PAPER

Seabird and Dolphin Mortality Associated with Underwater Detonation Exercises

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ABSTRACT

We report the details of two wildlife mortality events that were associated with underwater detonations. The detonations occurred as part of military training activities at Silver Strand Training Complex in San Diego, California. In March 2006, an underwater detonation resulted in 70 western grebes (*Aechmophorus occidentalis*) being killed by subsequent sequential detonations in the same training exercise. Ten of the 70 western grebes impacted were necropsied, verifying cause of death as primary blast injury. In March 2011, a time-delayed underwater detonation resulted in the death of three or possibly four long-beaked common dolphins (*Delphinus capensis*). While these blast events were unlikely to impact these species on a population level, underwater detonations do have the potential for population-level impacts on wildlife. Both events were accidental mortalities and the first ever documented from Navy underwater detonation training in Hawaii, Southern California, and along the U.S. East Coast. The Navy updated its underwater explosive mitigation measures after each of these mortality events to limit the potential of future mortalities by requiring sequential detonations to occur either less than 5 s or more than 30 min apart and by suspending time-delayed detonation training exercises until more robust precautionary measures can be developed.

Keywords: barotrauma, marine mammal, Navy, seabird, underwater explosion

Introduction

Both intentional and accidental mortality of wild marine mammals and birds in association with underwater explosions have been documented in several studies. Anderson et al. (1954) provided details of the dynamite depth charges that were routinely used in Alaska in the 1950s to control the harbor seal (*Phoca vitulina*) population during the salmon fishing season. Hi-Velocity Gelatin Powder (60%) in 11.3-kg packages set at mid-depth in waters 11-m deep was found to kill harbor seals within a 45.7-m radius. This method proved so effective that an estimated 19,000 harbor seals were killed between 1951 and 1954. More recently, Knudsen and Oen (2003) reported on blast-induced neurotrauma in minke whales (*Balaenoptera acutorostrata*) during directed kills using 30-g penthrite grenades detonated 60-70 cm inside an animal. Experimentally, sea otters (*Enhydra lutra*) and mallard ducks (*Anas platyrhynchos*) were found to be mortally impacted by underwater overpressure of 300 psi during underwater detonations of pentolite or trinitrotoluene (TNT) charges (<3.6 kg), respectively (Wright, 1971; Yelverton et al., 1973).

Fitch and Young (1948) noted the accidental deaths of California sea lions (*Zalophus californianus*), cormorants (*Phalacrocorax* spp.), and California brown pelicans (*Pelicanus occidentalis*) during explosive seismic operations in California that used 4.5-72.6 kg charge weights. Mortality in cormorants and brown pelicans only occurred when their body or head was submerged underwater. Ketten et al. (1993) described damage to the ear bones of two humpback whales (*Megaptera novaeangliae*) that died following a 5000-kg charge detonation.

Previous reports of accidental marine mammal and bird deaths in association with explosions have provided very little detail of the circumstances surrounding these events. Here we report the details of accidental deaths of western grebes (*Aechmophorus occidentalis*) and long-beaked common dolphins (*Delphinus capensis*) associated with two underwater detonation training events in the Silver Strand Training Complex (SSTC) in San Diego, California.

