Appendix E.1 In-Air Acoustic Effects on Pinnipeds from Weapons Firing Noise

Environmental Impact Statement/
Overseas Environmental Impact Statement
Hawaii-California Training and Testing
TABLE OF CONTENTS

List of Figures

List of Tables

APPENDIX E.1 In-Air Acoustic Effects on Pinnipeds from Weapons Firing Noise

This appendix presents the analysis of weapons firing at San Nicolas Island (SNI) and Pacific Missile Range Facility (PMRF) resulting in estimated in-air acoustic effects on pinnipeds. The acoustic stressors predicted to result in effects are (1) noise associated with missile and aerial target launches occurring on land-based sites at SNI and PMRF, and (2) noise associated with artillery firing at PMRF from land-based sites.

E.1.1 Predicting Effects from Missile and Aerial Target Launches at SNI

SNI is Navy owned and located within the PMSR approximately 60 miles southwest of Point Mugu, California. Due to its remote location, SNI is ideally suited as a site to launch missiles and aerial targets used for military training and testing. Typical airborne target systems include small jet-powered drones, supersonic missiles and targets, and full-scale unmanned fighter aircraft, which can be flown via remote control from the ground. Airborne targets can be launched from aircraft, surface launch sites at SNI, or from a support vessel. However, only launches from SNI would have the potential to affect pinnipeds hauled out on SNI during a launch event.

The number of annual target and missile launches from SNI would be consistent with past and ongoing activities (i.e., approximately 40 events per year), and the analysis of effects would also remain consistent with previously presented analyses (National Oceanic and Atmospheric Administration, 2022; U.S. Department of the Navy, 2022b).

Noises with sudden onset or high amplitude relative to the ambient noise level may elicit a behavioral response from pinnipeds resting on shore; however, noise from launches is typically detectable by pinnipeds on beaches at the west end of SNI for no more than a few seconds per launch (Holst & Greene Jr., 2005; Holst & Greene Jr., 2008). Pinniped reactions to launches from SNI are well documented (Burke, 2017; Holst et al., 2011; Holst & Greene Jr., 2005; Holst & Greene Jr., 2008; Holst & Greene Jr., 2010; U.S. Department of the Navy, 2020a, 2022a, 2023, 2024b; Ugoretz, 2014, 2015, 2016; Ugoretz & Greene Jr., 2012), and the results show that responses vary among species and scenarios. California sea lions, northern elephant seals, and harbor seals, the three species commonly hauled out on SNI, generally tolerate high sound levels without reacting strongly, whereas some individuals may react strongly when sound levels are lower. Responses from aerial target launches have ranged from momentary startle reactions to animals fleeing into the water or otherwise away from their resting sites. Of the three species on SNI, northern elephant seals have demonstrated a very high tolerance of acoustic disturbances (Holst & Greene Jr., 2008) and were removed from the list of target species for monitoring on SNI in 2010 (75 Federal Register 71672). In contrast, harbor seals are more easily disturbed. Regardless, most pinnipeds exhibit no more than short-term alert or startle responses (Holst et al., 2011; Holst & Greene Jr., 2005; Holst & Greene Jr., 2008). Displacement from a pre-disturbance location is typically short in duration (5–15 minutes); although some harbor seals that leave their haulout site and move into the water may not return until the following low tide, when the haulout site is again accessible.

A more detailed analysis of the environmental effects of launches from SNI was prepared by NMFS in 2014 (National Marine Fisheries Service, 2014). The resulting environmental assessment and Finding of No Significant Impact concluded that the effect of launches from SNI is related to the sound produced by the launch vehicles, and this sound would not result in substantial effects on marine mammals or to their role in the ecosystem. Launch vehicle sound might result in short-term behavioral effects, but no long-term displacement, TTS, or AINJ effects on hauled-out pinnipeds are anticipated.

