The Use of Seal Bombs in California Fisheries

Unknown Impacts Point to an Urgent Need for More Research

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Abstract

Commercial fishing in California is a significant source of jobs and incomes. The industry can also produce detrimental environmental impacts, including injuries to threatened and endangered marine mammals and damage to marine ecosystems. There are a host of state and federal legal and regulatory mechanisms in place to protect marine mammals and their habitat. Some of these are more effective than others, and all exist within a continually evolving political and economic landscape. Seal bombs are incendiary devices used by some fishers to deter sea lions, seals, and other mammals from fish nets and fishing grounds. Measures to allow the use of seal bombs were adopted in part to protect fishermen from mammal depredation, but there is increasing evidence that the devices are being used off the coast of California at higher levels than previously realized. The available evidence indicates that seal bombs may pose a significant risk to marine life, both due to risk of direct injury from the blasts and the large number of intense noise impulses being introduced into marine ecosystems filled with animals that depend on the natural soundscape to live and thrive. The current regulation of these devices is weak, informed by outdated and incomplete research. Further, the monitoring and enforcement of their use is minimal, and their direct consideration by seafood certification organizations is practically nonexistent. Therefore, the authors recommend that the state and federal agencies tasked with monitoring and enforcing the use of seal bombs in California immediately review their policies, and consider significant investments in seal bomb research and monitoring to ensure that they are being used according to the law and not producing significant harm to marine mammals.

I. California's Fishing Industry & the Use of Explosive Deterrents

The fishing and harvesting of marine resources has played an important role in California's history and economy. In 2016, the value of commercial fish landed in California totaled almost $200 million,[1] and in 2015, the industry supported over 122,000 jobs.[2] California's coasts host an incredibly rich assortment of marine mammals; over 34 species of pinnipeds, whales, otters, and other marine mammals can be found in Monterey Bay National Marine Sanctuary (MBNMS) alone.[3] As marine mammals such as whales, dolphins, and sea lions subsist on fish, commercial fishing activities off the coast sometimes lead to conflicts between humans and marine mammals.[4]

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In order to deter and chase pinnipeds away from fishing activity—which can damage gear, scare fish and diminish fish catch—fishermen in multiple fisheries in California use explosives such as "seal bombs" or "cracker shells".[4] Seal bombs used in California waters are firecrackers that contain approximately of 2-2.5g of explosive charge and sink and explode 1-4 meters[5] under the water's surface, producing a loud noise that can travel for kilometers underwater.[6] "Cracker shells are 12 gauge shotgun shells containing a sound and flash explosive charge that is designed to explode in the air or on the surface of the water at a distance of 75 to 100 yards from the point of discharge."[7]

Image 1: An example of a "seal bomb"

Credit: Anna Krumpel (formerly Meyer-Loebbecke)

These types of explosives are used in large numbers during times of intense fishing activity off the coast of California, with hydrophones recording a maximum of "37,500 [explosions] per month and 3,740 per day" near Catalina Island between 2005 and 2014.[8] As many as 500 blasts have been recorded in one hour during peak fishing season.[8] The blasts were found to occur primarily at night, strongly correlating with fishing activity targeting squid.[8] The hydrophone operated by the Monterey Bay Aquarium Research Institute (MBARI) in the Monterey Bay recorded over 3,000 explosions in the span of about a year, from mid-2015 to mid-2016,[9] with a maximum of almost 1,000 in a single month.[10] The hydrophone can pick up some sounds up to 500 kilometers away depending on intensity, frequency, seafloor topography, and other factors, though it is likely that these blasts are occurring within the Monterey Bay.[10]

Seal crackers are considered "high explosives" by the U.S. Bureau of Alcohol, Tobacco, Firearms, and Explosives (ATF) because they contain flash powder;[11] they can be compared to M-80s or cherry bombs.[12] As a result of misuse of these devices, in 2011 ATF began to more heavily enforce the Safe Explosives Act of 2002, mandating that those wishing to purchase seal bombs obtain a permit and clear a background check.[11] These devices have the potential to harm humans, marine mammals, other species, and the marine environment.[12] They have been shown to shatter bones of marine mammals[5] and to kill fish within the blast vicinity.[13]

Experiments done in California indicated that the use of cracker shells only deterred pinnipeds from boat activity for roughly 4 minutes, a timespan that increased to 6 minutes when combined

with acoustic harassment devices. The inadequate number of controlled scientific experiments on the use of seal bombs has made it difficult to determine their true effectiveness as a type of deterrent.[4] More data is needed on the effect of seal bombs on various marine mammals as well as on their exposure and risk.