Background

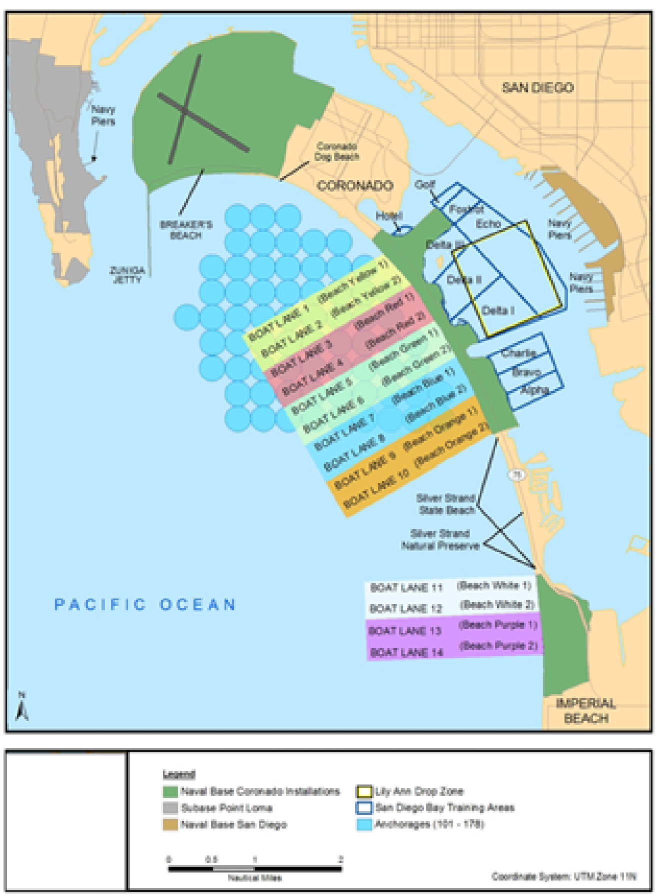
The SSTC is an area used by The U.S. Department of the Navy (hereinafter referred to as the Navy) for amphibious, special warfare, and mine countermeasure training activities. It is located on and adjacent to the Silver Strand, a narrow isthmus that separates San Diego Bay from the Pacific Ocean in San Diego, California (Figure 1). During training activities, approximately 255 underwater detonations are set in this area per year. The Navy has proposed increasing the number of detonations per year by 87% (U.S. Department of the Navy (DoN), 2011). However, the actual number of detonations varies from year to year.

Navy Explosive Ordnance Detachments (EOD) and other Navy underwater detonation training use military grade C4 explosive, which contains 91% cyclotrimethylene trinitramine (RDX), 5.3% dioctyl sebacate or adipate (DOS or DOA), 2.1% polyisobutylene (PIB), and 1.6% oil (Reardon & Bender, 2005). Nitrogen, carbon dioxide, water, carbon monoxide, and trace amounts of organic compounds are the byproducts of these explosions and are thus not thought to affect water quality or marine wildlife (DoN, 2011). C4 comes in standard 0.57-kg blocks that can be combined to produce explosive charges of increased weight. Either a timed fuze or command detonation fuze is used to allow an EOD diver time to move away from a set charge. Time-delayed detonation training is needed to ensure safe and effective use of these materials in a non-permissive environment in which a diver would need to place a charge and swim away undetected prior to detonation.

At the SSTC, underwater detonations occur in designated boat lanes that extend 1.97-nm seaward (Figure 1). A mitigation zone of 640 m is established around a detonation device. From a boat, two EOD observers scan the mitigation zone for marine mammals, birds, and sea turtles for at least 30 min before and after a detonation exercise. If wildlife is seen within or moving towards the mitigation zone during this time, the detonation is suspended until the area is clear of wildlife for a minimum of 30 min for marine mammals or sea turtles and 10 min for birds (DoN, 2011).

FIGURE 1

Silver Strand Training Complex (DoN, 2011). Boat lane colors reflect beach locales at the end of the boat lanes and are not relevant to this study.



Birds

Underwater detonations are more likely to impact diving birds such as loons, cormorants, grebes, auks, murres, and sea ducks because of the time that these birds spend under water. Birds at the sea surface are less vulnerable to underwater detonations because the impulse of the blast is attenuated at the water's surface, allowing them to survive impulse levels approximately three times greater than submerged birds can survive (Yelverton et al., 1973).

Pursuit divers, who remain at depth for longer periods of time, are at greater risk than surface feeders or plunge divers. Common pursuit diving seabirds in San Diego include the western grebe, Brandt's cormorant (*Phalacrocorax penicillatus*), and the double-crested cormorant (*Phalacrocorax auritus*) (Unitt, 2004). It is important to note that migrating birds often occur in large flocks when transiting through the area (e.g., loons, shearwaters) and could be impacted if a detonation coincided with their occurrence in the area.

