log(R) attenuation, the zone of influence is a circle with a radius of 250 m.

The method we use to estimate safe distances from the airgun indicates that, with a 25log(R) decay, an SPL of 190 dB is attained about 16 m away from the airgun, and an SPL of 180 dB is attained at about 40 m away. We propose that at all times, the safe distance for odontocetes and pinnipeds will be 50 m and for mysticetes, 100 m.

The Need for 24-hour Seismic Operations

Operating less than 24 hours each day incurs substantially increased cost for the leased ship, which the USGS cannot afford. The ship schedule provides a narrow time window for this project; already other experiments are scheduled to precede and follow ours. Thus we are not able arbitrarily to extend the survey time to include large delays for dark or poor visibility.

Reasons for around-the-clock operation that benefit the environment are: 1) when the airgun ceases to operate, marine mammals might move back into the survey area and incur an increased potential for harm when operations resume, and 2) daylight-only operations prolong our activities in a given area, thus increasing the likelihood that marine mammals will be harassed. The 1999 survey will require only two weeks, and it will be spread out geographically from Los Angeles to San Diego, so no single area will see long-term activity. In our view, the best course is to complete the experiment as expeditiously as possible.

For these reasons, we request that the Incidental Harassment Authorization allow 24-hour operations.

Marine Mammals in the Survey Area

The following discussion of marine-mammal species is excerpted (with permission) and modified from Calambokidis and Francis (1994).

Odontocetes

Some odontocetes occur in southern California waters but are not considered in detail below. These include beaked whales as well as pygmy and dwarf sperm whales, all of which are restricted to deeper offshore waters; several of the more tropical delphinids, such as the rough-toothed and striped dolphins; and false killer whales, which have a more tropical or subtropical distribution.

Bottlenose dolphin

Although bottlenose dolphins in the eastern North Pacific were seen north through central California from the 1950s through 70s, southern California waters once were the northern extent of their range (Norris and Prescott 1961, Dohl et al. 1981, Wells et al. 1990). After 1983, however, the range expanded, and sightings to Monterey Bay became common (Wells et al. 1990). The best estimate of the abundance of bottlenose dolphins off southern California is 2,340 (Barlow et al. 1993a, Barlow 1993, Forney and Barlow, in press; Hansen 1990).

Bottlenose dolphins in different areas exhibit both seasonal movements and site fidelity (Wells et al. 1990). The range for these movements appears to be between San Quintin and Ensenada, Baja California in the south (Caldwell et al. 1993) and Monterey Bay to the north (Wells et al. 1990).

The prey of coastal bottlenose dolphins in southern California consists of a number of fish and invertebrates (Walker 1981). Primary fish prey were croakers and surfperches (Walker 1981). Both the croakers and surfperches as well as other prey are primarily species that inhabit coastal inshore marine and estuarine waters (Eschmeyer et al. 1983).

Common dolphins

This section describes both the short-beaked and long-beaked dolphins. Common dolphins are the most abundant cetacean in southern California waters (Dohl et al. 1981, 1986); they number just under 250,000 (Barlow 1993, Barlow et al. 1993a). Most of these were the short-beaked form seen in offshore waters with only about 10,000 of the long-beaked, coastal form.

There has been a substantial increase in abundance of common dolphins off California in the late 1970s to the 1990s. In the late 1970s and early 1980s, an estimated 57,000 common dolphins were off southern California (Dohl et al. 1981, 1986), and none were seen off central and northern California (Dohl et al. 1983). Barlow (1993) suggested the increase to 250,000 by 1991 was the result of a northward shift in distribution. This was apparent from the frequent sightings off central and northern California in 1991, where they earlier had been absent.

The diet of common dolphins off southern California varies by season. Evans (1975) reported common dolphins fed primarily on anchovies and squid in the fall and winter and deep-sea smelt and various lantern fishes in the spring and summer.

Killer whales

Killer whales occur in all oceans and are the top predators in the marine food chain (Heyning and Dahlheim 1988, Bigg et al. 1987). Relatively few killer whales have been sighted in southern California waters. Although killer whales may be resident to some areas for extended periods or a season, they also can range widely. Killer whales individually identified off California have been resighted as far north as British Columbia and Glacier Bay, Alaska, and as far south as San Benitos Islands, Mexico (Black et al. 1993). The estimated killer whale population off California is 307 (Barlow 1993). A total of 88 individuals have been photographically identified off California, 40 of these off southern California (Black et al. 1993, N. Black, pers. comm.).