II. Impacts on Marine Life

The impacts of seal bombs on the area's various marine mammals have yet to be clearly determined, but initial evidence points to the potential for significant risk of harm for many species. A 1989 study done by the National Oceanic and Atmospheric Administration (NOAA) Southwest Fisheries Science Center indicated that one of the many types of seal bombs (albeit larger than the majority of bombs currently used in California) detonated within half a meter of a dolphin carcass can shatter its bones and is likely to cause moderate to severe injury within that distance.[5] This is concerning given that these devices are only effective as seal deterrents when detonated near the offending pinnipeds.[4] Scientific research on seal bombs has been lacking in recent years, but studies examining the effects of seal bombs on marine mammals are currently underway.[9]

According to Shawn Johnson, Director of Veterinary Services at the Marine Mammal Center, whether or not a seal has been killed by the immediate or delayed effects of a seal bomb would be difficult to determine once a carcass is found. However, over the past decade the Marine Mammal Center has recovered two sea lion carcasses displaying "evidence of intra-oral explosion, including traumatic injury to bone of maxilla and mandibles, soft tissue burns and prolapsed eye balls" (see Image 2 & 3 below), injuries that the Center believes were likely caused by seal bombs. It is important to note that it is likely that a seal that was severely injured by a seal bomb at sea would die and decompose offshore, and never be observed by Marine Mammal staff or other enforcement agencies.

Images 2 & 3: Dead sea lions recovered by Marine Mammal Center, whose deaths were likely caused by seal bombs

Credit: Shawn Johnson, Marine Mammal Center

Other marine animals such as fish can also be injured or killed by seal bombs; dead fish have been immediately observed in the vicinity of seal bomb blasts.[12] A single accidental human death has also been recorded and retrospectively studied; a swimmer was killed when a bomb—containing 3.0g of explosive charge—exploded within 0.3 meters of his body. The explosion "ruptured both eardrums, herniated brain tissue through ruptured areas in the cribriform plates, fractured cranial bones including the wings of the sphenoid and the left petrosal, and caused a 1.5-cm-deep wound above the scapula".[5]

Exploding seal bombs produce intense impulsive and broadband noise with energy at a wide range of frequencies, some of which can carry for tens of kilometers across the ocean. Researchers at the Scripps Acoustic Ecology Laboratory estimate that the bombs can be heard by whales and dolphins from up to 80 kilometers away.[6] The sound pressure levels of explosions from these devices can be detected from kilometers away; unpublished preliminary results from analyses of experiments conducted by researchers at MBARI and Scripps show that they can be higher than the 160 dB re 1 uPa received sound levels needed to initiate an avoidance response in gray whales in California's waters within a kilometer or more from the blast area.[14] As these devices are used typically in large quantities concentrated in short time periods, and across different locations, the aggregate potential for noise disturbance is an issue that warrants further research. There have been several reports of explosives driving whales away from whale-watching sites, and SCUBA divers too, have felt the impacts of seal bombs; divers in Monterey have described being driven out of the water by the noise and pressure waves from the blasts.[6]

Toothed whales are extremely sound-sensitive, and they are consequently likely to suffer adverse effects from underwater noise[14] Many types of toothed whales, including the sperm whale, killer whale, beaked whales, Pacific White-Sided dolphin, Risso's dolphin and Dall's porpoise, are found off the coast of California.[15] All species of whales are protected under the 1972 Marine Mammal Protection Act (MMPA) and many, including the gray whale, blue whale, and fin whale, are also protected under the 1973 Endangered Species Act (ESA). Whales in marine sanctuaries are also covered by the 1972 Marine Protection, Research, and Sanctuaries Act (MPRSA). Many

marine mammal species, notably large whales, rely on sound for communication, navigation, and food location and acquisition.[4] With up to tens of thousands of underwater explosions occurring during some months on California's coast, it is very possible that a number of these marine mammals are being adversely affected by the noise alone.