Although many birds are protected under the Migratory Bird Treaty Act (MBTA), the 2003 National Defense Authorization Act exempts the Armed Forces from these regulations during military readiness activities, such as underwater detonation training exercises. However, birds listed under the Endangered Species Act (ESA) are not exempt. For the SSTC, the Navy has implemented protective measures for three federally listed birds, the least tern (*Sternula antillarum*), snowy plover (*Charadrius alexandrinus*), and light-footed clapper rail (*Rallus longirostris*) (DoN, 2011). Xantus' murrelet (*Synthliboramphus hypoleucus*) is a pursuit diver and a candidate ESA species, which are causes for concern in relation to underwater explosions at SSTC. Although the ocean off San Diego is central to this species' range, it is uncommon in San Diego (Unitt, 2004) and not included in the SSTC mitigation plan. Underwater detonations are delayed or moved if birds are sighted, regardless of MBTA or ESA status.

Western grebes are found year-round in San Diego Bay, breeding in local lakes and lagoons. They are most abundant within a couple of miles from shore, from Point Loma to Imperial Beach, during the winter; migrants from the north and northeast arrive in October and depart in April (Unitt, 2004). Western grebes primarily feed on fish. However, the presence of crustaceans, polychaete worms, and bottom-dwelling fish in their diet suggests that they may at times forage along the bottom (Storer & Nuechterlein, 1992). A mean dive time of 30.4 s with a maximum of 63 s has been recorded for western grebes at a lake breeding ground, and it is presumed that longer dives are possible (Lawrence, 1950). This foraging strategy puts them at a high risk if they are feeding near underwater detonations.

Western Grebe Detonation Event

On 16 March 2006, six demolition charges of various weights were detonated on the ocean side of SSTC (Figure 1), 731 m from shore, at a depth of approximately 15 m. Although the exact weight of the charges is unknown, over 78% of detonation events at SSTC use less than 4.5 kg and none exceed 13.2 kg (DoN, 2010).

Following the first detonation, several dozen small fish were observed floating on the surface of the water, which attracted approximately 30 birds. As part of existing Navy mitigation, the divers relocated to another location approximately 91 m from the first site and detonated a second charge 10 min later. After the second detonation, more small fish and 5-10 birds were seen floating on the surface of the water in the vicinity of the second detonation. The third charge was moved another 91 m away and detonated 30 min later. Following this explosion, approximately 5-10 white-bellied birds were observed on the surface of the water in the vicinity of the new detonation site. The fourth, fifth and sixth detonations were also relocated 91 m from the previous sites. No fish or birds were observed on the surface of the water following the final three underwater explosions.

Following the training exercise described above, 70 dead western grebes were found within a 1-mile stretch of Silver Strand State Beach, which is a public beach between SSTC-North and SSTC-South (Figure 1). Ten of these specimens were collected and necropsied. Abundant coagulated blood within the oral cavity and coelom, hepatic capsule rupture, and severe pulmonary hemorrhage were present in the examined birds. Six birds examined had more extensive hepatic damage with liver fractures extending through the parenchyma and cardiac and renal hemorrhage. Primary blast trauma was determined to be the cause of death (Gurfield & St. Leger, 2006). The esophagus and ventriculus of three birds contained recently ingested top smelt (*Antherinops affinis*). However, there was no indication of tissue damage or parenchymal hemorrhage in the ingested top smelt that were examined, indicating that these fish were likely consumed at shallow depths while alive. Although the fish kill may have initially attracted birds to the area, there is no evidence to indicate that the grebes were feeding on the dead fish.

The injuries sustained by the western grebes at SSTC were similar to those reported by Yelverton et al. (1973) when they examined immersed ducks subjected to underwater blasts. All of the ducks necropsied in that study had pulmonary hemorrhage, ruptured livers, and ruptured kidneys. A subset of the 20 expired ducks in the Yelverton et al. (1973) study sustained injuries not found in our study, which included coronary air embolism (35%), ruptured air sacs (65%) and ruptured ear drums (75%). The mortality threshold for immersed birds and birds at the surface in that study was determined to be 36 and 100-120 psi ms, respectively.

There is insufficient information available on western grebes to determine if the deaths of 70 individuals would have an impact on the population. Although the population appears stable (Sauer et al., 2011), breeding colonies are typically small. In San Diego County, breeding colonies range from 12 to 400 individuals (Unitt, 2004), and breeding colonies elsewhere in California and Oregon are similarly small ($\bar{x}$ = 121.4, range: 2–462) (Konter, 2011). In this context, the SSTC blast could have decimated a local breeding colony of this population.