Prey of killer whales includes a wide variety of fish, cephalopods, pinnipeds, other cetaceans, as well as other prey such as birds, deer, and sea turtles (see reviews by Perrin 1982, Hoyt 1984, Jefferson et al. 1991).

Pacific white-sided dolphin

Pacific white-sided dolphins occur widely through the North Pacific, mostly in pelagic waters but occasionally close to shore (Leatherwood et al. 1982), especially around the western side of the northern Channel Islands. The abundance of Pacific white-sided dolphins in the entire North Pacific was estimated as 931,000 (Buckland et al. 1993b) and 970,000 (Hobbs and Lerczak 1993), though both these estimates were suspected to be biased upward due to attraction to the survey vessel. The abundance of Pacific white-sided dolphins off California was estimated as 103,724 based on aerial surveys in winter 1991 and 1992 (Barlow et al. 1993a, Forney and Barlow, In press).

Prey of Pacific white-sided dolphins off southern California is anchovy, whiting, and squid, in decreasing order. Other prey species included two species of croaker, white croaker and queenfish.

Northern right-whale dolphin

This dolphin is often seen associated with Pacific white-sided dolphins and its distribution in the eastern North Pacific is generally confined to temperate waters between 30∞ and 50∞ N (Leatherwood et al. 1982). Dohl et al. (1983) suggested that there might be separate populations off central and northern California based on a gap in sightings between these two areas of concentration.

In the southern California bight, sightings of northern right-whale dolphins were primarily distributed in more offshore waters. Their occurrence within the bight is seasonal with no sightings made during systematic surveys from 1975-78 having occurred during the warm-water months of July through October (Dohl et al. 1981).

The abundance of northern right whale dolphins in the entire North Pacific was estimated as 68,000, although this estimate may be biased by vessel avoidance or attraction (Buckland et al. 1993b). The abundance of northern right whale dolphins off California was estimated as 17,118 based on aerial surveys in winter 1991 and 1992 (Barlow et al. 1993a, Forney and Barlow, In press).

Leatherwood et al. (1982) considered squid to be the primary prey of northern right-whale dolphins although some animals caught in high seas driftnets had prey in their stomachs that was similar to that found in Pacific white-sided dolphins.

Risso's dolphins

Risso's dolphins, also known as grampus, are widely distributed and abundant from tropical waters of the North Pacific north to 50∞ and generally occur in waters seaward of the 100 fathom line (Leatherwood et al. 1982). There are several gaps in the north-south distribution of animals and also evidence of seasonal movements.

This species was the third most abundant cetacean off central and northern California and primarily occupied the outer continental-shelf and upper-slope (100 to 1,000 fathoms) waters (Dohl et al. 1983). The abundance off California in winter 1991 and 1992 was estimated as 27,146 based on aerial surveys (Barlow et al. 1993a, Forney and Barlow, In press). Abundance estimates for summer and fall 1991 off California were 9,433 based on ship surveys (Barlow 1993).

Off central California, the abundance of Risso's dolphin is seasonal, and animals show a preference for warmer waters along the continental slope and in other areas of steep bottom topography (Kruse 1989).

Risso's dolphins feed primarily on cephalopods (Leatherwood et al. 1982).

Pilot whales

Pilot whales are abundant in the eastern North Pacific from off Guatemala to Pt. Conception, California, although some occur north to the Gulf of Alaska (Leatherwood et al. 1982).

Pilot whales using the near-shore waters off Santa Catalina Island usually increase in number during the winter, apparently to feed on squid (Norris and Prescott 1961, Dohl et al. 1981, Shane and McSweeney 1990). Pilot whale occurrence off southern California has decreased sharply since the 1980s. No pilot whales were seen around Santa Catalina Island in 1987 and 1988 despite efforts to locate and identify them (Shane and McSweeney, 1990). No sightings of pilot whales were made along the California coast during aerial surveys covering the entire California coast in winters of 1991 and 1992 (Forney and Barlow, In press) or in ship surveys in summer / fall 1991 (Barlow 1993, Hill and Barlow 1992). The cause for this decline or shift in distribution is not known.