E.1.2 Impacts from Missile and Aerial Vehicle Launches and Artillery Firing at PMRF

PMRF is a Navy training and testing facility located on the western side of Kauai in the Hawaii Range Complex. Similar to SNI, the land area on PMRF is used to launch missiles and aerial targets critical for military training and testing. PMRF is also used as a location for Army and Marine Corps artillery firing.

Ranges to potential auditory effects on hauled out Hawaiian monk seals at PMRF were estimated for two noise sources: a non-impulsive missile or air vehicle launch and an impulsive artillery firing event.

E.1.2.1 Criteria to Assess Auditory Impacts on Monk Seals from Terrestrial Launch Noise

This analysis applies auditory impact thresholds for Temporary Threshold Shift (TTS) and Auditory Injury (AINJ) developed for phocids in air. The development of the auditory criteria is described in the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase IV) (U.S. Department of the Navy, 2024a)*. Use of the phocid in-air criteria in this analysis likely overestimates the potential effects on Hawaiian monk seals, because research by Ruscher (In Review) indicates monk seal hearing is less sensitive than other phocid species (e.g., harbor seals, ringed seals, spotted seals).

Aerial hearing thresholds for monk seals are most similar to those obtained with northern elephant seals, another species from the subfamily Monachinae for which aerial hearing thresholds are elevated relative to Phocinae (Reichmuth et al., 2013). The cause of this elevation is likely the near total occlusion of the external auditory canal in Monachinae (Ruscher et al., 2021). As this anatomical feature effectively reduces the amount of acoustic energy reaching the inner ear, it is likely that TTS onsets in Monachinae are elevated relative to Phocinae. This is supported by the finding of reduced TTS susceptibility in a harbor seal that learned to voluntarily close its auditory canal during controlled noise exposures (Kastak et al., 2005).

E.1.2.1.1 Non-Impulsive Missile or Air Vehicle Launch Noise

As described in the *Acoustic Measurements of Pacific Missile Range Facility (PMRF) Missile Launch: March 2023* technical memorandum, Sound Pressure Level (SPL) and Sound Exposure Level (SEL) were measured from a single Medium-Range Ballistic Missile Type 3 Configuration 2 (MRBM T3C2) Target Vehicle launch event at four locations on PMRF (Kim & Norman, 2023). The technical memorandum presented noise levels at the four locations where monitors were stationed and concluded that the received levels did not exceed Temporary Threshold Shift (TTS) or Auditory Injury (AINJ) thresholds based on Phase 3 criteria, which are similar to the Phase 4 criteria for phocids in air.

However, the closest recorder (ATAR 1) was approximately 1,365 feet from the launch location. This paper briefly describes the effort to use the acoustic data to estimate the size of the area surrounding the launch site that would have exceeded the Navy Phase 4 AINJ and TTS thresholds for phocids in air (PA). These distances to auditory thresholds, also referred to as ranges to effects, could be used as a tool to determine if there is overlap between launch noise that exceeds auditory thresholds and potential

Hawaiian monk seal haulout locations. If the results of the analysis show that auditory effects could occur at monk seal haulout locations, then the ranges to effects could also be used to define mitigation measures or geographic mitigation areas.

As mentioned above, there were four locations where acoustic measurements were collected during the launch, ATAR 1 through ATAR 4. The unweighted SPL of the non-impulsive event at ATAR1 (the closest location) was 129.1 dB re 20 µPa (peak received level of 143.2 dB re 20 µPa). Since the recorder was stationary and TTS/AINJ thresholds were not exceeded at that location, distances to threshold levels had to be estimated using the recorded acoustic data. This was accomplished using the spherical spreading model. In an ideal setting in which sound propagates away from a point source in air without any external influence (e.g., a barrier reflecting or attenuating the sound), the sound energy radiates uniformly outward in all directions from the source in a pattern referred to as spherical spreading. For each doubling of distance from a point source, the sound level attenuates (or drops off) at a rate of 6 dB. It is important to note that the spherical spreading model used in the analysis in this paper does not account for attenuation due to meteorological conditions, physical barriers in the environment, and variations in the type or density of vegetation impeding sound propagation, all of which would affect how far the sound propagates from the source and the ranges to auditory effects.