Dolphins

Only two cetacean species were originally considered by the Navy to occur regularly in the ocean area of SSTC (<3 nm of shore): the transient California gray whale (*Eschrictius robustus*) and the coastal population of the common bottlenose dolphin (*Tursiops truncatus*) (DoN, 2011). The California gray whale population is comprised of approximately 22,000 individuals (Punt & Wade, 2010), and a portion of the population can be seen passing within 0.5 nm of the San Diego shoreline from December to March (Hanson & Defran, 1993) during its migration. Other parts of the gray whale population migrate to and from Baja Mexico using offshore waters. There is little sighting information for gray whales within the SSTC, which appears to be slightly east of the typical southbound gray whale migration corridor (Sumich & Show, 2011). Two populations of common bottlenose dolphin are found off California: coastal and offshore. The coastal population consists approximately 450-500 individuals (Carretta et al., 2011a, 2011b; Dudzik et al., 2006) that typically travel in schools of approximately 20 individuals (Defran & Weller, 1999) and are present year-round within 0.5 nm of shore (Defran & Weller, 1999). Common dolphins (*Delphinus* spp.) were considered 'rare' within SSTC (DoN, 2011). The limited available data from coarse-scale ship surveys (>2 nm offshore) (Barlow & Forney, 2007) and fine-scale aerial surveys (<1.2 nm of shore) (Merkel & Associates, Inc., 2008) that were used for this determination did not provide sufficient coverage of SSTC waters to adequately describe cetaceans in this area. Sighting data from the coastal population of common bottlenose dolphin surveys conducted between 2008 and 2010 confirm coastal sightings of common dolphins, Risso's dolphins and Pacific white-side dolphins along the northern San Diego coast (Campbell et al., 2010a, 2010b).

Data from stranded animals can be used to complement our understanding of near-shore cetacean species that may be found in the SSTC. Using data from Danil et al. (2010) together with data collected in 2009 and 2010, we calculated the 10-year average of all cetacean species that have stranded in the area bounded by the San Diego Bay entrance and the Mexican border, within which the SSTC is found. Long-beaked common dolphins (*D. capensis*) are the most frequently stranded species in this area, followed by common bottlenose dolphins (Table 1). The majority of common bottlenose dolphins stranded in San Diego belong to the coastal population (74% coastal and 26% unknown) (Danil et al., 2010). Although gray whale strandings in SSTC are rare, they are frequently observed by whale watching boats offshore of SSTC from December to March during the whales' migration period. This difference highlights the value of combining knowledge about cetacean habitat use patterns, survey data and stranding records, and of considering the pros and cons of each information source to create a list of species likely to be impacted.

TABLE 1

Average number of cetacean strandings per year that occurred between San Diego Bay and the Mexican border between 2001 and 2010.

Common Name	Average per Year
Long-beaked common dolphin	3.5
Bottlenose dolphin	1.7
Pacific white-sided dolphin	0.3
Short-beaked common dolphin	0.3
Harbor porpoise	0.2
Cuvier's beaked whale	0.1
Gray whale	0.1
Northern right whale dolphin	0.1
Pygmy sperm whale	0.1
Short-finned pilot whale	0.1

On average, long-beaked common dolphin schools are composed of 375 individuals (Carretta et al., 2011a) that are typically found within 50 nm of the southern California shore line (Carretta et al., 2011b) and have been observed as close as 1.8 nm to shore in the Southern California Bight (SWFSC, unpublished data). Because sighting data are collected from large ships that generally operate >2 nm offshore, the use of the near-shore environment by long-beaked common dolphins is poorly known. The frequency of strandings recorded for this species suggests they use the near-shore environment more regularly than the shipboard sighting data suggest, particularly from March to July (Danil et al., 2010).

Potential biological removal (PBR) is the maximum number of animals that can be removed from a population through non-natural means and still maintain an optimum sustainable population (Marine Mammal Protection Act, 1994, Amendments). A PBR is calculated for each recognized population of a species. Only one population of long-beaked common dolphin is recognized in California waters; analyses to verify this assumption are underway (S. Chivers, personal communication). If multiple populations are found, estimates of abundance and PBR will be revised. Currently, the PBR for long-beaked common dolphins is 164 (Carretta et al., 2011b).

