Environmental Impact Statement/

Overseas Environmental Impact Statement

Point Mugu Sea Range

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Appendix D Military Expended Material and Direct Strike Impact Analyses

D.1 Estimating the Strike Impact Probabilities of Military Expended Materials on Marine Species

This section discusses the methods and results for quantifying the impact of military expended materials (MEM) under the environmental baseline, Alternative 1, and Alternative 2. Testing and training typically occurs in areas that are not called out or linked to specific activities for various reasons (e.g., flexibility and national security). This section describes the calculation of the disturbance footprint (i.e., military expended material footprint) of an instantaneous impact of MEM to marine species on the surface of the ocean. The actual instantaneous impact on the surface will depend on the number and location of MEM, which is likely much lower and more concentrated than the worst-case scenario described here. Longer-term impacts of MEM that come to rest on the seafloor are far more difficult to determine, but an area of total impact has been calculated; refer to the Marine Habitats (Section 3.3) of Chapter 3 (Affected Environment and Environmental Consequences) for the qualitative discussion.

The strike analysis begins with two data elements: (1) a tabular summary of the MEM footprint sizes, and (2) a tabular summary of area of impact for each MEM type at the surface. The data comes from the Point Mugu Sea Range (PMSR) action proponents and as a not to exceed maximum, represents the most flexibility with regard to expenditure of MEM. The descriptive dimensional data for the various MEM is reported in Table D-1.

Table D-1: Strike Area for Military Expended Materials at PMSR

MEM Group	*MEM Category*	*MEM Strike Cross-Sectional Area (ft.^{2})*	*Material Specific Notes*
Missiles	Air-to-Air	0.3491	Representative item: AIM-7 Sparrow
	Air-to-Surface	0.5454	Representative item: AGM-88 HARM
	Surface-to-Air, large	2.40	Representative item:RIM-174 SM 6
	Surface-to-Surface	1.07	Representative item: 12-SSM
	Subsurface-to-Surface	2.18	Representative item: JRGM-109E Tomahawk
	Subsurface-to-Air	38.48	Representative item: UGM-133A Trident
	Long Range Weapons	2.18	Representative item: Hypersonic (Only the boosters for the hypersonic are MEM, the vehicle is recovered)
Gun Ammunition	Small Caliber (0.50 cal, 7.62 mm)	0.0014	0.50 caliber
	Medium Caliber (20 mm, 25 mm, 30 mm)	0.0107	20 mm, 25 mm, 30 mm, 35 mm
	Large Caliber (127 mm, 5"/0.54 cal MK-45, 57 mm)	0.0491	MK-54 gun mount
Bombs	Bombs	0.66	Representative item: MK 82
Rockets	Rockets	0.0412	2.75"
Targets	Aerial Targets	28.27	Representative item: BQM-74E

Note: MEM = Military Expended Material

Military Expended Materials – Seafloor Impacts

To determine the potential level of disturbance of MEM on the seafloor, it was assumed that the impact footprint of the expended material is twice the size of its dimensions. By doubling the actual size of the MEM, the results should more accurately reflect the potential disturbance to soft bottom habitats (i.e., to account for sediment plumes). Items with casings (e.g., small-, medium-, and large-caliber munitions; flares; sonobuoys) have their impact footprints further doubled to account for both the item and its casing. To be conservative, items and their casings were assumed to be the same size, although in reality the items are a smaller size in order to fit in their casing. Table D-2 shows military expended materials and seafloor impact footprints within the PMSR Study Area.

