Appendix I Military Expended Materials, Direct Strike, and Ship Strike Effects Analysis

Environmental Impact Statement/

Overseas Environmental Impact Statement

Hawaii-California Training and Testing

TABLE OF CONTENTS

List of Figures

List of Tables

APPENDIX I Military Expended Materials, Direct Strike, and Ship Strike Effects Analysis

I.1 Estimating the Effect of Military Expended Materials and Underwater Explosions on Abiotic Substrates as a Habitat for Biological Resources

This section discusses the methods and results for quantifying two scenarios under Alternative 1 and Alternative 2 of the Proposed Action: (1) the highly improbable worst-case scenario of all military expended materials or underwater explosions occurring on one particular substrate type; and (2) the unlikely, but slightly more realistic, scenario of uniform or proportional effect distribution within a particular area. Training and testing typically occurs in areas that are not called out or linked to specific activities for various reasons (e.g., flexibility and national security). Because training and testing activities would not be conducted under the No Action Alternative, it will not be discussed in this appendix.

This section describes the calculation of the disturbance footprint (i.e., military expended material footprint or explosive crater footprint) of an instantaneous effect of military expended materials or explosions on the substrate. The actual instantaneous effect on the bottom will depend on the number and location of military expended materials expended and not recovered, which is likely much lower and more concentrated than either scenario being analyzed. Longer-term effects on the bottom are far more difficult to quantify—refer to Section 3.2 (Sediments and Water Quality) and Section 3.5 (Habitats) of Chapter 3 (Affected Environment and Environmental Consequences) for qualitative discussion.

The analysis requires two data elements: (1) a tabular summary of the military expended material or crater (underwater explosions) footprints expected in training and testing areas; and (2) a tabular summary of analysis dimensions, which includes abiotic substrate areas.

- The data for (1) comes from the Hawaii-California Training and Testing (HCTT) Action Proponents and represents the most locational flexibility with regard to expenditure of military expended materials and underwater explosions. The data for the number of military expended materials and in-water explosions are then multiplied by an estimate of the footprint size. The footprints listed for various expended materials in the 2018 HSTT EIS/OEIS were rough estimates compared to the more accurate estimates used for the current analysis.
    - The footprint sizes for military expended material are estimated to be twice the size of its material footprint, to account for some disturbed sediment around the object. Items with a casing have two separate entries in the data for their impact footprints. One incorporates that size of the unrecovered casing itself and the other is for the size of the projectile. A percentage of the casings are assumed to be recovered and are not included in the footprints, which is an improvement over the analysis in the 2018 Final EIS/OEIS.
    - The footprint sizes for in-water explosive effects on the bottom are based on equations and empirical data reported in Gorodilov and Sukhotin (1996) and O'Keeffe and Young (1984). The crater footprint was then doubled to account for an area of ejected substrate.

- The data for analysis dimensions (data element 2) comes from the Benthic Habitat Database Technical Report, in addition to spatial data depicting training and testing areas.

The combined analysis dimensions data was used to create a table of substrate category acreage by training and testing areas, and large marine ecosystems. Within the HCTT Study Area there are acreages of substrate that are included under Protective Measures Assessment Protocol (PMAP) categories from the Phase III Hawaii-Southern California Training and Testing EIS/OEIS. These PMAP categories indicate the amount of mapped substrate that may be protected by Navy mitigation measures. However, the PMAP areas were not excluded from the quantitative effects analysis due to how PMAP is implemented. For more information on the substrates protected under PMAP see Chapter 5 (Mitigation).

The percentage of affected substrate was calculated by totaling the effect footprint of individual activities divided by the total area of a given substrate in the training or testing area for which the effects could occur. The results are provided in Table I-2 through Table I-5.

Assumptions used in the Scenario 1 analysis included the following:

- Areas of unknown substrate type were not included in the analysis.
- The analysis focused on substrates that are likely to have habitat for sedentary benthic organisms; therefore, areas that are not likely to have substrate inhabited by these organisms (i.e., the Pacific Basin and Abyssal Zone open ocean areas) were excluded from the analysis.
- Artificial substrate was removed from the analysis because it was inconsistently mapped or mapped with a degree of uncertainty considered too high for quantitative analysis.

I.2 Effects on Seafloor Habitats – Military Readiness Activities

Table I-1 shows the Study Area bottom types. Using the methodology and assumptions described under Section I.1 (Estimating the Effect of Military Expended Materials and Underwater Explosions on Abiotic Substrates as a Habitat for Biological Resources), Table I-2 through Table I-5 show single-year effects on applicable habitat types, from both explosive charges and military expended materials.