In 2009, a fine-scale survey was conducted off the west coast of California and Baja California, Mexico. One of the primary objectives of this survey was to estimate abundance of long-beaked common dolphins. Sightings made during this survey documented the coastal nature of this species (Figure 2 in Chivers et al., 2010) and the limited ability of the regularly conducted coarse-scale surveys off California to capture the distribution of long-beaked common dolphins (e.g., ≤7 sightings/survey) (Barlow & Forney, 2007). The abundance estimated for long-beaked common dolphins off California in 2009 was 118,207 (CV = 33%), which is much higher than any previous estimate (Carretta et al., 2011a).

Long-beaked Common Dolphin Detonation Event

On 4 March 2011, mine countermeasure training was conducted on the ocean side of SSTC (Figure 1). A single time-delayed C4 block demolition charge with a total net explosive weight of 3.97 kg (3.4 kg block + 0.57 kg detonation cord) was detonated on the sandy ocean floor at a depth of 14.6 m, in boat lane 10 (Figure 1), approximately 0.5-0.75 nm from shore. At 5 min prior to the detonation, a group of 100-150 long-beaked common dolphins was observed entering the 640-m mitigation zone by EOD safety observers. Options to retrieve the charge via divers or from the surface to stop the detonation were considered. However, the short time interval to detonation made this too risky for personnel. An effort to discourage the dolphins from entering the area by placing a boat between the detonation site and the school of dolphins was unsuccessful. One minute after the detonation, three dolphins were observed motionless at the surface. The rest of the school continued to travel in the same direction as it had been prior to the detonation. The Navy recovered the three animals and transferred them to the local stranding network for necropsy. An additional long-beaked common dolphin stranded dead approximately 68 km north of the detonation site, 3 days later. All four dolphins sustained typical mammalian primary blast injuries (Phillips & Zajtchuk, 1991), which will be described in a future publication.

The distances from various types of underwater detonations at which death, injury, and temporary hearing loss (called a temporary threshold shift, TTS) are expected to occur in marine mammals have been estimated by the Navy and are termed the Zone of Influence (ZOI) (DoN, 2010). The ZOI for the specific charge weight of 3.4 kg has not been empirically modeled, and so the ZOI for the next closest charge weight (4.5 kg) for a bottom detonation was used (DoN, 2010). Based on these estimates (Table 2), the dolphins killed would have been within 36.6 m of the blast.

The observed mortality does not exceed the current PBR of 164 for this population, indicating that the blast event alone will not adversely affect the long-beaked common dolphin population. However, had four common bottlenose dolphins belonging to the coastal population been killed in the blast, a population effect would be expected, because the PBR for this population is 2.4 (Carretta et al., 2011a, 2011b). The coastal common bottlenose dolphin is common in the waters off San Diego (Defran & Weller, 1999) and found within 500 m of the shoreline 99% of the time (Hanson & Defran, 1993). The small size of this population and its occurrence in the very near-shore waters of San Diego make this population of critical concern in relation to underwater detonation activities occurring in the region. To date, however, there has not been any documented mortality of this species from Navy training activities.

TABLE 2

Estimated ZOI for 4.5-kg C4 explosive detonated on a sandy-silt bottom of 7.3-22 m in depth (DoN, 2010).

Impact	ZOI (m)
Mortality (30.5 psi ms)	36.6
50% Tympanic membrane rupture	73.2
Onset of slight lung injury	146.3
TTS (182 dB re 1μPa^2 s)	219.5
TTS (23 psi)	329.2

Summary

The fish, western grebe, and long-beaked common dolphin deaths reported here demonstrate the impact of underwater detonations on wildlife. An unknown number of individuals in these events likely sustained injuries that may or may not have impacted their ability to survive their exposure to the blasts. While these two species were examined and thus are known to have been affected, other species were also affected. Top smelt associated with the grebe incident were seen floating after detonation. However, none were collected for necropsy examination. The only fish available for investigation were consumed by the grebes. This abundance of marine fauna in areas of detonation makes mortality events in multiple species a possibility. Additionally, while deaths are sustained by individuals, the population level impacts need to be carefully considered. Our review of the information available for the wildlife species impacted in these events illustrate the need to carefully consider what species might be impacted and to review multiple data sources in making the determination. Insufficient information about western grebes limits an assessment of the impact on their population, but the 2006 mortality event had the potential to severely impact a breeding colony. The best available information on long-beaked common dolphins suggests a population-level impact would not be expected from this single event alone.