The Navy applies weighted SEL thresholds to assess auditory impacts as well as peak pressure thresholds for impulsive sources. Unweighted peak SPL and weighted SEL thresholds for non-impulsive sources are used by regulatory agencies to estimate impacts on phocid seals. The SEL metric is based on auditory weighting functions for specific species and their hearing sensitivities. To estimate distances to weighted SEL thresholds for the monk seal, the time waveform from ATAR 1 was filtered using the audiometric weighting function for phocids in air, and a SEL was calculated using the estimated 4.7 second duration of the event (Kim & Norman, 2023). The TTS weighted non-impulsive SEL threshold for phocids in air is 134 dB re $(20\ \mu Pa)^2s$, and the AINJ weighted SEL non-impulsive threshold for phocids in air is 154 dB re $(20\ \mu Pa)^2s$. To estimate a range to effect, the time waveform was scaled until the calculated SEL matched first the AINJ threshold and then the TTS threshold. The unweighted peak SPL of the waveform was then noted, and utilizing the spherical spreading model as described above, the approximate distance to the peak SPL threshold was calculated. Using this method, the distances to the weighted SEL thresholds were estimated to be as follows:

Weighted Non-Impulsive AINJ Threshold (SEL) = 6 feet

Weighted Non-Impulsive TTS Threshold (SEL) = 620 feet

These distances centered on the launch site are shown in Figure E.1-1. The figure shows the areas around the launch site that would be exposed to sound levels at each threshold. Monk seals hauled out on the beach would not be exposed to noise from a launch that would exceed either TTS or AINJ thresholds.

Figure E.1-1: Distances to Non-Impulsive Phocid Thresholds from Launch of T3C2 missile

The T3C2 missile represented the maximum non-impulsive sound source that would be used at PMRF and thus a "worst case" scenario for potential auditory effects to hauled out monk seals. However, a smaller rocket fired from the High Mobility Artillery Rocket System (HIMARS) would be used more regularly at PMRF. An acoustic analysis estimating ranges to auditory effects from the HIMARS is outlined below.

1. Levels of HIMARS launches at PMRF at various distances from the launch were obtained from U.S. Department of the Navy (2021). The levels are reported in overall dBA (based on the A-weighted SPL used for human noise effects measurements, see Houser et al. (2017); thus, the frequency-specific levels necessary to apply PCA weighting for monk seals were not available.
2. The PCA and A-weighting curves were compared (Figure E.1-2). The A-weighting function discounts less acoustic energy than the PCA function across its entire frequency range, except for below 10 Hz (where both functions are near -80 dB) and above 20 kHz (where the A-weighting function is not defined). The SPL in dBA was therefore considered to be a conservative estimate of PCA-weighted SPL for the HIMARS activity.
3. The duration of the HIMARS launches was reported as 4 sec by U.S. Department of the Navy (2021), therefore 6 dB was added to the dBA values to estimate A-weighted SEL at various ranges.
4. The A-weighted source SEL at the HIMARS launch was estimated using the "dBA @ source" and "dBA @ 250 m" columns from U.S. Department of the Navy (2021), with the latter corrected assuming spherical spreading loss. These levels were 171 and 134 dB re $(20\ \mu Pa)^2$, respectively.
5. The estimated A-weighted source SELs were compared to the PCA non-impulsive TTS and AINJ criteria of 134 and 163 dB re $(20\ \mu Pa)^2$, respectively.
6. Ranges to TTS based on the "dBA @ source" and "dBA @ 250 m" values were 71 m (232 ft) and 1 m (3 ft), respectively.
7. Ranges to AINJ based on the "dBA @ source" and "dBA @ 250 m" measurements were 2.5 m (8 ft) and 0.04 m (<1 ft), respectively.
8. Based on these calculations, it is expected that no TTS or AINJ effects would occur for monk seals at ranges of greater than 61 m (200 ft) from HIMARS firing sites at PMRF comparable to that described in U.S. Department of the Navy (2021).
9. Haulout sites on beaches at PMRF are more than 200 ft from any of the HIMARS launch sites.