Table I-1: Area and Percent Coverage of Abiotic Substrate Types in the Study Area

Study Area	Habitat						Total Area (km^2)
	Hard		Mixed		Soft		
	Area (km^2)	%	Area (km^2)	%	Area (km^2)	%	
Hawaii	421,755	5.37	132,133	1.68	7,300,565	92.95	7,854,453
California	1,960	0.22	98,532	11.06	790,400	88.72	890,893
Total	423,715	4.85	230,665	2.64	8,090,965	92.52	8,745,346

Table I-2: Effect from MEM on or Near the Bottom for Military Readiness Activities under Alternative 1 in a Single Year

Training Areas	Impact Footprint (Acres)			Effect by Bottom Type (Acre)		
	Training	Testing	Combined	Hard	Mixed	Soft
Hawaii Study Area	1.794	1.136	2.930	0.263	0.303	2.364
California Study Area	5.282	2.870	8.152	0.018	0.892	7.241
Grand Total	**7.076**	**4.006**	**11.082**	**0.280**	**1.196**	**9.605**

Table I-3: Effect from MEM on or Near the Bottom for Military Readiness Activities under Alternative 2 in a Single Year

Training Areas	Impact Footprint (Acres)			Effect by Bottom Type (Acre)		
	Training	Testing	Combined	Hard	Mixed	Soft
Hawaii Study Area	2.121	1.686	3.808	0.341	0.394	3.072
California Study Area	6.219	4.010	10.229	0.023	1.120	9.086
Grand Total	**8.340**	**5.696**	**14.036**	**0.364**	**1.514**	**12.158**

Table I-4: Effect from Explosives on or Near the Bottom for Military Readiness Activities under Alternative 1 in a Single Year

Training Areas	Crater Footprint (Acres)			Effect by Bottom Type (Acre)		
	Training	Testing	Combined	Hard	Mixed	Soft
Hawaii Study Area	6.162	1.462	7.623	0.683	0.789	6.151
California Study Area	23.019	8.330	31.349	2.809	3.245	25.293
Grand Total	**29.181**	**9.792**	**38.973**	**3.492**	**4.034**	**31.443**

Table I-5: Effect from Explosives on or Near the Bottom for Military Readiness Activities under Alternative 2 in a Single Year

Training Areas	Crater Footprint (Acres)			Effect by Bottom Type (Acre)		
	Training	Testing	Combined	Hard	Mixed	Soft
Hawaii Study Area	6.439	2.121	8.560	0.708	0.818	6.374
California Study Area	26.160	17.832	43.992	3.942	4.553	35.492
Grand Total	**32.599**	**19.953**	52.551	4.650	5.371	41.866

I.3 Statistical and Probability Analysis for Estimating Direct Strike Effect 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 a marine animal from any military items resulting from the proposed training and testing activities falling toward (or directed at) the sea surface. For the purposes of this section, military items include non-explosive practice munitions, sonobuoys, acoustic countermeasures, targets, and high-energy lasers. Only marine mammals and sea turtles will be analyzed using these methods because animal densities are necessary to complete the calculations and density estimates are currently only available for marine mammals and sea turtles within the Study Area. The analysis conducted here does not account for explosive munitions because impacts from explosives are analyzed within the Navy Acoustic Effects Model as described in the report, Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase IV Training and Testing (U.S. Department of the Navy, 2024). Table I-6 provides a list of symbols used in the equations located in the preceding sections.

Table I-6: A List of Symbols and Their Brief Descriptions as They Are Used in the Analysis

Symbol	Explanation
A_S	Area of an individual marine animal
L_S	Length of an individual marine animal
W_S	Width of an individual marine animal
N_S	Number of individual animals within a single marine species
D_S	Density of animals within a single marine species
A_{TotS}	The total footprint area of a single marine species
A_{RC}	The area of a single testing/training range
L_{mun}	The length of an individual piece of military expended material
W_{mun}	The width of an individual piece of military expended material
A_{mun}	The area of an individual piece of military expended material
N_{mun}	The total number of military expended materials used of a single type (e.g., non-explosive bomb)
A_I	The total area of military expended materials used of a single type (e.g., non-explosive bomb)
A_{TotI}	The area of impact for all types of military expended materials; the impact footprint
A_{BZ}	The area of the buffer zone around the impact footprint
A_{Final}	The total area of concern, including the buffer zone (A_{BZ}), the impact footprint (A_{TotI}), and the total animal footprint of a single marine species (A_{TotS})
R_{TotS}	The total footprint radius of a single marine species
R_{TotI}	The total footprint radius of the impact footprint for all types of military expended materials
R_{BZ}	The buffer zone radius of the impact footprint for all types of military expended materials
P	The probability of impacting a marine animal through a military expended material direct exposure impact
T	Total number of possible surface animal exposures associated with a direct impact from military expended materials