Over the past few years, acoustic pollution in the marine environment has become a topic of widespread concern within the marine conservation community. For example, the Natural Resources Defense Council (NRDC) has a program focused on acoustic pollution in the ocean and helped produce the Emmy Award-winning documentary, Sonic Sea, which brought the issue to the attention of the public in 2016. National and international bodies including the National Research Council of the National Academies, the International Maritime Organization, and the United Nations have also recently given extensive consideration to this issue.† Commercial shipping traffic represents the greatest contribution to acoustic ocean pollution,[16] but anthropogenic sources of noise in the marine environment also include fishing activities, recreational and commercial boats, aerial activity,[17] sonar systems for military purposes, fishing, and research, and seismic surveys for oil and gas exploration.[18]

The background noise intensity in some areas of California's marine environment that have been systematically measured has increased drastically since the mid-1960's.[16] Marine mammals use sound for feeding, "communication, individual recognition, predator avoidance, prey capture, orientation, navigation, mate selection, and mother-offspring bonding".[18] Anthropogenic noise can lead to behavior changes in marine mammals; responses vary depending on the species, sound, and source.[17] Potential effects of noise pollution on marine mammals include physical injury, temporary and permanent noise-induced hearing loss, behavioral changes such as altered migration and foraging patterns, and inability to detect important sounds like those that assist with communication, food sourcing, and navigation.[19] Acoustic pollution such as sonar testing has been linked to acute decompression sickness in marine mammals, which may lead to death through beaching.[16] Long-term, cumulative impacts are not well-known, but given the noise produced by tens of thousands of seal bombs over many months, it is likely a significant source of additional acoustic pollution in California waters.

III. Existing Regulation of Seal Bombs

Regulation of the use of seal bombs in California's commercial fishing industry is complicated. On a federal level, sale of the devices is regulated by ATF. National Marine Fisheries Service (NMFS) collaborates with the State of California and the Pacific Fishery Management Council (PFMC),[20] "one of eight regional fishery management councils established by the Magnuson Fishery Conservation and Management Act of 1976"[21] to regulate fishing activities in California's

† Some of the recent efforts to understand the effects of ocean noise on marine mammals are presented in the following documents: National Academies of Sciences, E., and Medicine (2017). Approaches to Understanding the Cumulative Effects of Stressors on Marine Mammals. Washington DC: The National Academies Press. National Research Council (NRC) (2005). Marine mammal populations and ocean noise: determining when noise causes biologically significant effects. National Acadamies Press.
Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO). (2014). Noise from commercial shipping and its adverse effects on marine life, outcome of DE 57. MEPC 66/15/17.

waters. Federally, the 1972 MPRSA, the 1972 National Marine Sanctuaries Act (NMSA), the 1972 MMPA and the 1973 ESA are applicable to the use of seal bombs off the coast of California. On a state level, the California Department of Fish and Wildlife (CDFW) manages fishing in California's state waters, and the 1970 California Endangered Species Act applies to all endangered species which may be harmed by the use of seal bombs in California.

Federal Regulation

As seal bombs are explosives, their sale is federally regulated by ATF.[22] ATF conducts "inspections of applicants for licenses or permits as explosive material manufacturers, importers, dealers, and users, as well as periodic inspections" once every three years.[23] According to Ronald J. Borg, Senior Industry Operations Investigator at ATF's San Francisco Field Division, "We do not monitor the actual usage of the materials, only its accountability."[23] ATF does not approach vessels on the water; inspections are conducted once ships are docked. Borg adds, "We can, however, conduct inspections if we had reason to suspect or reasonable cause to believe that criminal activity was or is ongoing."[23]