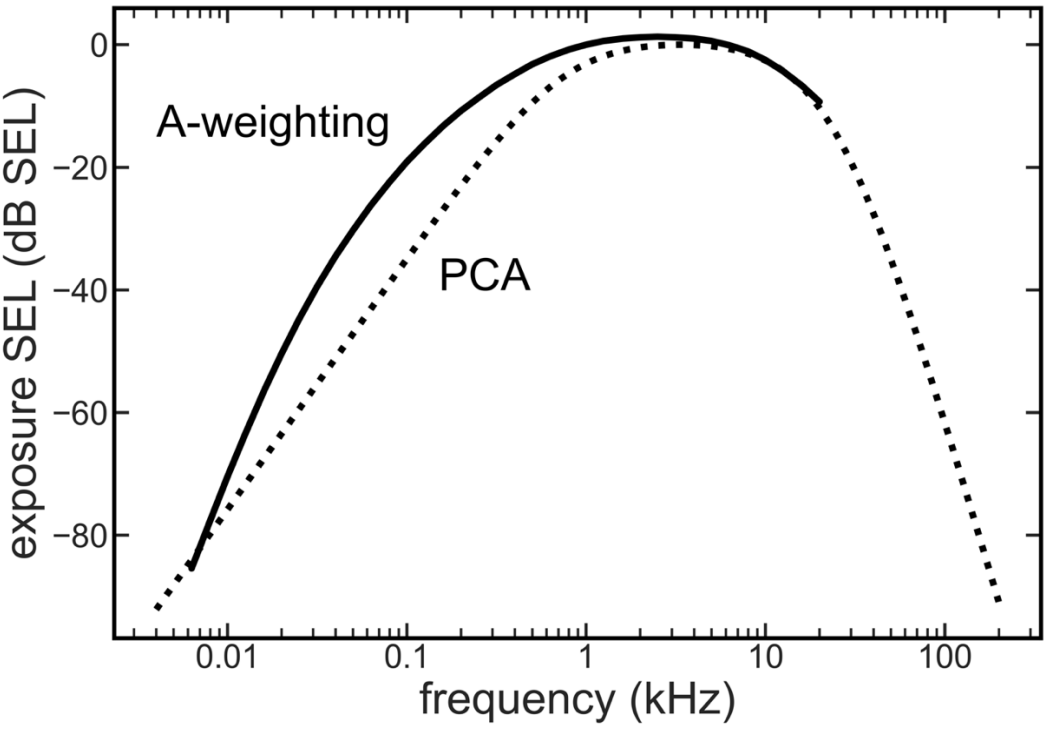

Figure E.1-2: Comparison of A-Weighting and PCA Weighting Functions. The A-weighting curve is commonly employed by sound level meters to estimate perceived loudness by humans.

E.1.2.1.2 Impulsive Artillery Firing Noise

Artillery firing activities are proposed under the PMRF Land-Based Training and Testing EA, which is currently in development. While only the at-sea components of the range complexes are considered in this EIS/OEIS, the potential effects of sound related to missiles, targets, or artillery projectiles fired from PMRF on pinnipeds hauled out along the coastline are analyzed in this EIS/OEIS. The events would take place in the same locations at PMRF where the missile and launch vehicle activities would be conducted, and noise from those events have the potential to reach monk seal haulout locations.