Dall's porpoise

Dall's porpoise are widely distributed across the North Pacific (Leatherwood et al. 1982). Though they generally prefer colder waters, in the eastern North Pacific their range extends south to Baja California (Jefferson 1988). The abundance of Dall's porpoise in the North Pacific has been estimated as 1,186,000 (Buckland et al. 1993b) and 1,590,000 (Hobbs and Lerczak

1993). The abundance of Dall's porpoise off California in 1991 was estimated as 78,422 based on vessel surveys (Barlow et al. 1993a, Barlow 1993). All these estimates were suspected to be biased high due to attraction to the survey vessel (Buckland et al. 1993b, Hobbs and Lerczak 1993). The magnitude of this upward bias could inflate abundance estimates as much as 5-fold (Turnock and Quinn 1991). Sightings of Dall's porpoise are widely distributed off southern California; they occur in both inshore and offshore waters. A large number of sightings have been made in the Santa Barbara Channel.

Dall's porpoise feed on squid, crustaceans, and many kinds of fish (Leatherwood et al. 1982), including jackmackerel, and capeline (Scheffer 1953).

Sperm whale

Sperm whales inhabit all oceans of the world and generally occur in offshore waters deeper than 1,000 m (Gosho et al. 1984, Leatherwood et al. 1982). Sperm whales sightings in coastal California waters are rare (Leatherwood et al. 1987). Deep-water cephalopods are the primary food of sperm whales. Sperm whales generally migrate to higher latitudes during the summer.

Sperm whales are listed as endangered due to exploitation during commercial whaling, though their populations remain fairly large. Sperm whale abundance off California (out to 300 nmi) was estimated as 756 from vessel surveys in 1991 (Barlow 1993).

Mysticetes

Five species of baleen whales are common to southern California waters and several others are infrequent visitors. The five most common species are minke, gray, humpback, blue, and fin whales. Three other species, the northern right, sei, and Bryde's whales infrequently occur off southern California (Leatherwood et al. 1987) and are not considered here.

Gray whales

Gray whales usually pass through southern California in December and January during the southbound migration and northbound in February and March with mothers and calves slightly later (Rice and Wolman 1971, Pike 1962). Migrating whales travel a variety of routes off southern California; most whales travel west of the channel islands. Gray whales migrate between their breeding grounds in Baja California, Mexico, and their principal feeding grounds in the Bering and Chukchi Seas (Rice and Wolman 1971). Not all animals, however, complete the migration to these northern areas. Some gray whales feed in more southern waters and can be seen along the coast California (Patten and Samaras 1977) through the spring and summer.

The population size of the stock of gray whales along the eastern North Pacific has been estimated as just over 20,000 animals (Buckland et al. 1993a, IWC 1990, MMC 1993). The population has been steadily increasing at an estimated annual rate of about 3% (Buckland et al. 1993a, Reilly 1984, IWC 1990). NMFS has removed this species from the List of Endangered and Threatened Wildlife.

A wide variety of prey have been documented for gray whales, although the majority of the gray whale population feeds on amphipods in the Bering Sea (Nerini 1984).

Humpback whales

Humpback whales are distributed widely in the earth's oceans and are considered endangered due to heavy exploitation during whaling (Johnson and Wolman 1984). Humpback whales migrate between low latitude breeding grounds and high latitude feeding areas. In the North Pacific, humpback whales primarily breed in the waters off Mexico, Hawaii, and the Bonin Islands.

Precise abundance estimates have recently been made for humpback whales that occur off California. The population of humpback whales that feed along the coast of California, Oregon, and Washington was estimated as 581 in 1992 (Calambokidis et al. 1993b). Other surveys in 1991 yielded a similar estimate of 802 (CV 0.52) whales (Barlow 1993). Although most of these animals move to breeding grounds in the winter, aerial surveys conducted in the winter / spring off California yielded an estimate of 375 animals (Forney and Barlow, In press).

Humpback whales have been sighted periodically off southern California (Leatherwood et al. 1987, Bonnell et al. 1980). Calambokidis et al. (1993b) reported a large concentration of humpback whales in the Santa Barbara Channel in June and July of 1992 when 97 different individuals were identified photographically. Most of these animals moved north later in the year. Multiple sightings of the same animal during the season and inter-year re-sightings of some individuals indicate that some whales probably spend extended periods feeding off southern California.

Off central California, humpback whales have been observed primarily feeding on euphausiids (Kieckhefer 1992). In the summers of 1988 and 1991, humpback whales observed off southern California just north of Pt. Conception appeared to be feeding primarily on fish.

Blue whales

Blue whales are distributed widely throughout the worlds oceans, although their populations were severely depleted by commercial whaling in the 20th century (Mizroch et al. 1984a). The blue whale population off California is estimated to be just over 2,000 whales (Barlow 1993) or 1,000 whales (Calambokidis et al. 1993b). Despite the disagreement in these estimates, they both indicate that a large blue whale population feeds in California waters; these waters may be one of the most densely used areas worldwide by this species since the onset of commercial whaling. Blue whales come to California waters to feed during the late spring, summer, and fall (Calambokidis et al. 1989, Dohl et al. 1983). Worldwide, blue whales feed almost exclusively on euphausiids (Nemoto 1970).