Table D-2: Seafloor Impact Area for Military Expended Materials at PMSR

MEM Group	*MEM/Category*	*Seafloor Footprint (ft.²)*	*Material Specific Notes*
Missiles	Air-to-Air (AIM-7 Sparrow)	8.00	Representative item: AIM-7 Sparrow
	Air-to-Surface (AGM-88 HARM)	10.83	Representative item: AGM-88 HARM
	Surface-to-Air (RIM-174 SM 6)	38.50	Representative item:RIM-174 SM 6
	Surface-to-Surface (12-SSM)	18.67	Representative item: 12-SSM
	Subsurface-to-Surface (RGM-109E Tomahawk)	35.00	Representative item: JRGM-109E Tomahawk
	Subsurface-to-Air (UGM-133A Trident)	308.00	Representative item: UGM-133A Trident
	Long Range Weapons (LRASM and Hypersonic)	35.00	Representative item: Hypersonic (Only the boosters for the hypersonic are MEM, the vehicle is recovered)
Gun Ammunition	Small Caliber (0.50 cal, 7.62mm)	0.01	0.50 caliber
	Medium Caliber (20mm, 25mm, 30mm)	0.09	20 mm, 25 mm, 30 mm, 35 mm
	Large Caliber (127mm, 5"/0.54 cal, 57mm)	0.54	MK-54 gun mount
Bombs and Rockets	Bombs (MK 82)	9.09	Representative item: MK 82
	Rockets (2.75”)	0.80	2.75"
Targets	Aerial Targets[2] (BQM-74E)	78.00	Representative item: BQM-74E

Note: MEM = Military Expended Material

D.2 Calculating the Statistical Probability for Estimating Direct Strike Impact and Number of Potential Exposures from Military Expended Materials

This section discusses the methods and results for calculating the probability of a direct strike of an animal from any military items from the proposed testing and training activities falling toward (or directed at) the sea surface. The analysis conducted here does not account for direct impacts from explosive munitions because those impacts are analyzed using the Navy Acoustic Effects Model as

described in the *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (U.S. Department of the Navy, 2020).

D.2.1 Direct Strike Analysis

The analysis involves an estimate the impact probability (P) and number of exposures (T) associated with direct impact of military items on marine species on the sea surface within the PMSR in which the activities are occurring. The statistical probability analysis is based on probability theory and modified Venn diagrams with rectangular "footprint" areas for the individual animal (A) and total impact (I) inscribed inside the testing and training area (R). The analysis is over-predictive and conservative, in that it assumes (1) that all animals would be at or near the surface 100 percent of the time, when in fact many marine mammals spend the majority of their time underwater; and (2) that the animals are stationary, which does not account for any movement or any potential avoidance of the testing and training activity.

- A = length*width, where the individual animal's width (breadth) is assumed to be 20 percent of its length for marine mammals. This product for A is multiplied by the number of animals (N_a) in the specified testing and training area (i.e., product of the highest average month animal density [D] and testing and training area [R]: $N_a = D*R$) to obtain the total animal footprint area ($A*N_a = A*D*R$) in the testing and training area. As a conservative scenario, the total animal footprint area is calculated for the species with the highest average month density in the testing and training area with the highest use of military items within the entire Study Area.
- $I = N_{mun}$*length*diameter, where N_{mun} = total annual number of military items for each type, and "length" and "diameter" refer to the individual military equipment dimensions. For each type, the individual impact footprint area is multiplied by the total annual number of military items to obtain the type-specific impact footprint area ($I = N_{mun}$*length*diameter). Each testing and training activity uses one or more different types of military items, each with a specific number and dimensions, and several testing and training activities occur in a given year. When integrating over the number of military items types for the given activity (and then over the number of activities in a year), these calculations are repeated (accounting for differences in dimensions and numbers) for all military items types used, to obtain the type-specific impact footprint area (I). These impact footprint areas are summed over all military items types for the given activity and then summed (integrated) over all activities to obtain the total impact footprint area resulting from all activities occurring in the testing and training area in a given year. As a conservative scenario, the total impact footprint area is calculated for the testing and training area with the highest use of military items within the entire Study Area.

Though marine species are not randomly distributed in the environment, a random point calculation was chosen due to the intensive data needs that would be required for a calculation that incorporated more detailed information on an animal's or military item's spatial occurrence.

The analysis is expected to provide an overestimation of the probability of a strike for the following reasons: (1) it calculates the probability of a single military item (of all the items expended over the course of the year) hitting a single animal at its species' highest seasonal density; (2) it does not take into account the possibility that an animal may avoid military activities; (3) it does not take into account the possibility that an animal may not be at the water surface; (4) it does not take into account that most projectiles fired during testing and training activities are fired at targets, and so only a very small portion of those projectiles that miss the target would hit the water with their maximum velocity and

force; and (5) it does not quantitatively take into account the Navy avoiding animals that are sighted through the implementation of mitigation measures (for consideration of mitigation during analysis see Section 3.7.5, Environmental Consequences, in Marine Mammals).