I.3.1 Direct Impact Analysis

A probability was calculated to estimate the impact probability (P) and number of exposures (T) associated with direct impact of military items on marine animals and sea turtles on the sea surface within the specified training or testing area (A_{RC}) in which the activities are occurring. The statistical probability analysis is based on probability theory with "footprint" areas for marine animals and total impact inscribed inside the training or testing area. 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, marine mammals spend the majority of their time underwater (e.g., Fonseca et al., 2022; Hochscheid, 2014; Irvine et al., 2017; Lagerquist et al., 2000; Mate et al., 1995), and (2) that the animals are stationary, which does not account for any movement or any potential avoidance of the training or testing activity area. There is some research that suggests marine mammals will avoid areas where there is sonar activity but not areas where there is just vessel traffic noise; so, avoidance behavior in marine mammals is situationally dependent (for review see (Ellison et al., 2012)). For sea turtles, research has demonstrated changes in behavior of sea turtles in response to anthropogenic sounds (O'Hara & Wilcox, 1990; Samuel et al., 2005), but more research is needed to determine if they portray avoidance behavior to any form of anthropogenic activity.

There are three types of areas incorporated into the analyses: species area (A_S), total impact footprint area (A_{TotI}), and the buffer zone of the impact area (A_{BZ}). For each calculation, a basic area is assessed using either the area calculation for a rectangle (A = length * width) or a circle ($A = \pi R^2$, where R is the radius of a circle). These area calculations were used in four different scenarios that make assumptions about the type of interaction between the marine animal and the military expended materials. For the initial three scenarios, all areas are calculated using the rectangular method. For the fourth scenario, all areas are calculated using the circular method.

- 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) with a military expended material directly hitting a marine animal. This scenario assumes the marine animal is fully inside the impact area when contact with the military expended material is made.
- Scenario 2: Dynamic scenario with end-on collision. It is assumed that the military expended material is moving through the water, in the same direction as the length of the impact zone, for a distance of six times the initial length of the impact area. The concept here is that the military expended material has forward momentum along the length of the impact area and can make contact with the marine animal at any point inside of this new impact footprint area.
- Scenario 3: Dynamic scenario with broadside collision. It is assumed that the military expended material is moving through the water, in the same direction as the width of the impact zone, for a distance of six times the initial width of the impact area. The concept here is that the military expended material has forward momentum along the width of the impact area and can make contact with the marine animal at any point inside of this new impact footprint area.
- Scenario 4: Purely static, radial scenario, in which the rectangular animal, buffer zone, and impact footprints are replaced with circular footprints. Basically, the assumption is that the animal and the military expended materials are moving in circular patterns, rather than straight paths. This scenario assumes the marine animal is fully inside the impact area when contact with the military expended material is made.

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 six times the impact area's length or width. Significantly different values may result from the static and dynamic orientation scenarios. Both 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).

The method of area (A_S, A_{TotI}, and A_{BZ}) calculation will vary slightly with each scenario. First, the basic concepts behind the area calculations are addressed below.

- The individual animal area (A_S) was calculated by multiplying the length and the width of the animal ($A_S = L_S * W_S$), where width was 20 percent of the length for marine mammals and 84% of the length for sea turtles. Then, the species density and the range complex (A_{RC}) size were incorporated to produce the species total area (A_{TotS}). A_S was multiplied by the number of animals (N_S) in the specified training or testing area, where N_S was the product of the highest average month animal density (D_S) and the area of the range complex ($A_{TotS} = A_S * N_S = A_S * D_S * A_{RC}$). As a conservative scenario, the total animal footprint area was calculated for the species with the highest average monthly density in the training or testing area with the highest use of military items within the entire Study Area. For the remainder of the calculations A_{TotS} was used to represent the presence of the species within the area.

- To assess the impact footprint area (A_I) for a single type of munition used in the range complex, the area of the munition (A_{mun}) was calculated by multiplying the length and width of the munition ($A_{mun} = L_{mun} * W_{mun}$). Then, A_{mun} was multiplied by the total number of that munition type used in a year (N_{mun}). Thus, $A_I = N_{mun} * A_{mun}$ is the impact footprint for a single type of munition in a single range complex over a year.
- The A_I for each munition type used in the range complex was then summed across all munition types to get a total impact footprint (A_{TotI}) for a year within a single range complex. As a conservative scenario, the total impact footprint area was calculated for the training or testing area with the highest use of military items within the entire Study Area. This total impact footprint area was then converted back into the length-width assessment, with the ratio of the impact area mirroring the animal $\frac{W_S}{L_S} = \frac{W_{TotI}}{L_{TotI}}$.
- In addition to the impact footprint and the species footprint, a buffer zone around the impact area footprint was included in the analysis. The purpose of this buffer zone was to be overly protective of the species to ensure that any species just outside of the impact area were also included in the analysis. The buffer zone was simply calculated by taking half of the area of the total impact footprint ($A_{BZ} = A_{TotI} * 0.5$) for the rectangular scenarios. For the circular scenarios, an additional buffer zone radius (R_{BZ}) was calculated.