Blue whales sighted from 1975 to 1985

occurred mostly west the Channel Islands and in the western portion of the Santa Barbara Channel. In 1992, over 100 blue whales spent extended periods feeding in the Santa Barbara Channel and around San Miguel Island (Calambokidis et al. 1993b).

Minke whale

In the northeast Pacific Ocean Minke whales range from the Chukchi Sea, Alaska, south to Baja California (Stewart and Leatherwood 1985). Little is known about the migrations and movements of minke whales in the North Pacific, although individual whales seasonally use feeding grounds off California, Washington, and British Columbia, primarily during the summer and fall (Dorsey et al. 1990).

Abundances of minke whales along the California coast has been estimated at 659 from vessel surveys during summer-fall, 1991 (Barlow 1993) and 71 from aerial surveys conducted winter-spring, 1991-92 (Forney and Barlow, In press).

Minke whales are seen in southern California throughout the year (Leatherwood et al. 1987). After gray whales, minke whales were the most common baleen whale sighted during aerial and vessel surveys from 1975 to 1978 (Dohl et al. 1981). Locations of minke whale sightings show a more inshore distribution than most of the other large whales. Although the south side of the northern Channel Islands had the highest concentrations of sightings, there were also frequent sightings off Palos Verdes. Sightings occurred year-round, although they were most common in the spring and summer.

Minke whales feed primarily on small schooling fish and euphausiids and to a lesser degree copepods (Nemoto 1970).

Fin whale

Fin whales are the second largest whale, after blue whales, and occur in latitudes above 20∞ in all oceans (Mizroch et al. 1984b; Leatherwood et al. 1987). Like most other baleen whales, fin whales are thought to migrate between low latitude areas in winter months and higher latitude feeding areas in summer months. This pattern has not been well defined for specific groups of animals and there is evidence of potential year-round occurrence in some areas.

Fin whale populations also remain endangered as a result of depletion from commercial whaling. The abundance of fin whales in the waters off California out to 300 nmi in 1991 was 935 (Barlow 1993). Although there is little direct evidence, fin whale populations would be expected to be increasing as they recover from exploitation.

Fin whales were seen primarily west of the Channel Islands with relatively few sightings close to the coast. Although sightings occur in all seasons, numbers peak in summer with frequent sightings in a number of areas including the Santa Barbara Channel during this season (Leatherwood et al. 1987). Despite the year-round sightings, there is evidence that many of the animals are transitory to the area.

Unlike the more specialized blue whale, fin whales feed on euphausiids, copepods, and small fish (Nemoto 1970). Despite the varied diet of fin whales in other areas, most animals caught during whaling off California had euphausiids in their stomachs and only 7% having anchovies (Rice 1977).

Pinnipeds and Sea Otters

California sea lion

California sea lions breed on islands from Southern California southward through Baja California and into the Gulf of California, Mexico. Adult males range from as far south as southern mainland Mexico (Gallo and Solorzano 1991, Gallo and Ortega 1986) and as far north as British Columbia (Bigg 1988). Primarily males make a seasonal northern migration to feeding areas off northern California, Oregon, Washington, and British Columbia. California sea lions occur year-round in southern California, despite the yearly migration. Centers of concentration vary by season with highest densities occurring around the northern Channel Islands and Santa Barbara Island in summer and fall and around Santa Catalina and San Clemente Islands in winter and spring (Bonnell and Ford 1987).

California sea lion breeding populations in the SCB have increased dramatically in the last 50 years. From a population of only a few thousand in the 1930s, the U.S. population has increased to approximately 87,000 animals by 1987 (Boveng 1988b) and 111,000 by 1990 (Lowry et al. 1992).

Primary prey of California sea lions in spring and summer on the Channel Islands are Pacific whiting, market squid, rockfish, jack mackerel, and northern anchovy (Antonelis et al. 1984; Lowry et al. 1990, 1991; and Clarke et al. 1967).