The likelihood of an impact is calculated as the probability (P) that the animal footprint (A) and the impact footprint (I) will intersect within the testing and training area (R). This is calculated as the area ratio A/R or I/R, respectively. Note that A (referring to an individual animal footprint) and I (referring to the impact footprint resulting from the total number of military items N_{mun}) are the relevant quantities used in the following calculations of single-animal impact probability [P], which is then multiplied by the number of animals to obtain the number of exposures (T). The probability that the random point in the testing and training area is within both types of footprints (i.e., A and I) depends on the degree of overlap of A and I. The probability that I overlaps A is calculated by adding a buffer distance around A based on one-half of the impact area (i.e., 0.5*I), such that an impact (center) occurring anywhere within the combined (overlapping) area would impact the animal. Thus, if L_i and W_i are the length and width of the impact footprint such that $L_i*W_i = 0.5*I$ and $W_i/L_i = L_a/W_a$ (i.e., similar geometry between the animal footprint and impact footprint), and if L_a and W_a are the length and width (breadth) of the individual animal such that $L_a*W_a = A$ (= individual animal footprint area), then, assuming a purely static, rectangular scenario (Scenario 1), the total area $A_{tot} = (L_a + 2*L_i)*(W_a + 2*W_i)$, and the buffer area $A_{buffer} = A_{tot} - L_a*W_a$.

Four scenarios were examined with respect to defining and setting up the overlapping combined areas of A and I:

1. **Scenario 1**: Purely static, rectangular scenario. Impact is assumed to be static (i.e., direct impact effects only; non-dynamic; no explosions or scattering of military items after the initial impact). Hence the impact footprint area (I) is assumed to be rectangular and given by the product of military items length and width (multiplied by the number of military items). $A_{tot} = (L_a + 2*L_i)*(W_a + 2*W_i)$ and $A_{buffer} = A_{tot} - L_a*W_a$.
2. **Scenario 2**: Dynamic scenario with end-on collision, in which the length of the impact footprint (Li) is enhanced by Rn = 5 military items lengths to reflect forward momentum. $A_{tot} = (L_a + (1 + R_n)*L_i)*(W_a + 2*W_i)$ and $A_{buffer} = A_{tot} - L_a*W_a$.
3. **Scenario 3**: Dynamic scenario with broadside collision, in which the width of the impact footprint (W_i) is enhanced by R_n = 5 military items lengths to reflect forward momentum. $A_{tot} = (L_a + 2*W_i)*(W_a + (1 + R_n)*L_i)$ and $A_{buffer} = A_{tot} - L_a*W_a$.
4. **Scenario 4**: Purely static, radial scenario, in which the rectangular animal and impact footprints are replaced with circular footprints while conserving area. Define the radius (R_a) of the circular individual animal footprint such that $\pi*R_a^2 = L_a*W_a$, and define the radius (R_i) of the circular impact footprint such that $\pi*R_i^2 = 0.5*L_i*W_i = 0.5*I$. Then $A_{tot} = \pi*(R_a + R_i)^2$ and $A_{buffer} = A_{tot} - \pi*R_a^2$ (where $\pi = 3.1415927$).

Static impacts (Scenarios 1 and 4) assume no additional aerial coverage effects of scattered military items beyond the initial impact. For dynamic impacts (Scenarios 2 and 3), the distance of any scattered military items must be considered by increasing the length (Scenario 2) or width (Scenario 3), depending on orientation (broadside versus end-on collision), of the impact footprint to account for the forward horizontal momentum of the falling object. Forward momentum typically accounts for five object lengths, resulting in a corresponding increase in impact area. Significantly different values may result from the static and dynamic orientation. Both of these types of collision conditions can be calculated

each with 50 percent likelihood (i.e., equal weighting between Scenarios 2 and 3, to average these potentially different values).