These calculations were then fed into the final calculation area (A_{Final}) for the three rectangular scenarios (Scenarios 1-3). So, $A_{Final1} = A_{BZ1} + A_{TotI1} + A_{TotS}$, where 1 designates Scenario 1. The same concept was applied for Scenarios 2 and 3, except the L_{TotI} for Scenario 2 was multiplied by 6 and the W_{TotI} for Scenario 3 was multiplied by 6, which influence both A_{TotI} and A_{BZ} for each of the scenarios. In each case, the buffer zone could also be calculated by simple subtraction $A_{BZ} = A_{Final} – A_{TotI} – A_S$, for each respective scenario. For Scenario 4, the radial scenario, the area calculation was based on a circle. $A_{Final4} = \pi * (R_{TotS} + R_{TotI} + R_{BZ})^2$. To calculate the buffer zone from the final area, the following equation could also be used: $A_{BZ4} = \sqrt{(\frac{A_{Final4}}{\pi})} - R_{TotI} - R_{TotS}$.

Impact probability (P) is the probability of impacting one animal at its species peak density, with the given number, type, and dimensions of all military items used in training or testing activities occurring in the area per year. Therefore, P is the ratio of the final area for each scenario, which includes the species area, the impact footprint, and the buffer zone of the impact footprint, and the range complex area ($P = \frac{A_{Final}}{A_{RC}}$, where A_{Final} is based on the value calculated in each scenario). The total number of possible exposures (T) within a given year is a product of the species density, the area of the range complex, and the impact probability ($T = (D_S * A_{RC})*P$). Using this procedure, P and T were calculated for each of the four scenarios, for the Endangered Species Act (ESA)-listed marine mammals and the non-ESA marine mammal and ESA-listed sea turtle species with the highest average month density (used as the annual density value) and for each military item type. 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 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 training and testing 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.

I.3.2 Parameters for Analysis

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

- Two action alternatives: Alternative 1 and Alternative 2. Animal densities, animal dimensions, and military item dimensions are the same for the two action alternatives.
- Two training or testing areas: Hawaii Study Area and California Study Area. Areas are approximately 806,027 square kilometers and 912,350 square kilometers, respectively.
- The following types of non-explosive munitions or other items:
  - **Small-caliber projectiles**: up to and including 0.50 caliber rounds
  - **Medium-caliber projectiles:** larger than 0.50 caliber rounds but smaller than 57 millimeters (mm) projectiles
  - **Large-caliber projectiles:** includes projectiles greater than or equal to a 57 mm projectile
  - **Missiles:** includes rockets and jet-propelled munitions
  - **Bombs:** Non-explosive practice bombs and mine shapes, ranging from 10 to 2,000 pounds
  - **Torpedoes:** includes all lightweight torpedoes
  - **Sonobuoys:** includes all sonobuoys
  - **Targets:** includes expended airborne and surface, as well as mine shapes
  - **Lightweight torpedo accessories:** includes all accessories that are dropped along with the torpedo (e.g., nose cap, air stabilizer)
  - **Anchors:** includes blocks used to anchor mine shapes to the seafloor
  - **Acoustic countermeasures:** includes aircraft deployed acoustic countermeasures
  - **High-energy lasers**: includes high-energy laser weapons that are directed at a surface target
  - **Expended bathythermographs**: small sensor deployed from ships
- Animal species of interest: The species of ESA-listed marine mammals expected in the HCTT Study Area and the non-ESA listed marine mammal with the highest average month density in the Hawaii Study Area and the California Study Area.
- All sea turtles are ESA-listed and are included if their presence in each area is expected.

I.3.3 Output Data

Estimates of impact probability (P) and number of exposures (T) for a given species of interest were made for the specified training or testing area with the highest annual number of military items used 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 military items) for the two alternatives.

Results for marine mammals and sea turtles are presented in Table I-7 through Table I-10.