Northern sea lion

The northern (or Steller) sea lion ranges from Japan along the Pacific Rim to southern California, with most large rookeries in the Gulf of Alaska and the Aleutian Islands (Loughlin et al. 1984, 1987). Until recently, northern sea lions also bred on San Miguel Island off southern California (Bartholomew 1967, Loughlin et al. 1992a). A population of 2,000 animals bred on San Miguel Island in the 1930's and declined to less than 100 animals by 1958 (Bartholomew 1967). This decline is not a geographically isolated event. Overall in California, counts of northern sea lions have dropped from 6,000-7,000 in the 1960's, to 2,500-3,000 in 1982, to about 2,000 in 1989 (Loughlin et al. 1984, 1992b). Worldwide in 1989, the northern sea lion population was estimated at 116,000 individuals, representing a decrease of as much as 48% from 1961 levels (Loughlin et al. 1992b).

The northern sea lion feeds primarily on fish and cephalopods, with prey varying by area and season (Loughlin et al. 1992a).

Harbor seal

Harbor seals are found across the temperate and subarctic latitudes of the Northern Hemisphere (Reeves et al. 1992). The minimum population size for California in 1991 was 23,000 (Hanan et al. 1992). Harbor seal populations in many areas of the eastern North Pacific have generally increased over the last 20-30 years. During the 1970s and 1980s, annual increases in abundance of 5-20% have been reported for harbor seals in California (Boveng 1988a). Counts of both the entire California mainland and the Channel Islands have shown a pattern of rapid increase through the early 1980s followed by a slower rate of increase or no change from 1982 to 1993. Both site fidelity and long distance movements have been documented in harbor seals (Reeves et al. 1992).

Harbor seals feed on a wide variety of fish, cephalopods, and invertebrates. Principal prey included Pacific whiting, plainfin midshipman, walleye pollock, capelin, sandlance, tomcod, staghorn sculpin, starry flounder, herring, rockfish, salmon, squid, octopus, and crustaceans.

Northern elephant seal

Northern elephant seals breed on islands off the coast of Mexico, in southern California (Channel Islands), and in central California. During the non-breeding season, they range as far north as the Gulf of Alaska and Aleutian Islands (Condit and Le Boeuf 1984, DeLong and Stewart 1991, Reeves et al. 1992). The majority of the northern elephant seal population breeds in the southern California offshore region. Adult males and females make two foraging migrations each year to separate areas of the north Pacific with males traveling to the Gulf of Alaska and along the Aleutian Islands and females visiting areas farther south offshore of Washington and Oregon (Stewart and DeLong 1990).

The world population of northern elephant seals has been estimated at just over 100,000 in 1991 (Reeves et al. 1992, Stewart and Huber 1993). Total pups born at California rookeries in that year exceeded 21,000, 85% of which were born on San Nicolas and San Miguel Islands (Barlow et al. 1993b). Cooper and Stewart (1983) estimated growth of northern elephant seal populations at 14-53% percent annually, averaging 14.5% across the rookeries surveyed in California from approximately 1960 through 1980. They estimated the Mexican populations grew at 8.3% annually from 1965-1977.

In general, elephant seals are rarely seen at sea. Elephant seals were more often seen inshore in the spring as compared to the rest of the year when they were widely scattered off southern California (Bonnell et al. 1980). They were consistently observed in the vicinity of Santa Monica Bay and the San Clemente Escarpment especially during the winter and spring.

Northern elephant seals primarily eat vertically migrating epi- and meso-pelagic squid, in addition to Pacific whiting, cusk-eels, rockfish, sharks, rays, and ratfish (Condit and Le Boeuf 1984, DeLong and Stewart 1991, Sinclair 1994). Recent data on adult males and females show they feed in deep waters seaward of the continental slope (Le Boeuf et al. 1985, 1986, Reeves et al. 1992).

Northern fur seal

Northern fur seals breed on Robben Island, Japan, the Kuril and Commander

Islands, Russia, the Pribilof Islands and Bogoslof Island, Alaska, and San Miguel Island, California. Females and juveniles from the primary breeding grounds in Alaska migrate south along the west coast of the United States after the summer breeding season to areas off the coast of British Columbia, Washington, Oregon, and California.

The population of northern fur seals in the Pribilofs is presently estimated at 982,000 (Loughlin et al., In prep.) with an additional 1771 pups on San Miguel Island in 1990 (DeLong and Melin 1992). Declines in the population of this species in the last 30 years have been attributed to the long-term effects of a kill of young females in the 1950s and 1960s (York and Hartley 1981) and to entanglement in discarded pieces of nets (Fowler 1982).

Off southern California, this species is found primarily along the Santa Rosa Cortes Ridge and near the Tanner Bank (Bonnell et al. 1980). Northern fur seals radio-tagged in the summer on San Miguel Island, the sole breeding ground in California, foraged northwest of the island in oceanic waters over the continental slope (Antonelis et al. 1990).