Artillery or weapons-firing noise is considered an impulsive sound. An example of artillery that could be used is the 155mm M777 Howitzer. No acoustic measurements of artillery firing noise have been recorded at PMRF, so an estimate of ranges to auditory effects was based on published measurements. A recent study in which service members wore sensors while conducting various gun and blast activities is described in *Dynamic monitoring of service members to quantify blast exposure levels during combat training using BlackBox Biometrics Blast Gauges: explosive breaching, shoulder-fired weapons, artillery, mortars, and 0.50 caliber gun*s (Wiri et al., 2023). The analysis presented here is based on overpressure measurements reported in this study from firing a 155mm M777 Howitzer. Median and maximum peak overpressure were measured at 17 kPa (178.6 dB re 20 µPa) and 44 kPa (186.8 dB re 20 µPa), respectively. The average distance of personnel wearing sensors from the firing position is approximated to be 6 feet based on diagrams presented in the study.

Using the spherical spreading model and the maximum overpressure recorded, the distance to an approximate received level of 162 dB re 20 µPa (the Phase 4 impulsive peak SPL unweighted AINJ

threshold for phocids in air) would be approximately 95 feet from the source. The impulsive unweighted peak SPL threshold for TTS is 156 dB, which would be approximately 190 feet from the source.

Unweighted Impulsive AINJ Threshold (peak SPL) = 95 feet

Unweighted Impulsive TTS Threshold (peak SPL) = 190 feet

Wiri et al. (2023) only presented data in the time-domain, meaning only sound levels are noted and no frequency information is provided. Without frequency characteristics of the sound, weighting cannot be applied to the results presented in the study. Applying a weighting function would decrease the acoustic energy perceived by monk seals, and the range to TTS effects would be less than those for unweighted values.

These distances centered on the firing site are shown in Figure E.1-3. The figure shows the areas around the firing site that would be exposed to sound levels at each threshold. Monk seals hauled out on the beach would not be exposed to noise from a launch that would exceed the AINJ or TTS thresholds.

Figure E.1-3: Distances to Impulsive Phocid Thresholds from Firing of 155mm M777 Howitzer

E.1.3 Summary of Impacts from In-Air Acoustic Stressors

SNI: Pinnipeds hauled out on the shoreline of SNI have been observed to behaviorally react to the sound of launches of targets and missiles from launch pads on the island (Naval Air Warfare Center Weapons Division, 2018; U.S. Department of the Navy, 2020b, 2022b, 2023). The estimate of the number of behavioral effects that would be expected due to in-air noise from launches was based on observations of pinnipeds over three monitoring seasons (2015–2017) divided by the number of launch events over that same time period. The Navy determined that the numbers presented in Table E.1-1 represent the number of pinnipeds expected to be hauled out at SNI based on surveys over the five-year period from 2014 to 2019 (U.S. Department of the Navy, 2020a) and the average number of effects observed per launch event (U.S. Department of the Navy, 2020b, 2022b, 2023). The estimated behavioral effects presented in Table E.1-1 are the same as those analyzed in NMFS Letter of Authorization for activities conducted on the PMSR in July 2022 (National Oceanic and Atmospheric Administration, 2022).

Table E.1-1: Behavioral Effects From In-Air Weapons Noise Due to Launches of Targets and Missiles from San Nicolas Island under Alternative 1 and Alternative 2

Species	Stock	Annual	7-Year Total
Family Otariidae (eared seals)			
California sea lion	U.S.	11,000	77,000
Family Phocidae (true seals)			
Harbor seal	California	480	3,360
Northern elephant seal	California Breeding	40	280

PMRF: From 2020 to 2023, an annual average of 215 monk seals were counted hauled out on the beach at PMRF (unpublished Navy data). Over that timeframe, the maximum number of seals counted during a single observation was five and the minimum was zero; for 65 percent of observations, zero hauled out seals were observed. Based solely on the average annual counts, the Action Proponents conservatively estimated that weapons firing noise at PMRF would result in 215 behavioral effects annually on hauled out monk seals (Table E.1-2).