Impact probability (P) is the probability of impacting one animal with the given number, type, and dimensions of all military items used in testing and training activities occurring in the area per year, and is given by the ratio of total area (A_{tot}) to testing and training area (R): $P = A_{tot}/R$. Number of exposures is $T = N*P = N*A_{tot}/R$, where N = number of animals in the testing and training area per year (given as the product of the animal density [D] and range size [R]). Thus, $N = D*R$ and hence $T = N*P = N*A_{tot}/R = D*A_{tot}$. Using this procedure, P and T were calculated for each of the four scenarios, for Endangered Species Act (ESA)-listed marine mammals and the marine mammal species with the highest average month density (used as the annual density value). The scenario-specific P and T values were averaged over the four scenarios (using equal weighting) to obtain a single scenario -averaged annual estimate of P and T. The potential number of exposures (T) are reported in Table D-3.

D.2.2 Parameters for Analysis

Impact probabilities (P) and number of exposures (T) were estimated by the analysis for the following parameters:

1. **Two action alternatives**: Alternative 1 and Alternative 2. Animal densities, animal dimensions, and military item dimensions are the same for both of the action alternatives.
2. **One Environmental Baseline**: The Environmental Baseline. Animal densities, animal dimensions, and military item dimensions are the same for the Environmental Baseline as for Alternatives 1 and 2.

- **One testing and training area**: PMSR.
- The following types of non-explosive munitions or other items:
    a. **Small-caliber projectiles:** up to and including .50 caliber rounds
    b. **Medium-caliber projectiles:** larger than .50 caliber rounds but smaller than 57 millimeter (mm) projectiles
    c. **Large-caliber projectiles:** includes projectiles greater than or equal to a 57 mm
    d. **Missiles:** includes rockets and jet-propelled munitions
    e. **Bombs and Rockets:** Non-explosive practice bombs and mine shapes, ranging from 10 to 2,000 pounds and rockets (2.75", unguided)
    f. **Targets:** includes expended airborne and surface targets
- **Animal species of interest:** The seven species of ESA-listed marine mammals and the three (one pinniped and two dolphins) non-ESA listed marine mammal species with the highest average month density, depending on season of the year, in the testing and training area of interest.

D.2.3 Input Data

Input data for the direct strike analysis include all ESA-listed species and select animal species having the highest densities in the PMSR as a worst-case analysis for each the species group (cetacean, pinniped, and sea turtle) likely to be in the area and MEM proposed for use under each of the two action alternatives and potentially struck while at the surface. Animal species data include (1) highest average

month density estimate for the species of interest, and (2) adult animal dimensions (length and width). The animal's dimensions are used to calculate individual animal footprint areas (A = length*width), and animal densities are used to calculate the number of exposures (T) from the impact probability (P): T = N*P. N = number of animals in the testing and training area per year (given as the product of the animal density [D] and range size [R]). MEM data include (1) MEM category (e.g., projectile, bomb, rocket, target), (2) MEM dimensions (length and width), and (3) total number of MEM used annually. The quantity of MEM proposed for use are different between the two action alternatives. All animal species input data, the MEMs' identification, category, and dimensions are the same for the two alternatives.

D.2.4 Output Data

Estimates of impact probability (P) and number of exposures (T) for a given species of interest were made for the specified testing and training area with the highest annual number of MEM used for the current baseline of activities and for each of the two action alternatives. The calculations derived P and T from the highest annual number of military items used in the Study Area for the given alternative. Differences in P and T between the alternatives arise from different numbers of events (and therefore MEM) for the two alternatives. Exposure estimates for marine species are presented in Table D-3. As shown in Table D-3, the number of estimated exposures for each species is orders of magnitude less than 1. The probabilities for exposures to occur are also extremely low and therefore negligible.

Table D-3: Estimated Representative Marine Species Exposures from Direct Strike of Military Expended Materials by Area and Alternative in a Single Year

PMSR			
Species	***Testing and Training[1]***		
	Current Environmental Baseline	***Alternative 1***	***Alternative 2***
Blue Whale	1.10E-05	2.47E-05	1.54E-05
California Sea Lion*	2.47E-05	7.45E-05	3.99E-05
Fin Whale	2.54E-05	5.87E-05	3.61E-05
Gray Whale	1.03E-04	2.62E-04	1.53E-04
Guadalupe Fur Seal	4.78E-05	1.48E-04	7.83E-05
Humpback Whale	1.26E-05	3.18E-05	1.87E-05
Leatherback Sea Turtle	4.14E-07	1.25E-06	6.70E-07
Long Beaked Common Dolphin*	1.25E-03	3.86E-03	2.04E-03
Northern elephant seal*	3.15E-05	9.50E-05	5.09E-05
Sei Whale	3.50E-08	8.26E-08	5.12E-08
Short Beaked Common Dolphin*	1.21E-03	3.74E-03	1.98E-03
Sperm Whale	6.84E-06	1.68E-05	1.00E-05

*Species are not listed under the Endangered Species Act; however, they are the most dense cetaceans and pinnipeds in the Study Area during certain seasons of the year.