The population on San Miguel Island grew rapidly between 1969 and 1978 with 34% and 46% increases in pups born at Castle Rock and Adams Cove, respectively. There has been no evidence of a decline in this population apart from a drop following the 1982-83 El Niño (DeLong and Antonelis 1991).

In the winter and spring, large numbers of fur seals, primarily migrants from the Bering Sea populations feed along the California coast beyond the edge of the continental shelf (Fiscus and Kajimura 1969, Bonnell et al. 1980). Off California, primary prey were anchovy, whiting, saury, rockfish, and jack mackerel (Kajimura 1984).

Sea otters

The historic range of the sea otter encompassed the temperate coastal waters of the North Pacific Rim from northern Japan around to California. Now only small scattered groups occur in Russia, the Aleutian Islands, the Alaska Peninsula, the Kodiak Archipelago, Prince William Sound, and California (Hoover 1988). Otters are capable of traveling long distances, and have occasionally been seen off southern California. Sea otter home ranges consist of heavily used areas connected by travel corridors (Riedman and Estes 1990). Occasionally otters have been seen as far south as Baja California including individuals sighted around the Channel Islands, in Santa Monica Bay, and Los Angeles Harbor (Leatherwood et al. 1978).

The diet of the sea otter varies considerably among individuals and in California consists mainly of abalone, red sea urchins, and rock crabs (Riedman and Estes 1990). Otters in this region also consume kelp crabs, various species of clams, turban snails, mussels, octopus, sea stars, fat innkeeper worms, chitons, and seabirds (Estes et al. 1981, Riedman and Estes 1990).

Recent (1989) counts showed 1,864 otters in central and northern California

(Jameson and Estes unpubl. data in Riedman and Estes 1990) and an additional 22 on San Nicolas Island (Rathbun et al. 1989).

Potential Effects of Seismic Surveys on Marine Mammals

Seismic surveys are conducted to obtain information about rock formations that are several thousands of feet deep. These surveys are accomplished by transmitting sound waves into the earth, which are reflected off subsurface formations and recorded with detectors in the water column. A typical marine seismic source is an airgun array, which releases compressed air into the water creating an acoustical energy pulse that is directed downwards toward the seabed. Hydrophones spaced along a streamer just below the surface of the water receive the reflected energy from the subsurface formations and transmit data to the seismic vessel. Onboard the vessel, the signals are amplified, digitized, and recorded on magnetic tape.

Disturbance by seismic noise is the principal means of taking marine mammals by this activity. Vessel noise may provide a secondary source. Also, the physical presence of vessel(s) could also lead to some non-acoustic effects involving visual or other cues. Depending upon ambient conditions and the sensitivity of the receptor, underwater sounds produced by open-water seismic operations may be detectable a substantial distance away from the activity. Any sound that is detectable is (at least in theory) capable of eliciting a disturbance reaction by a marine mammal or of masking a signal of comparable frequency. An incidental harassment take is presumed to occur when marine mammals in the vicinity of the seismic source (or vessel) react to the generated sounds or visual cues.

Seismic pulses are known to cause some species of whales, including gray and bowhead whales, to behaviorally respond within a distance of several kilometers (Richardson et al. 1995). Although some limited masking of low-frequency sounds is a possibility for those species of whales using low frequencies for communication, the intermittent nature of seismic source pulses will limit the extent of masking. Bowhead whales, for example, are known to continue calling in the presence of seismic survey sounds, and their calls can be heard between seismic pulses (Richardson et al. 1986).

When the received levels of noise exceed some behavioral reaction threshold, cetaceans will show disturbance reactions. The levels, frequencies, and types of noise that will elicit a response vary between and within species, individuals, locations and season. Behavioral changes may be subtle alterations in surface-dive-respiration cycles. More conspicuous responses, include changes in activity or aerial displays, movement away from the sound source, or complete avoidance of the area. The reaction threshold and degree of response are related to the activity of the animal at the time of the disturbance. Whales engaged in active behaviors such as feeding, socializing or mating are less likely than resting animals to show overt behavioral reactions, unless the disturbance is directly threatening. Hearing damage is not expected to occur during the project. While it is not known whether a marine mammal very close to an airgun array would be at risk of temporary or permanent hearing impairment, temporary threshold shift (TTS) is a theoretical possibility for animals within a few hundred meters (Richardson et al. 1995). However, planned monitoring and mitigation measures (described below) are designed to detect marine mammals occurring near the seismic array and to avoid, to the greatest extent practicable, exposing them to sound pulses that have any possibility of causing hearing damage.