Following the point of sale of seal bombs, information on their use and impacts is lacking. As of November 2017, "officials with both the California and the US federal governments say they do not know how many fishermen are using explosive deterrents, or whether they're being used appropriately."[6] Impacts on marine mammals and on the marine environment are also generally unknown.[24] Fisheries monitoring on the California coast has been performed with attention to other issues, and the issue of seal bombs has been largely overlooked. In a telephone conversation with the author on Feb 23, 2018, Kristy Long at NMFS stated that there are very few fisheries observers in relation to the number of fishing vessels. According to Robert Anderson, a pinniped expert with NMFS, "It would be impossible to watch every fisherman using an explosive device. It falls on you as a fisherman to make sure you're in compliance with the law."[6]

On the guidance document issued by NMFS, potential methods fishers can use to deter Pacific harbor seals, California sea lions, and eastern U.S. stock Steller sea lions from damaging their gear and catch include "pyrotechnics (e.g., bird screamers, bangers, underwater firecrackers, cracker shells)", yet exclude methods that have "an increased likelihood of causing injury or death".[25] Due to the lack of information on the deleterious effects of seal bombs on marine mammals, it is entirely possible that they may, in fact, cause such effects. The NMFS guidance document on distinguishing serious from non-serious injury of marine mammals does not provide guidance on noise-related injuries "because NMFS scientists making injury determinations are unlikely to detect noise related injuries in live animals and because the state of science on identifying noise-related injuries in live marine mammals is still developing."[26] The document only addresses the obvious physical impacts that might be immediately visible as a result of explosives, such as "body cavity exposure" or "visible blood loss".[26]

Fishing activities in California's national marine sanctuaries are managed by the State of California, NMFS, and PFMC. Fishing in California state waters is managed by CDFW, and fishing in federal waters is managed by NMFS and PFMC.[27] The national marine sanctuaries are mandated to "protect all sanctuary resources on an ecosystem wide basis" under the MPRSA. However, in MBNMS, commercial fishing activity is "not being regulated as part of the sanctuary regime and is not included [...] as an activity subject to future regulation." In fact, Sanctuary prohibitions that

may indirectly affect fishing activities have been written to explicitly exempt [...] traditional fishing activities",[20] although it is questionable whether the use of potentially harmful explosives should be considered part of this category. The NMSA (National Maritime Safety Administration) prohibits the destruction, loss of, or injury of sanctuary resources, but also excludes fishing activity.[28]

The MMPA is a federal law protecting California sea lions, pacific harbor seals, and other marine mammals, such as cetaceans.[29] Under the MMPA, NMFS is responsible for regulating activities that could seriously injure or kill marine mammals, and the taking of a marine mammal by a member of the public is punishable by a large fine.[20] The term "taking" in this case refers to all forms of harassment, including moving, injuring, or causing the loss of a marine mammal,[20] and "harassment" refers to "any act of pursuit, torment, or annoyance" which could lead to a marine mammal being injured, disturbed or having its behavioral patterns disrupted.[29] It is allowed under the MMPA, however, for commercial fishers to deter pinnipeds from damaging their gear or catch as long as this activity does not cause marine mammal mortality or serious injury.[29] However, the injurious effects of seal bombs have not been closely studied nor monitored, despite evidence that they have the potential to cause serious injury.

In the case that marine mammals are killed or injured as a result of commercial fishing activity, the MMPA also allows their "incidental take" as long as a permit has been issued.[29] The MMPA "mandates that all commercial fisheries be classified by the level of incidental marine mammal death and serious injury"[30] Fisheries are divided into three categories based on their record of incidental death or serious injury of marine mammals.[29] These figures are reported in the annual Marine Mammal Stock Assessment Reports.[30]

Many species that are found along the California coast—including the gray whale, killer whale, sperm whale, blue whale, Guadalupe fur seal, western Steller sea lion and sea otter—are also listed under the ESA. The Pacific harbor seal, the eastern U.S. stock of Steller sea lions, and the California sea lion were removed from the list of threatened species under the ESA in 2013.[31] Responsibility for implementing the ESA is shared by NMFS and the U.S. Fish and Wildlife Service (FWS). NMFS is responsible for endangered and threatened marine mammal species with the exception of a few, including sea otters, which are managed by FWS.[32] Under the ESA, a species listed as endangered cannot be legally harassed, injured, or killed.[32] However, the ESA, like the MMPA, allows owners of commercial fishing vessels the "incidental take" of endangered or threatened species, but requires the issuance of an incidental take permit and accompanying Habitat Conservation Plan.[33]