The occurrence of two wildlife mortality events in the past 6 years at SSTC coupled with the proposed increase in underwater detonations suggests that periodic events could occur in the future. In order to reduce the chances of this occurring, the Navy reviewed and amended their mitigation procedures for underwater detonation training exercises following the 2006 and 2011 mortality events (Chip Johnson, personal communication). The events revealed three important points to consider in establishing mitigation procedures: (1) the need to carefully consider the species likely to be present in an area, (2) the difficulty of mitigating impacts during time-delayed detonation training exercises, and (3) the potential for sequential detonations to have multiple impacts on wildlife. In response to these observations, the Navy took a proactive approach and revised their standing mitigation procedures (C. Johnson, personal communication). The changes implemented included (1) adding long-beaked common dolphins, short-beaked common dolphins (*D. delphis*), Pacific white-side dolphins (*Lagenorhyncus obliquidens*), and Risso's dolphins (*Grampus griseus*) to their list of species that may inhabit the SSTC, (2) suspending time-delayed underwater detonations off the U.S. West Coast, U.S East Coast, and Hawaii pending development of new mitigation measures with National Marine Fisheries Service approval, and (3) implementing time interval restrictions (<5 s or >30 min apart) on sequential detonations. These measures will further reduce risk to wildlife and heighten awareness of species likely impacted.

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References

Anderson, C., Rothwell, I.H., Bell, K., Denny, H., Kallenberg, R.C., & Wakefield, J.H. 1954. Annual Report for 1954. Juneau: Alaska Department of Fisheries. 92 pp.

Barlow, J., & Forney, K.A. 2007. Abundance and population density of cetaceans in the California Current ecosystem. Fish Bull. 105:509-26.

Campbell, G.S., Weller, D.W., & Hildebrand, J.A. 2010a. SIO small boat based marine mammal surveys in Southern California: Report of Results for August 2009–July 2010, 35 pp.

Campbell, G.S., Weller, D.W., & Hildebrand, J.A. 2010b. SIO small vessel marine mammal surveys in Southern California: Report of Results for June 2008–May 2009, 20 pp.

Carretta, J.V., Chivers, S.J., & Perryman, W.L. 2011a. Abundance of the long-beaked common dolphin (*Delphinus capensis*) in California and western Baja California waters estimated from a 2009 ship-based line-transect survey. Bull Southern Calif Acad Sci. In press.

Carretta, J.V., Forney, K.A., Oleson, E., Martien, K., Muto, M.M., Lowry, M.S., … Hill, M.C. 2011b. U.S. Pacific Marine Mammal Stock Assessments: 2010. NOAA Technical Memorandum NMFS-SWFSC-476, U.S. Department of Commerce, 334 pp.

Chivers, S.J., Perryman, W.L., Kellar, N.M., Carretta, J.V., Archer, F.I., Redfern, J.V., … Ballance, L.T. 2010. Ecosystem Survey of *Delphinus* Species Cruise Report. NOAA Technical Memorandum NOAA-TM-NMFS-SWFSC-464, U.S. Department of Commerce, 53 pp.

Danil, K., Chivers, S.J., Henshaw, M.D., Thieleking, J.L., Daniels, R., & St. Leger, J.A. 2010. Cetacean strandings in San Diego County, California, USA: 1851–2008. J Cetacean Res Manag. 11:163-84.

Defran, R.H., & Weller, D.W. 1999. Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (*Tursiops truncatus*) off San Diego, California. Mar Mammal Sci. 15:366-80. http://dx.doi.org/10.1111/j.1748-7692.1999.tb00807.x.

Dudzik, K.J., Baker, K.M., & Weller, D.W. 2006. Mark-recapture abundance estimate of California coastal stock bottlenose dolphins: February 2004 to April 2005. Administrative Report No. LJ-06-02C, Southwest Fisheries Science Center, National Marine Fisheries Service, La Jolla, 15 pp.

Fitch, J., & Young, P. 1948. Use and effect of explosives in California coastal waters. Calif Fish Game. 34:53-70.