Table I-7: Estimated Representative Marine Mammal Exposures from Direct Strike of a High-Energy Laser by Area and Alternative in a Single Year

Hawaii Study Area				
Species	Training		Testing	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Blue Whale	0.0000006	0.0000006	0.0000006	0.0000006
Fin Whale	0.0000026	0.0000026	0.0000027	0.0000027
Humpback Whale	0.0001250	0.0001250	0.0001273	0.0001277
Sperm Whale	0.0000683	0.0000683	0.0000699	0.0000702
Sei Whale	0.0000008	0.0000008	0.0000009	0.0000009
Killer Whale	0.0000017	0.0000017	0.0000019	0.0000019
False Killer Whale (MHI Insular DPS)	0.0000020	0.0000020	0.0000023	0.0000024
Hawaiian Monk Seal	0.0000460	0.0000460	0.0000507	0.0000516
Rough-toothed Dolphin	0.0022764	0.0022764	0.0040113	0.0047075
California Study Area				
Species	Training		Testing	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Blue Whale	0.0021360	0.0021360	0.0026125	0.0027501
Fin Whale	0.0770323	0.0021360	0.0807100	0.0815756
Gray Whale	0.0398065	0.0021360	0.0452267	0.0466958
Humpback Whale	0.0016596	0.0021360	0.0022606	0.0024442
Sperm Whale	0.0001209	0.0021360	0.0002654	0.0003145
Sei Whale	0.0000006	0.0021360	0.0000078	0.0000106
Killer Whale	0.0000001	0.0021360	0.0000049	0.0000067
Guadalupe Fur Seal	0.0007741	0.0021360	0.0031727	0.0040357
Short-beaked Common Dolphin	1.4873838	1.4873838	1.5124785	1.5131423

Table I-8: Estimated Representative Sea Turtle Exposures from Direct Strike of a High-Energy Laser by Area and Alternative in a Single Year

Hawaii Study Area				
Species	**Training**		**Testing**	
	Alternative 1	**Alternative 2**	**Alternative 1**	**Alternative 2**
Green Turtle	0.0000001	0.0000001	0.0000002	0.0000002
Hawksbill Turtle	0.0000000	0.0000000	0.0000000	0.0000000
Leatherback Turtle	0.0000032	0.0000032	0.0000038	0.0000039
Loggerhead Turtle	0.0000029	0.0000029	0.0000037	0.0000039
Olive Ridley Turtle	0.0000014	0.0000014	0.0000021	0.0000023
California Study Area				
Species	**Training**		**Testing**	
	Alternative 1	**Alternative 2**	**Alternative 1**	**Alternative 2**
Green Turtle	0.0057387	0.0057387	0.0061786	0.0061921
Leatherback Turtle	0.0000019	0.0000019	0.0000042	0.0000043
Loggerhead Turtle	0.0001591	0.0001591	0.0002079	0.0002096

Table I-9: Estimated Representative Marine Mammal Exposures from Direct Strike of Military Expended Materials by Area and Alternative in a Single Year

Hawaii Study Area				
Species	**Training**		**Testing**	
	Alternative 1	**Alternative 2**	**Alternative 1**	**Alternative 2**
Blue Whale	0.0000040	0.0000045	0.0000024	0.0000032
Fin Whale	0.0000077	0.0000085	0.0000055	0.0000066
Humpback Whale	0.0002346	0.0002492	0.0001881	0.0002124
Sperm Whale	0.0001560	0.0001680	0.0001180	0.0001378
Sei Whale	0.0000076	0.0000086	0.0000044	0.0000060
Killer Whale	0.0000196	0.0000223	0.0000113	0.0000156
False Killer Whale (MHI Insular DPS)	0.0000330	0.0000377	0.0000185	0.0000260
Hawaiian Monk Seal	0.0004796	0.0005445	0.0002783	0.0003825
Rough-toothed Dolphin	0.0053458	0.0057675	0.0040113	0.0047075
California Study Area				
Species	**Training**		**Testing**	
	Alternative 1	**Alternative 2**	**Alternative 1**	**Alternative 2**
Blue Whale	0.0031050	0.0032710	0.0026125	0.0027501
Fin Whale	0.0836673	0.0845990	0.0807100	0.0815756
Gray Whale	0.0504150	0.0521321	0.0452267	0.0466958
Humpback Whale	0.0029248	0.0031521	0.0022606	0.0024442
Sperm Whale	0.0004465	0.0005101	0.0002654	0.0003145
Sei Whale	0.0000180	0.0000216	0.0000078	0.0000106
Killer Whale	0.0000118	0.0000143	0.0000049	0.0000067
Guadalupe Fur Seal	0.0063822	0.0075207	0.0031727	0.0040357
Short-beaked Common Dolphin	1.9583771	2.0361045	1.7250189	1.7907992

Table I-10: Estimated Representative Sea Turtle Exposures from Direct Strike of Military Expended Materials by Area and Alternative in a Single Year

Species	Training		Testing	
Hawaii Study Area				
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Green Turtle	0.0000139	0.0000161	0.0000073	0.0000107
Hawksbill Turtle	0.0000025	0.0000029	0.0000013	0.0000019
Leatherback Turtle	0.0000652	0.0000746	0.0000360	0.0000511
Loggerhead Turtle	0.0001002	0.0001151	0.0000540	0.0000778
Olive Ridley Turtle	0.0000940	0.0001083	0.0000498	0.0000726
California Study Area				
Species	**Training**		**Testing**	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Green Turtle	0.0202469	0.0230685	0.0121948	0.0143809
Leatherback Turtle	0.0001430	0.0001730	0.0000596	0.0000818
Loggerhead Turtle	0.0025325	0.0030239	0.0011550	0.0015238