State Regulation

On a state level, fishing in California waters is managed by CDFW. According to CDFW, the department "does not track or record use of seal bombs"[22] as they are not a type of gear.[34] According to John Urgoetz, Environmental Program Manager for the CDFW:

> *"The California Fish and Game Commission regulations implementing State statutes regarding the use of explosives in State Waters specifically exempt explosives designated by the State Fire Marshall as agricultural and wildlife fireworks (Title 14, California Code*

of Regulations, Section 225.1). The State Fire Marshall considers Seal Bombs as this type of device and they are therefore allowed as a deterrent device for use in fisheries."

From what we can gather from state officials, there is no state program in place for monitoring the use of seal bombs or assessing their frequency or impacts, nor are any efforts currently underway to bring them under greater scrutiny and/or management.

IV. Connection between Seal Bombs and Seafood Certification

Consumers who seek out seafood that has been assessed by one of the many organizations that rate seafood sustainability do so for many reasons, including ethical and health concerns and to promote local fisheries. Currently, seafood caught using seal bombs is not automatically disqualified from being certified by any of the leading certification bodies, and it difficult to determine the extent to which these bodies are assessing potential seal bomb impacts on marine ecosystems. The result is that it is possible that seal bombs are used in some of the fisheries that receive positive sustainability ratings, and that consumers who do not want to purchase seafood from fisheries where seal bombs are used cannot rely on these rating bodies.

One of the most well-known and widely utilized sustainable seafood advisory tools, the Monterey Bay Aquarium's Seafood Watch Program, assigns a color-coded sustainability score for each fishery analyzed. Organizations and companies such as Fishwise and Real Good Fish base their sustainable seafood recommendations on this standard. According to Seafood Watch Program representative Peter Adame, there are currently no reports that specifically mention the use of seal bombs, as they are "not a common method for commercial fishing."[35] Adame says that the Seafood Watch Program would consider the impact of the explosives "under two criteria: Impacts on Other Species and Habitat Impacts."[35] These impacts, however, are currently unknown.

The Marine Stewardship Council (MSC), a sustainable seafood certification organization, does not specifically mention seal bombs in its guidance document on fisheries certification. MSC bars fisheries from certification that use explosives as a method of fishing.[36] However, there is no such ban for fisheries that use the explosives as a deterrent. According to Matt Gummery, fisheries certification manager for MSC, "There are several areas where fishery impacts on marine mammals would be addressed by a third-party scientist assessment team, even if there was a lack of data. The assessment team would be required to use data-limited assessment methods (a semi-quantitative approach that uses any available data and stakeholder input to determine precautionary scores) to assess the risk of a negative impact."[37] Fisheries are also scored by MSC on how frequently they review and implement alternative measures to minimize fishery-related mortality of endangered, threatened, or protected species.[37]

Ultimately, sustainable seafood listings and certifications are only as good as the information received by the organizations that produce them, and information on seal bomb impacts on marine mammals is practically nonexistent. MSC will not certify a fishery that specifically targets marine mammals,[37] but if the mammals are taken as a by-product of fishing activity, certification is possible.

Currently, Seafood Watch and MSC sustainability determinations do not preclude fisheries from using seal bombs as deterrents. It is hard to know how many fisheries positively rated by Seafood Watch or MSC use seal bombs, but Seafood Watch assigns a yellow rating to squid caught by the California squid fishery, which is one of the fisheries that likely uses the greatest number of seal bombs in its operations.[8]

V. The Need for More Research, Monitoring, and Dialogue on Seal Bomb Use in California Waters

The use of seal bombs in California fisheries presents a system almost completely lacking in data, monitoring, and enforcement. The regulatory system for seal bombs is broken if it requires the users of the devices to self-regulate without having any system in place to objectively assess the impacts of seal bombs, nor a data collection and monitoring program in place to correlate the use of seal bombs with marine mammal injury and death. Fishers who use seal bombs have no incentive to self-regulate, and there are no government or third-party entities directly monitoring their use of these devices.