Estimated Number of Marine Mammals that Might be Incidentally Harassed

Table 1 gives our estimate of the number of marine mammals that might be incidentally harassed during the 1999 survey. In 1998 the USGS conducted a survey using a GI-gun off southern California, under the supervision of marine-mammal biologists. The righthand column in Table 1 gives the numbers of marine mammals that were observed during this survey. The estimated mammal populations (Calambokidis and Francis, 1994) are also shown in Table 1. Our estimate of the number of marine mammals that might be harassed is based on the population of each mammal type, on its distribution relative to the nearshore survey area, and on the number of individuals that were observed during the 1998 season.

Proposed Mitigation of Potential Environmental Impact

The USGS's proposed mitigation to reduce the potential for marine-mammal harassment includes:

(1) The survey is scheduled for May and June, when Gray whales are not migrating.

(2) To avoid potential Level A harassment of, or injury to, marine mammals, safety zones will be established and monitored continuously (during daylight hours). Whenever the seismic vessel approaches a marine mammal closer than the distance mentioned below and described in more detail in both the application and the draft EA, the USGS will shut off airguns.

(3) For gray, fin, blue and humpback whales, the marine mammal species near the survey area that are considered to be most sensitive to the frequency and intensity of sound that will be emitted by the airgun array, airgun operations will cease when members of these species approach within 100 m of the seismic vessel.

(4) For odontocetes, with their lower sensitivity to low frequency sound, airgun operations will cease when these animals approach a safety zone of 50 m.

(5) For pinnipeds (seals and sealions), if the seismic vessel approaches a pinniped, a safety radius of 50 m will be maintained from the animal(s). However, if a pinniped approaches the towed airgun array, the USGS will not be required to shutdown the airguns. Experience indicates that pinnipeds will come from great distances to scrutinize seismic operations. Seals have been ob-

Table 1

Species of Marine Mammal	Estimated Population (Calambokidis and Francis, 1994)	Notes	Number That May be Incidentally Harassed	Number Sighted During the 1998 Survey
Bottlenose dolphin	2,340	1	100	
Common dolphin	250,000	1	4,000-6,000	3,981
Killer whales	307	2	5	
Pacific white-sided dolphin	103,734	2	100	
Northern right-whale dolphin	17,118	2	100	
Risso's dolphin	10,000	2	100	8
Unidentified dolphin				2,159
Pilot whale		3	0	
Dall's porpoise	78,422	2	100	
Unidentified porpoise				5
Cuvier's beaked whale				1
Sperm whale	756	2	0	
Gray whale	20,000	4	0	
Humpback whale	581	5	0	
Blue whale	1,000-2,000	2	0	3
Minke whale	71-659	2	10	4
Fin whale	935	6	0	
Unidentified whale				1
California sea lion	111,000	7	200	146
Northern sea lion	2,000	2	50	
Harbor seal	23,000	2	200	
Northern elephant seal	100,000	8	100	
Northern fur seal	980,000	9	100	2
Unidentified pinniped				2
Sea otter	1,864	10	10	

Notes on population estimates:
1. off southern California
2. off all of California
3. population peaks in winter, rare at other times
4. December-March migrations, mainly west of the Channel Islands
5. June-July population peak in the Santa Barbara Channel
6. in all of offshore California, mainly west of the Channel Islands
7. mainly in the Channel Islands
8. worldwide population
9. Pribilof Islands, Alaska
10. mainly off of central and northern California

served swimming within airgun bubbles, 10 m (33 ft) away from active arrays and, more recently, Canadian scientists, who were using a high-frequency seismic system that produced sound closer to pinniped hearing than will the USGS airgun array, describe how seals frequently approached close to the seismic source, presumably out of curiosity. Therefore, because pinnipeds indicate no reaction to seismic noise, the above-mentioned mitigation plan has been proposed. Instead, the USGS will gather information on how often pinnipeds approach the airgun array on their own volition, and what effect the airguns appear to have on them.

(6) During seismic survey operations, the ship's speed will be 4 to 5 knots so that when the airguns are being discharged, nearby marine mammals will have gradual warning of the ship's approach and can move away.

(7) The USGS plans to have marine biologists onboard the seismic vessel who will have the authority to stop airgun operations when a mammal enters the safety zone. These observers will monitor the safety zone to ensure no marine mammals enter the zone, and record observations on marine mammal abundance and behavior.