Gurfield, N., & St. Leger, J.S. 2006. Peracute mass mortality of western grebes due to underwater primary blast trauma. In: Proceedings of the American Association of Veterinary Laboratory Diagnosticians 50th Annual Conference, p. 43. Reno, NV: AAVLD.

Hanson, M.T., & Defran, R. 1993. The behavior and feeding ecology of the Pacific coast bottlenose dolphin, *Tursiops truncatus*. Aquat Mammals. 19:127-42.

Ketten, D.R., Lien, J., & Todd, S. 1993. Blast injury in humpback whale ears: Evidence and implications. J Acoust Soc Am. 94:1849-50. http://dx.doi.org/10.1121/1.407688.

Knudsen, S.K., & Oen, E.O. 2003. Blast-induced neurotrauma in whales. Neurosci Res. 46:377-86. http://dx.doi.org/10.1016/S0168-0102(03)00101-9.

Konter, A. 2011. Interbreeding of *Aechmophorus* grebes. Wilson J Ornithol. 123:132-6. http://dx.doi.org/10.1676/10-091.1.

Lawrence, G.E. 1950. The diving and feeding activity of the Western Grebe on the breeding grounds. Condor. 52:3-16. http://dx.doi.org/10.2307/1364743.

Marine Mammal Protection Act Amendments of 1994 (Public Law 103-238, April 30, 1994, 108 Stat. 532).

Merkel and Associates, Inc. 2008. Marine mammal surveys in the vicinity of the Point Loma Naval Complex, San Diego, California. Final Report. Prepared for Naval Facilities Engineering Command Southwest. Contract No. N68711-03-D-7001, DO 0039, 18 pp.

Phillips, Y.Y., & Zajtchuk, J.T. 1991. The management of primary blast injury. In: Textbook of Military Medicine. eds. Bellamy, R.F., Zajtchuk, R., 295-336. Washington, DC: Office of the Surgeon General.

Punt, A.E., & Wade, P.R. 2010. Population status of the eastern North Pacific stock of gray whales in 2009. NOAA Technical Memorandum NOAA-TM-NMFS-AFSC-207, 43 pp.

Reardon, M.R., & Bender, E.C. 2005. Differentiation of composition C-4 based on the analysis of the process oil. J Forensic Sci. 50:564-70. http://dx.doi.org/10.1520/JFS2004307.

Sauer, J.R., Hines, J.E., Fallon, J.E., Pardieck, D.J., Ziolkowski, D.J., Jr., & Link, W.A. 2011. The North American Breeding Bird Survey, Results and Analysis 1966–2009. Version 3.23.2011. Laurel, MD: USGS Patuxent Wildlife Research Center.

Storer, R.W., & Nuechterlein, G.L. 1992. Western Grebe (*Aechmophorus occidentalis*). In: The Birds of North America. ed. Poole, A. Ithaca, NY: Cornell Lab of Ornithology. http://bna.birds.cornell.edu/bna/species/026a.

Sumich, J.L., & Show, I.T. 2011. Offshore migratory corridors and aerial photogrammetric body length comparisons of southbound gray whales, *Eschrichtius robustus*, in the Southern California Bight, 1988–1990. Mar Fish Rev. 73:28-34.

Unitt, P. 2004. San Diego County Bird Atlas. San Diego, CA: San Diego Natural History Museum. 645 pp.

U.S. Department of the Navy, 2010. Incidental harassment authorization application for Navy training conducted within the Silver Strand Training Complex. Prepared by U.S. Department of the Navy. December.

U.S. Department of the Navy, 2011. Silver Strand Training Complex Environmental Impact Statement. Prepared by U.S. Department of the Navy, Naval Facilities Engineering Command, Southwest Division. January.

Wright, R. 1971. Amchitka Bioenvironmental Program. Effects of underwater overpressures on sea otters and other aquatic animals. Final Progress Report, July 1, 1967–June 30, 1969. Batelle Columbus Labs, Report No. BMI-171-130, 39 pp.

Yelverton, J.T., Richmond, Q.D.R., & Fletcher, E.R. 1973. Safe distances from underwater explosions for mammals and birds. Lovelace Foundation, Report No. DNA 3114T, 64 pp.