The serious injury or death of a marine mammal, if caused by seal bombs, would have to be witnessed and proven before any action would be taken against those responsible, which is entirely backwards from a precautionary or incentive-based management standpoint. In addition, there is a paucity of fisheries observers in California waters who could collect the appropriate data and alert regulatory personnel of violations.

The issue of seal bomb use, however, has recently made its way into the California policy spotlight. The sanctuary's management plan is currently being updated, and there is public and Sanctuary Advisory Council interest in addressing seal bombs issues. According to the MBNMS program's Andrew DeVogelaere, the Sanctuary is "concerned about the potential incidental impacts of specific fishery technique on all sanctuary resources including benthic habitats or marine mammals".[20] If it is found that seal bombs "have a significant adverse effect on marine mammals, the Secretary of Commerce may prohibit such deterrent methods, after notice and opportunity for public comment, through regulation under this Act."[29] The responsibility for analyzing fishing activities for negative impacts falls to NOAA, who can make changes under the NMSA.[38] If seal bombs present issues, "NOAA would consult with the State, PFMC and NMFS as well as the industry to determine an appropriate course of action."[20]

Many California fishermen claim that the use of seal bombs is economically necessary, as without them, they would lose a lot of fish and gear to pinnipeds. Larry Collins, the president of the San Francisco Crab Boat Owner's Association, however, explained that when seal bombs are used, the seals "swim away, and they swim right back. It's probably more effective to throw raw potatoes at them."[11] Other than the California squid fishery, most other Californian fisheries do not use seal bombs. Due to the known adverse effects and the difficulties in effectually modifying or regulating their use, seal bombs were prohibited from use in the eastern tropical Pacific yellowfin tuna purse seine fishery (although these bombs were larger than the ones currently used in California).[39]

As with the overall uncertainty regarding the marine impacts of seal bombs in California, there is no way to objectively examine the overall economic impacts of seal bombs, since there is

insufficient supporting evidence on the potential losses to fishermen. An argument could be made that even if seal bombs provide a net economic benefit to fishermen, the damage inflicted on the marine environment does not justify their use; there is simply a lack of robust and consistent data with which to make any meaningful economic assessment at all.

Given the weak and uncertain regulatory environment, the authors recommend that the state and federal agencies tasked with monitoring and enforcing the use of seal bombs in California immediately review their policies and invest more resources in researching and creating dialogue around this issue. There is the potential that seal bombs pose a significant threat to marine life in California, both due to risk of direct injury from the blasts and the high level of acoustic pollution they generate.

Due to the potential unintended consequences of such a policy change, it is important that the state and federal agencies also review any likely changes in fishery practices that might accompany limits or a ban on the use of seal bombs. It is possible that fishers might resort to other practices that also have negative environmental impacts, or that they have ideas for improvements that could diminish environmental impacts. Fishers should be brought into the conversation from the beginning so that any regulatory changes produce sustainable outcomes.

References

[1] "Table 15 - Poundage And Value Of Landings Of Commercial Fish Into California By Area – 2016." California Department of Fish and Wildlife. June 1, 2017. Accessed April 8, 2018. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=145767&inline.

[2] National Marine Fisheries Service. 2017. Fisheries Economics of the United States, 2015. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-F/SPO-170, 247p. Accessed May 25, 2018. https://www.st.nmfs.noaa.gov/economics/publications/feus/fisheries_economics_2011.

[3] Office of National Marine Sanctuaries. 2015. Monterey Bay National Marine Sanctuary Condition Report Partial Update: A New Assessment of the State of Sanctuary Resources 2015. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of National Marine Sanctuaries, Silver Spring, MD. 133pp.

[4] Jefferson, Thomas A., and Barbara E. Curry. "Acoustic Methods of Reducing or Eliminating Marine Mammal-fishery Interactions: Do They Work?" *Ocean and Coastal Management* 31, no. 1 (1996): 41-70. Accessed March 8, 2018. https://swfsc.noaa.gov/uploadedFiles/Divisions/PRD/Publications/Jefferson_Curry1996(32).pdf.