The analysis of behavioral effects from in-air noise was not conducted in the Navy's Acoustic Effects Model, which only analyzes effects from underwater sound sources. Based on a basic estimate of the range to behavioral effects from in-air noise using a very conservative threshold, the Action Proponents assumed any monk seal on the beach at PMRF would be affected by weapons firing noise. Since the entire beach at PMRF is not observed at the same time, the analysis conservatively assumes that monk seals are hauled out somewhere along the beach whenever a launch or firing event would occur and would be exposed and respond to weapons firing noise. This is a conservative approach since, as noted above, daily observations indicate that most frequently no monk seals are observed hauled out on the beach. Furthermore, since monk seal in-air hearing appears to be less sensitive than hearing in other phocid seals (Ruscher et al., 2025; Ruscher et al., 2021), it is likely that some monk seals would not respond to weapons firing noise during an event.

Table E.1-2: Behavioral Effects From In-Air Weapons Noise Due to Launches of Targets and Missiles and Artillery Firing at PMRF under Alternative 1 and Alternative 2

Species	Stock	Annual	7-Year Total
Family Phocidae (true seals)			
Hawaiian monk seal	NA	215	1,505

References

Burke, J. H. (2017). *Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2016–November 2017*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Holst, M., C. Greene, J. Richardson, T. McDonald, K. Bay, S. Schwartz, and G. Smith. (2011). Responses of pinnipeds to Navy missile launches at San Nicolas Island, California. *Aquatic Animals 37* (2): 139–150. DOI:10.1578/AM.37.2011.139

Holst, M. and C. R. Greene Jr. (2005). *Marine Mammal and Acoustical Monitoring of Missile Launches on San Nicolas Island, California, August 2001 – May 2005*. Silver Spring, MD, and Long Beach, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Holst, M. and C. R. Greene Jr. (2008). *Marine Mammal and Acoustical Monitoring of Missile Launches on San Nicolas Island, California, August 2001 – March 2008*. Silver Spring, MD, and Long Beach, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Holst, M. and C. R. Greene Jr. (2010). *Marine Mammal and Acoustical Monitoring during Vehicle Launches on San Nicolas Island, California, June 2009 – June 2010*. Silver Spring, MD, and Long Beach, CA: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Houser, D. S., W. Yost, R. F. Burkard, J. J. Finneran, C. Reichmuth, and J. Mulsow. (2017). A review of the history, development and application of auditory weighting functions in humans and marine mammals. *The Journal of the Acoustical Society of America 141* (3): 1371–1413. DOI:10.1121/1.4976086

Kastak, D., M. Holt, C. Kastak, B. Southall, J. Mulsow, and R. Schusterman. (2005). *A voluntary mechanism of protection from airborne noise in a harbor seal* [Type]. Presented at the 16th Biennial Conference on the Biology of Marine Mammals. San Diego, CA.

Kim, K. H. and R. G. Norman. (2023). *Acoustic Measurements of PMRF Missile Launch: March 2023* (GSI Technical Memorandum 546-4). Santa Barbara, CA: Greeneridge Sciences, Inc.

National Marine Fisheries Service. (2014). *Issuance of Regulations to Take Marine Mammals by Harassment Incidental to U.S. Navy Missile Launch Activities at San Nicolas Island, California*. Silver Spring, MD: National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

National Oceanic and Atmospheric Administration. (2022). Taking and importing marine mammals; Taking marine mammals incidental to the U.S. Navy training and testing activities in the Point Mugu Sea Range Study Area. *Federal Register 87* (130): 40888-40966.

Naval Air Warfare Center Weapons Division. (2018). *Application for an Incidental Harassment Authorization Under the Marine Mammal Protection Act for Marine Mammals from Target and Missile Launch Activities at San Nicolas Island, California*. Silver Spring, MD.