I.4 Navy and Coast Guard Vessel Strike of Large Whale Species

Vessel strike to marine mammals is not associated with any specific training or testing activity but rather an inadvertent, limited, sporadic, and incidental result of Navy and Coast Guard vessel movement within the Study Area. A detailed analysis of HCTT strike data and probability calculations used to justify the HCTT strike request are presented here. The Navy and Coast Guard do not anticipate vessel strikes to result in a significant population threat to marine mammal populations within the HCTT Study Area. This assessment is based on the probabilities presented in the strike analysis, the cumulative recent history of Navy vessel strikes over 16.6 years from January 2009 through August 2025 (7 strikes), establishment and updates to the Navy's Marine Species Awareness Training requirements across the Navy, and adaptation of additional mitigation measures since 2018. However, the Navy and Coast Guard are electing to request takes from vessel strikes in the HCTT Study Area as a cautionary acknowledgment that some probability of ship strike could occur over a seven-year authorization. Stricken animals are not easily identifiable to the species level; therefore, the Navy or Coast Guard cannot quantifiably predict that any proposed strike takes will be of a particular species. The Navy and Coast Guard therefore seek take authorization for a select combination of the marine mammal stocks in the HCTT study area that may be more susceptible to being struck.

I.4.1 Summary of Navy Ship Strike Request

Based on the probabilities of whale strikes suggested by an analysis of past strike data and anticipated future training and testing at-sea days, the Navy requests authorization for take of no more than seven (7) large whales of any of the following combined stocks, by injury or mortality, resulting from vessel strike incidental to the Navy training and testing activities within any portion of the Study Area over the course of the seven years of the HCTT regulations.

This strike request would include a combination of the following species and stocks, not to exceed seven (7) total strikes over seven years:

- one strike for blue whales (Eastern North Pacific Stock)
- up to five strikes for fin whales (California/Oregon/Washington Stock)

- up to two strikes for gray whales (Eastern North Pacific Stock)
- one strike for humpback whales (Mainland Mexico-California-Oregon-Washington Stock)
- one strike for humpback whales (Central America/Southern Mexico-California-Oregon-Washington Stock)
- one strike for humpback whales (Hawaii Stock)
- one strike for sei whales (Eastern North Pacific Stock)
- one strike for sperm whales (Hawaii stock)

I.4.2 Summary of Coast Guard Ship Strike Request

Based on the probabilities of whale strikes suggested by an analysis of past strike data and anticipated future training and testing at-sea days, the Coast Guard requests authorization for take of no more than two (2) large whales of any of the following combined stocks, by injury or mortality, resulting from vessel strike incidental to the Coast Guard training activities within any portion of the HCTT Study Area over the course of the seven years of the HCTT regulations. This strike request would include a combination of the following species and stocks, not to exceed two (2) total strikes over seven years:

- one strike for blue whales (Eastern North Pacific Stock)
- up to two strikes for fin whales (California/Oregon/Washington Stock)
- up to two strikes for gray whales (Eastern Pacific Stock)
- up to two strikes for humpback whales (Mainland Mexico-California-Oregon-Washington Stock)
- up to two strikes for humpback whales (Central North Pacific Stock)

I.4.3 Probability of Vessel Strike of Large Whale Species

To conduct a statistical analysis of future Navy ship strikes within HCTT, three basic components are required:

1. Number of Navy or Coast Guard ship strikes to large whales for the 16.6-year period prior to the period for which new Marine Mammal Protection Act (MMPA) authorization is being sought (2009–2025).
2. Amount of Navy or Coast Guard at-sea surface vessel days for the 16.6-year period (2009–2025) prior to the period for which new MMPA authorization is being sought.[1]
3. Estimate of future Navy or Coast Guard at-sea surface vessel days for the requested new authorization seven-year period (December 2025–December 2032).

I.4.3.1 HCTT Strikes

There were seven large whale strikes within HCTT by Navy surface ships between January 2009 and August 2025 (Figure I-1), all in Southern California (SOCAL). For the Coast Guard, there was one strike in

[1] To assess the most current vessel traffic information available, the Navy utilized a classified positional database currently known as Authoritative Maritime Services. Roughly 800 million positional vessel data records spanning the years 2016–2023 were extracted and analyzed. The positional data was spatially explicit meaning only records of position and transits within the subareas of HCTT were used; SOCAL Range Complex, Hawaii Range Complex, Point Mugu Sea Range, Northern California Range Complex, and the transit lane between California and Hawaii. Most of the data records obtained are civilian commercial shipping (tanker vessels, cargo vessels, large fishing vessels, etc.). Navy vessel transits typically only account for 5 percent or less of overall total vessel movements within the Study Area. For this ship strike analysis, only Navy and Coast Guard data is presented. Later in this analysis, it is explained how the most recent dataset was used to make assumptions about vessel traffic from 2009 to 2015.