(8) Emergency shut-down. If observations are made that one or more marine mammals of any species are attempting to beach themselves when the seismic source is operating in the vicinity of the beaching, the airgun array will be immediately shut off and NMFS contacted.

(9) Upon notification by a local stranding network that a marine mammal has been found dead where the airgun had recently been operated, NMFS will investigate the stranding to determine whether a reasonable chance exists that the airgun survey caused the animal's death. If NMFS determines, based upon a necropsy of the animal(s), that the death was likely due to the seismic source, the survey must cease until procedures are altered to eliminate the potential for future deaths

Monitoring Airgun Use

Monitoring of marine mammals while the airguns are active will be conducted 24 hours each day. Two trained, marine-mammal observers will be onboard the seismic vessel to mitigate the potential environmental impact from airgun use and to gather data on the species, number and reaction of marine mammals to the airgun. Each observer will work 6 hours during daylight and 6 hours at night. During daylight, observers will use Tasco 7x50 binoculars with internal compasses and reticules to record the horizontal and vertical angle to sighted mammals. Nighttime operations will be conducted with a commercial handheld light magnification scope.

Monitoring data to be recorded during airgun operations include which observer is on duty and what the weather conditions are like, such as Beaufort Sea state, wind speed, cloud cover, swell height, precipitation and visibility. For each mammal sighting the observer will record the time, bearing and reticule readings, species, group size, and the animal's surface behavior and orientation.

Observers will instruct geologists to shut off the airgun array whenever a marine mammal enters a safety zone.

Potential Effect on Habitat

No impact on the habitat or food sources of marine mammals is likely from using this small GI gun for the short period of the survey.

Possible Modifications or Alternatives to the Proposed Survey

The instructions for this permit request stipulate that we consider alternatives to the proposed experiment. Options to change the activity are limited but we might conduct it in some other way, such as with a low-powered source or in a different season.

To abandon this study altogether is a poor option. In the introductory section of this application we described the societal relevance of this project, that it would help scientists understand the regional earthquake hazard and aid city planners in establishing building codes. Another facet of this study is understanding coastal aquifers and how to stem the intrusion of salt water into them. If the project were canceled, such information would be unavailable.

The source strength might be reduced to limit the environmental impact. However, the proposed airgun is already small, and the problem with this option is that we cannot significantly reduce the source strength without jeopardizing the success of this survey. This judgment is based on our decades-long experience with seismic-reflection surveys but especially on the 1998 survey that was conducted in the same general area as outlined herein. If we were to reduce the airgun size and then fail to obtain the required information, then another survey would need to be conducted, and this would double the potential impact on marine mammals.

This project could be carried out at some other time of year, and we are open to suggestions. However, we talked with biologists to find out the best time for the project to be conducted. We want to avoid the gray whale migrations and the mid-summer arrival of other mysticete species. These other species remain mostly in the area of the Channel Islands, but some individuals venture closer to the mainland. An important point is that biologists can best prevent harm to mammals when daylight is long, such as near the solstice.

Reporting

The USGS will provide an initial report to NMFS within 160 days of the completion of the 1999 phase of the marine seismic project. This report will provide dates and locations of seismic operations, details of marine mammal sightings, and estimates of the amount and nature of all takes by harassment. A final technical report will be provided by USGS within 1 year of completion of the 1999 phase of the marine seismic project. The final technical report will contain a description of the methods, results, and interpretation of all monitoring tasks.

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Certification and Signature:

We hereby certify that the foregoing information is complete, true, and correct to the best of my knowledge and belief. We understand that this information is submitted for the purpose of obtaining a permit under one or more of the following statutes and the regulations promulgated there under, as indicated in Section I. of this application:

The Endangered Species Act of 1973 (16 U.S.C. 1531-1543) and regulations (50 CFR 222.23(b)); and / or The Marine Mammal Protection Act of 1972 (16 U.S.C. 1361-1407) and regulations (50 CFR Part 216); and / or The Fur Seal Act of 1966 (16 U.S.C. 1151-1175).

We also understand that any false statement may subject us to the criminal penalties of 18 U.S.C. 1001, or to penalties provided under the Endangered Species Act of 1973, the Marine Mammal Protection Act of 1972, or the Fur Seal Act of 1966, whichever are applicable.

Wm R. Normark Date 14 JANUARY 1999

William R. Normark

Research Geologist

Michael A. Fisher Date 1/14/99

Michael A. Fisher

Research Geophysicist