Reichmuth, C., M. M. Holt, J. Mulsow, J. M. Sills, and B. L. Southall. (2013). Comparative assessment of amphibious hearing in pinnipeds. *Journal of Comparative Physiology A: Neuroethology, Sensory Neural, and Behavioral Physiology 199* (6): 491–507. DOI:10.1007/s00359-013-0813-y

Ruscher, B., J. M. Sills, N. Packard, T. L. Kendall, T. M. Williams, and C. Reichmuth. (2025). Psychoacoustic data confirm reduced hearing sensitivity in Hawaiian monk seals relative to Phocinae seals. *Endangered Species Research 56* 19-26. DOI:10.3354/esr01377

Ruscher, B., J. M. Sills, B. P. Richter, and C. Reichmuth. (2021). In-air hearing in Hawaiian monk seals: Implications for understanding the auditory biology of Monachinae seals. *Journal of Comparative Physiology Neuroethology, Sensory, Neural, and Behavioral Physiology 207* (4): 561–573. DOI:10.1007/s00359-021-01498-y

Ruscher, B., Sills, J.M., Packard, N., Kendall, T. L., Williams, T. M. (In Review). Psychoacoustic data confirm reduced hearing sensitivity in Hawaiian monk seals relative to Phocinae seals. *Endangered Species Research*.

U.S. Department of the Navy. (2020a). *Comprehensive Pinniped Monitoring Report, Missile Launches on San Nicolas Island, California, June 2014 – June 2019*. Silver Spring, MD: National Marine Fisheries Service.

U.S. Department of the Navy. (2020b). *Quantifying Acoustic Impacts on Marine Species: Methods and Analytical Approach for Activities at the Point Mugu Sea Range*. Newport, RI: Naval Undersea Warfare Center Division.

U.S. Department of the Navy. (2021). *Hawaii Range Complex Re-Initiation Terrestrial Biological Evaluation*. Naval Station Pearl Harbor, HI: Commander, U.S. Pacific Fleet.

U.S. Department of the Navy. (2022a). *Pinniped Monitoring Report, Missile Launches on San Nicolas Island, California, June 2021 – June 2022*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

U.S. Department of the Navy. (2022b). *Point Mugu Sea Range Final Environmental Impact Statement/Overseas Environmental Impact Statement*. Point Mugu, CA: U.S. Department of the Navy.

U.S. Department of the Navy. (2023). *Point Mugu Sea Range Annual Monitoring and Activity Report July 2022 – July 2023*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

U.S. Department of the Navy. (2024a). *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase IV)*. San Diego, CA: Naval Information Warfare Center, Pacific.

U.S. Department of the Navy. (2024b). *Point Mugu Sea Range Annual Monitoring and Activity Report, July 2023 – July 2024*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Ugoretz, J. (2014). *Final Comprehensive Report Pinniped Monitoring during Missile Launches on San Nicolas Island, California, June 2009 - June 2014*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Ugoretz, J. (2015). *Pinniped Monitoring during Missile Launches on San Nicolas Island, California, December 2014 - November 2015*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Ugoretz, J. (2016). *Pinniped Monitoring During Missile Launches on San Nicolas Island, California, December 2015–November 2016*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Ugoretz, J. and C. R. Greene Jr. (2012). *Pinniped Monitoring during Missile Launches on San Nicolas Island, California, September 2011 - September 2012*. Point Mugu, CA: Naval Air Warfare Center Weapons Division.

Wiri, S., T. Massow, J. Reid, J. Whitty, C. Dunbar, W. Graves, A. Gonzales, D. Ortley, J. Longwell, C. E. Needham, A. Ziegle, V. Phan, F. Leonessa, and J. L. Duckworth. (2023). Dynamic monitoring of service members to quantify blast exposure levels during combat training using BlackBox Biometrics Blast Gauges: explosive breaching, shoulder-fired weapons, artillery, mortars, and 0.50 caliber guns. *Frontiers in Neurology 14* 1175671. DOI:10.3389/fneur.2023.1175671