[5] Myrick, Albert C., Jr., Martin Fink, and Cheryl B. Glick. *Identification, Chemistry, and Behavior of Seal Bombs Used to Control Dolphins in the Yellowfin Tuna Purse Seine Fishery in the Eastern Tropical Pacific: Potential Hazards.*Report no. LJ-90-08. Southwest Fisheries Center. March 1990. Accessed February 18, 2018.

[6] Bland, Alastair. "Why California Fishermen Are Throwing Deafening 'Seal Bombs' at Sea Lions…and why no one is stopping them." Hakai Magazine. November 20, 2017. Accessed February 13, 2018. https://www.hakaimagazine.com/news/california-fishermen-are-throwing-explosives-sea-lions/?xid=PS_smithsonian.

[7] "Final Environmental Assessment: Reducing the Impact on At-risk Salmon and Steelhead by California Sea Lions in the Area Downstream of Bonneville Dam on the Columbia River, Oregon and Washington." National Marine Fisheries Service Northwest Region. March 12, 2008. http://www.westcoast.fisheries.noaa.gov/publications/protected_species/marine_mammals/pinnipeds/sea_lion_removals/sec-120-final-ea-08.pdf.

[8] Meyer-Loebbecke, Anna, Amanda J. Debich, Ana Širović, Jennifer S. Trickey, Marie A. Roch, James V. Carretta, Sean M. Wiggins, John A. Hildebrand, Annette Denziger, Hans-Ulrich Schnitzler, and Simone Baumann-Pickering. "The Use of "Seal Bombs" in Fisheries and Possible Influences on Cetacean Acoustic Behavior in Southern California." Digital image. Accessed April 8, 2018.

[9] Ryan, John and Anna Krumpel (formerly Meyer-Loebbecke). Passive Acoustic Monitoring [unpublished data]. Monterey: Monterey Bay Aquarium Research Institute and Scripps Institute of Oceanography; 2016.

[10] Ryan, John. 'Sound Exhibit'. Email, 2018.

[11] "ATF cracks down on bombs used to scare seals." Homeland Security News Wire. May 11, 2011. Accessed February 13, 2018. http://www.homelandsecuritynewswire.com/atf-cracks-down-bombs-used-scare-seals.

[12] Petras, Elizabeth. *A Review of Marine Mammal Deterrents and Their Possible Applications to Limit Killer Whale (Orcinus Orca) Predation on Steller Sea Lions (Eumetopias Jubatus).*Report. Alaska Fisheries Science Center. February 2003. Accessed March 12, 2018. https://www.afsc.noaa.gov/Publications/ProcRpt/PR 2003-02.pdf.

[13] *Environmental Assessment on Protecting Winter-run Wild Steelhead from Predation by California Sea Lions in the Lake Washington Ship Canal*. National Marine Fisheries Service and Washington Department of Fish and Wildlife. Seattle, 1995.

[14] Lewis, John A. *Effects of Underwater Sound on Marine Fish and Mammals*. Technical paper. Aeronautical and Maritime Research Laboratory, Defence Science and Technology Organisation. Melbourne, 1990.

[15] Harvey, Jim. "Marine Mammals Table of Contents." MBNMS Site Characterization: Marine Mammals - Table of Contents. November 20, 2017. Accessed April 15, 2018. https:// montereybay.noaa.gov/sitechar/mamm.html.

[16] "Acoustic Pollution and Marine Mammals." Nature Education. 2014. Accessed April 6, 2018. https://www.nature.com/scitable/spotlight/acoustic-pollution-and-marine-mammals-8914464.

[17] "Noise." NOAA Office of National Marine Sanctuaries. Accessed April 4, 2018. https://sanctuaries.noaa.gov/science/sentinel-site-program/monterey-bay/noise.html.

[18] "Marine Mammals and Noise: A Sound Approach to Research and Management." Marine Mammal Commission. March 2007. Accessed March 4, 2018. https://www.mmc.gov/wp-content/uploads/fullsoundreport.pdf.

[19] U.S. Department of Commerce. NOAA National Marine Fisheries Service. *2018 Revisions To: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts.* NOAA Technical Memorandum NMFS-OPR-59. 2018. 1-167.