[1]Exposure estimates are provided in scientific notation because they are very small, but the numbers can easily be converted to standard notation. For example, the value for blue whale in the current environmental baseline column is 0.000011, and the value for California sea lion is 0.0000247.

D.3 Direct Vessel Strike With Marine Mammals

It is Navy policy to report all marine mammal strikes by Navy vessels. The information is collected by the Chief of Naval Operations Energy and Environmental Readiness Division and provided to the National

Marine Fisheries Service (NMFS) on an annual basis. Only the Navy and the U.S. Coast Guard report in this manner. Therefore, it should be noted that Navy vessel strikes reported in the scientific literature and NMFS databases are the result of the Navy's commitment to reporting all vessel strikes to NMFS rather than a greater frequency of collisions relative to other ship types. Historically and as a cautionary practice today, some Navy strikes are reported to NMFS even though the strike to a marine mammal could not be confirmed, or if large cetacean was struck, then the exact species may not be known. Most vessel strikes of marine mammals reported involve commercial vessels and occur over or near the continental shelf (Laist et al., 2001). Reporting to NMFS of whale strikes by commercial vessels is not required, and reporting rates are therefore unknown but likely to be much lower than actual occurrences.

Between 2007 and 2009, the Navy developed and distributed additional training, mitigation, and reporting tools to Navy operators to improve marine mammal protection and to ensure compliance with upcoming permit requirements. In 2007, the Navy implemented the Marine Species Awareness Training, as discussed in Chapter 5 (Standard Operating Procedures and Mitigation), which is designed to improve the effectiveness of visual observations for marine resources, including marine mammals. In subsequent years, the Navy issued refined policy guidance regarding marine mammal incidents (e.g., ship strikes) in order to collect the most accurate and detailed data possible in response to a possible incident. For over a decade, the Navy has implemented the Protective Measures Assessment Protocol software tool, which provides operators with notification of the required mitigation and a visual display of the planned testing and training activity location overlaid with relevant environmental data. Similar mitigation, reporting, and monitoring requirements have been in place since 2009 and are expected to continue into the future. Therefore, the conditions affecting the potential for ship strikes are the most consistent across this time frame.

Based on a 10-year historical record used to conduct a probability analysis, there have been no ship strikes to marine mammals from Navy vessels in the PMSR over the past 10 years (i.e., 2009 to 2019). In addition, there have been no Navy ship strikes in the PMSR since 1995, when the Navy started reporting strikes and collecting data. Therefore, the Navy cannot calculate the probability of a Navy vessel striking a whale during the proposed testing and training activities in the Study Area. The level of vessel use and the manner in which the Navy tests in the future (2021 to 2028) is expected to be consistent, decrease, or increase depending on the type of vessel considered with baseline conditions. While some risk of a vessel strike exists for all the U.S. West Coast waters, 74 percent of blue whale, 82 percent of humpback whale, and 65 percent of fin whale known vessel strike mortalities occur in the shipping lanes associated with the ports of San Francisco and Los Angeles/Long Beach (Rockwood et al., 2017). Because there have been no ship strikes to marine mammals in the PMSR by Navy vessels in the past, and the level of vessel use in the future is not anticipated to increase significantly, there would not be an increased risk of strike to marine mammals as a result of the Proposed Action. The risk of a vessel strike would remain at current levels and would be unlikely.

Large unmanned surface vessels are an emerging technology area. However, the Self Defense Test Ship, Mobile Ship Target, and other unmanned targets have been used on the PMSR for several years without incident to marine mammals. Within the timeframe covered by this analysis, the Navy anticipates that testing of and training with large unmanned surface vessels (used as surface targets) in the PMSR Study Area could occur up to approximately eight at-sea days per year. During some testing of and training with large unmanned surface vessels, the platforms would be manned by testing and training personnel who would serve as Lookouts and would have the ability to over-ride autonomous navigation; however,

other testing and training would occur while the platform is unmanned. Autonomous marine mammal detection technologies are being investigated, but it is assumed that these technologies may not be available for large unmanned surface vehicle testing and training in the timeframe covered by this analysis.