Hawaii over the same period. It should be noted that there were 13 years where no Navy strikes occurred, including a consecutive 11-year period with no strikes (2010–2020, 2022, 2024).

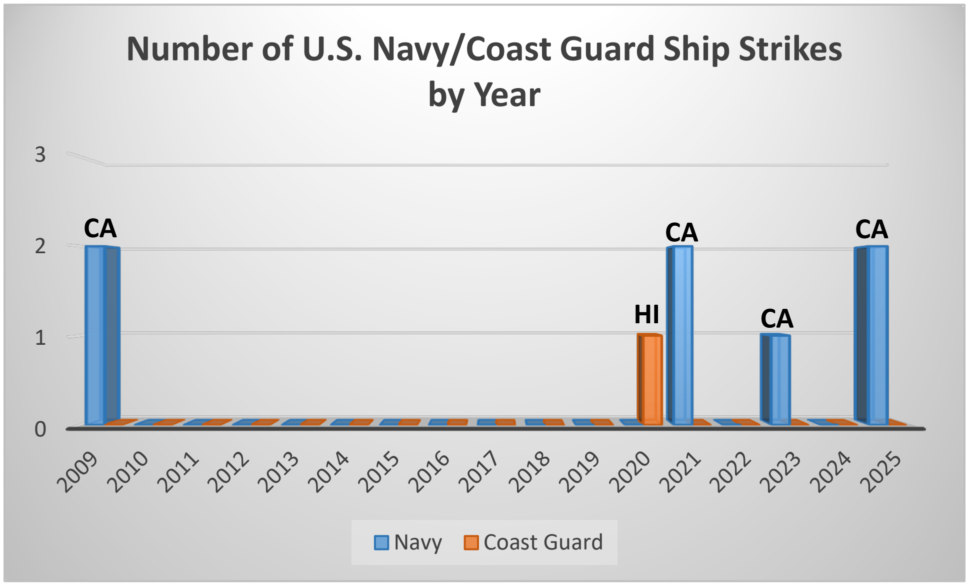

Figure I-1: HCTT Navy and Coast Guard Ship Strikes 2009–2025

I.4.3.2 HCTT Number of At-Sea Days (7 Years from 2017 to 2023)

Background **-** The entire period of Navy at-sea MMPA authorization for Hawaii and California was considered in the analysis of strike history. The period from 2009 to 2025, therefore, was selected as the most appropriate time frame to calculate potential probability of a large whale ship strike from Navy or Coast Guard vessels in the HCTT Study Area over the term of anticipated new seven-year permit (December 2025–December 2032).

The analysis discussed in the application is specific to Navy larger size class vessels over 127 meters (m) (418 feet [ft.]) that have been involved with HCTT strikes between 2009 and 2025. While required to report any strike incidents, there have been no Navy reports over the analysis period (2009–2025) of vessel strikes to whales in HCTT from smaller Navy vessel and boat classes (e.g., tugs, service craft, landing craft, special operations Rigid Hull Inflatable Boat. Furthermore, no vessel movement tracking data is available for these smaller craft which are not subject to the same systems as larger vessels. In addition, during the Hawaii-Southern California Training and Testing Phase III authorization period from 2018 to date there have been no whale strikes from various size classes of Navy unmanned surface vessels (USV).

Tracking data for Coast Guard vessels is only available for larger ship classes longer than 100 m (328 ft.). The one Coast Guard strike within the Study Area was from a smaller craft between 40 and 100 ft. for which tracking data is not available. For calculation purposes, the larger Navy and Coast Guard vessel tracking data is sufficient for worst case serious injury or mortality probability predictions. Smaller vessel and craft sizes at-sea time is relatively similar in both the prior permit period and forecasted future permit period

Analysis Assumptions- The Navy's analysis based on 2016–2023 data has significantly better fidelity related to vessel at-sea days specifically within the Study Area than previously used analysis. The current information overall is more accurate by area and time. Previous estimates of at-sea vessel days between

2009-2015 included movements throughout the Pacific, not just within the Study Area. Nor did the data provide results proportioned to the various sub-areas or range complexes within HCTT. Therefore, the Navy used the average of the 2016–2023 annual values as a surrogate for annual at-sea days for each year between 2009 and 2015. The annual value for 2023 was used for 2024.

As expected, due to the higher number of homeported ships in San Diego as opposed to Pearl Harbor[2], more Navy ship traffic occurs in the Southern California Range Complex (Figure I-2).