[20] National Oceanic and Atmospheric Administration, Department of Commerce. Final Rule. "Monterey Bay National Marine Sanctuary Regulations, Part III: 15 CFR Chapter IX, Subchapters A and B and Part 944." Federal Register 57, no.182 (September 18, 1992): RIN 0648-AC63. https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/ management/fr/57_fr_43309.pdf.

[21] "Who We Are and What We Do." Pacific Fishery Management Council. Accessed April 2, 2018. https://www.pcouncil.org/.

[22] Grady, Katherine. 'Seal Bombs Information'. Email, 2018.

[23] Borg, Ronald. 'Explosives Inquiry'. Email, 2018.

[24] Anna Krumpel (formerly Meyer-Loebbecke) (Visiting PhD student at Scripps Acoustic Ecology Laboratory), interviewed by Aimee Kerr in Monterey, February 23, 2018.

[25] "Potential Deterrence Methods for Pacific Harbor Seals, California Sea Lions & Eastern U.S. Stock Steller Sea Lions." NOAA Fisheries West Coast Region. November 2015. Accessed February 18, 2018. http://www.westcoast.fisheries.noaa.gov/ publications/ protected_species/marine_mammals/pinnipeds/sea_lion_removals/112515_potential_deterrence_methods.pdf.

[26] "Guidelines for Distinguishing Serious from Non-Serious Injury of Marine Mammals Pursuant to the Marine Mammal Protection Act." National Marine Fisheries Service. January 27, 2012. Accessed February 18, 2018. http://www.nmfs.noaa.gov/pr/pdfs/serious_injury_procedure.pdf.

[27] "Monterey Bay National Marine Sanctuary: Resource Issues: Fishing and Harvesting." NOAA Office of National Marine Sanctuaries. November 20, 2017. Accessed February 19, 2018. https://montereybay.noaa.gov/resourcepro/resmanissues/fishing.html.

[28] National Marine Sanctuaries Act, United States Code § 32-1431 et seq. (1972).

[29] Marine Mammal Protection Act of Oct. 21, 1972, Pub. L. No. 92-522, 86 Stat. 1027, 16 U.S.C. §§ 1361-1407 (1976).

[30] "Marine Mammal Protection Act List of Fisheries." NOAA Fisheries. Accessed March 28, 2018. https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries.

[31] "Sea Lion Removal: Deterring Problem Seals, California Sea Lions & Steller Sea Lions." NOAA Fisheries West Coast Region. August 2014. Accessed March 12, 2018. http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/deterring_qa.html.

[32] "Laws & Policies: Endangered Species Act." NOAA Fisheries. Accessed February 23, 2018. https://www.fisheries.noaa.gov/topic/laws-policies#endangered-species-act.

[33] "Endangered Species Permits and Conservation Plans." NOAA Fisheries. June 1, 2017. Accessed February 20, 2018. http://www.nmfs.noaa.gov/pr/permits/ESA_permits.html.

[34] Melanie Parker (California Department of Fish and Wildlife), interviewed by Aimee Kerr at the CDFW Marine Region Main Office in Monterey, March 2, 2018.

[35] Adame, Peter. 'Seal Bombs and Seafood Watch'. Email, 2018.

[36] "MSC Fisheries Certification Requirements and Guidance, Version 2.0." October 1, 2014.

Marine Stewardship Council. Accessed February 22, 2018. https://www.msc.org/documents/scheme-documents/fisheries-certification-scheme-documents/fisheries-certification-requirements-version-2.0.

[37] Gummery, Matt. 'Information on Seal Bombs'. Email, 2018.

[38] "NOAA's Regulation of Fishing in National Marine Sanctuaries." United States Office of Ocean and Coastal Resource Management, Marine Sanctuaries Division. July 2008. Accessed March 17, 2018. https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/library/pdfs/noaa_regs_nmsfishing_2008.pdf.

[39] National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce. Proposed Rule. "Taking and Importing of Marine Mammals; Deterrence Regulations and Guidelines, Part 216: 50 CFR." Federal Register 60, no.87 (May 5, 1995): RIN 0648–AH19. http://www.westcoast.fisheries.noaa.gov/publications/frn/1995/60fr22345.pdf.