Unlike for manned naval vessels, there are no historical at-sea hours or strike data upon which a large unmanned surface vessel strike analysis can be based. An additional eight at-sea days annually is a small increase in risk compared to the risk based on historical data for manned vessels; however, actual additional risk is assumed to be greater because of the lack of both lookouts and implementation of procedural mitigation. Still, this increased risk would be limited because large unmanned surface vessel at-sea days are a small portion (less than 10 percent) of overall vessel predicted at-sea days per year; large unmanned surface vessels would be substantially smaller than most naval vessels; and a portion of large unmanned surface vessel tests would include lookouts while transiting who could implement avoidance mitigation.

D.4 Seafloor Impact Area

This section describes the estimate of the seafloor disturbance due to an instantaneous impact of MEM on the seafloor. An instantaneous impact refers to the impact at the time an item first comes to rest on the seafloor; it does not consider impacts that could potentially occur due to an item residing on the seafloor over the long term (e.g., over years), such as scouring, accumulation of sediments adjacent to the item, or encrustation by benthic invertebrates. The total instantaneous impact on seafloor substrate and the benthic environment will depend on the number of MEM used and the locations where the materials reside on the seafloor. Longer-term impacts on benthic habitat and seafloor sediments are more difficult to quantify; refer to the analysis of benthic habitats in Section 3.3 (Marine Habitats) for a qualitative discussion on potential impacts on habitats and Section 3.2 (Sediments and Water Quality) for analysis on potential impacts on seafloor substrates from expended materials residing on the seafloor. The approach described in this appendix is consistent with the approach taken in the Navy's at-sea analyses for testing and training activities. For example, refer to the 2020 Northwest Training and Testing Supplemental Final Environmental Impact Statement/Overseas Environmental Impact Statement (see Appendix F, Military Expended Materials and Direct Strike Impact Analyses).

The seafloor impact analysis is based on a summation of the total number of MEM proposed for use in the PMSR and the combined footprint of those materials. The number of items (e.g., missiles) expended during the proposed testing and training events under each alternative is provided in Chapter 2 (Description of Proposed Action and Alternatives). The area of each type of expended material was estimated as the product of the item's length and width or diameter. The number of each type of MEM was then multiplied by the estimate of the area of that expended material to calculate a total seafloor impact area that would result from all expended materials of that type (e.g., all missiles). The same calculation was made for each type of expended material, and then the impact areas for all expended materials were combined to estimate at total impact area on the seafloor under each alternative. However, this total seafloor impact area only accounts for the dimensions of the expended materials.

To determine the potential level of disturbance of MEM on marine substrates, it was assumed that the impact area (or footprint) of an expended material on the seafloor was twice the size of the initial seafloor impact footprint based on the physical dimensions of the expended item (unless specified otherwise in this Appendix). Doubling the initial footprint is intended to account for any disturbance to soft bottom habitats that may extend beyond the item, such as a sediment plume that may arise when a

larger expended item impacts soft, unconsolidated sediments on the seafloor. Doubling the initial impact footprint is done regardless of the substrate type or expended material type and likely overestimates disturbance to hard bottom habitats where disturbance to the substrate is less likely to extend beyond the dimensions of the expended item (e.g., no sediment plume would be expected). Items with casings (e.g., small-, medium-, and large-caliber projectiles; flares) have their impact footprints doubled again (i.e., multiplied by four) to account for both the item and its casing, which may reside apart from the item. Items and their casings were assumed to be the same size, although in reality an item (e.g., a projectile) must be smaller than its casing to fit in the casing.

The seafloor impact footprint from expended materials used in testing and training activities in the PMSR under baseline conditions, Alternative 1, and Alternative 2 is shown in Table D-4.

Table D-4: Seafloor Impact Footprint from Military Expended Materials

Seafloor Impact Footprint (Acres)		
Current Baseline	**Alternative 1**	**Alternative 2**
0.20	0.73	0.32

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