Results- In this analysis, cumulative Navy at-sea days from 2009 to August 2025 was calculated to be 36,306 days for Navy manned vessels greater than 127 m (418 ft. or Littoral Combat Ship [LCS] size and above[3]) and various sizes of USVs.

For Coast Guard vessels greater than 100 m (328 ft.), the cumulative total from 2009 to 2024 was 4,351 days based on review of the same dataset as used for the Navy.

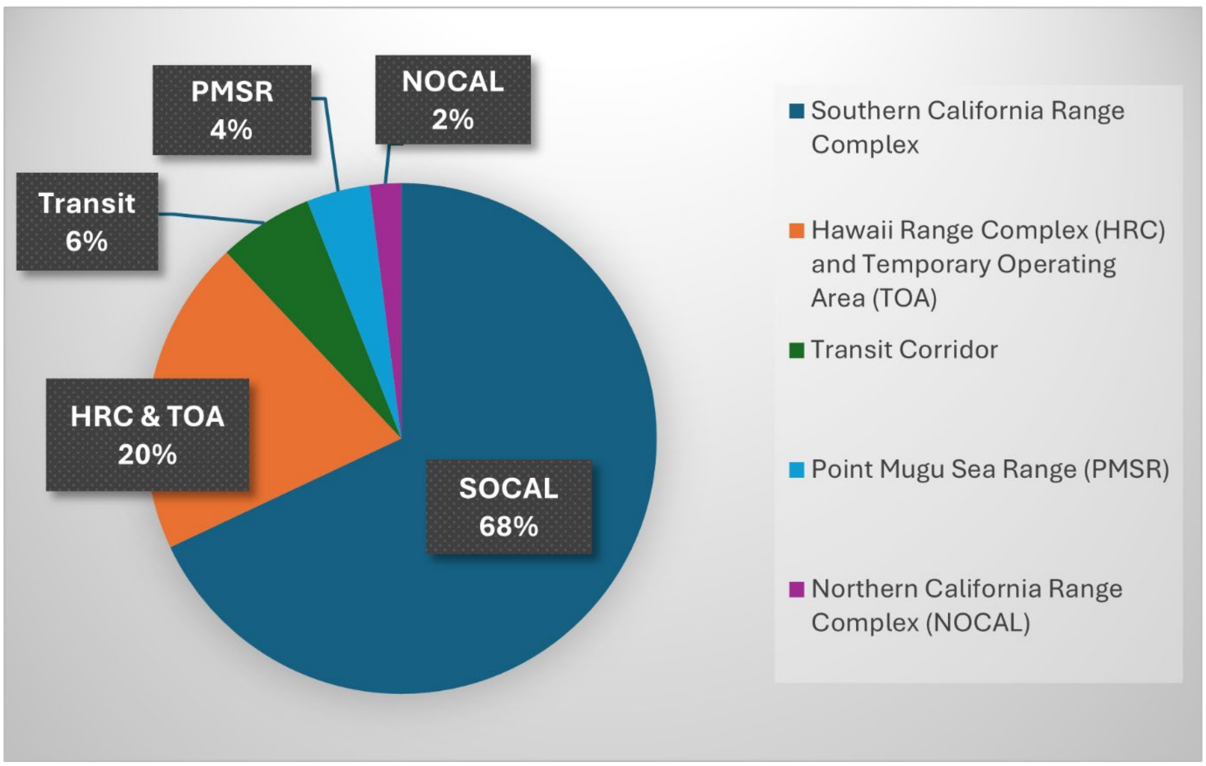

Figure I-2: U.S. Navy At-Sea Surface Vessel Days by Sub-Areas Within HCTT 2016–2023

[2] As of February 2025, there were 55 Navy surface vessels homeported in San Diego with another 7 that could be part of training in SOCAL but are homeported in the Pacific Northwest. Nineships are homeported in Hawaii although some of these would also travel to SOCAL for various integrated training activities.

[3] LCS is the smallest U.S. Navy ship class included in the vessel strike analysis based on the data available. To date, there has not been a Navy ship strike of a whale from a LCS vessel. The smallest Navy ship class with documented strikes from 2009 to 2024 is the Arleigh Burke destroyer (Guided Missile Destroyer). Guided Missile Destroyers can be up to 505 feet (154 m) long depending on destroyer build year and version.

I.4.3.3 HCTT Estimate of Future At-Sea Days (7 Years from December 2025 to December 2032)

Caveats- Navy surface vessel traffic within the HCTT Study Area has been variable by year from 2009 to August 2025. Therefore, the Navy believes an average of the 16.6-year cumulative total from 2009 to August 2025 is a sufficient prediction of future at-sea days for manned surface ships from 2026 to 2032.

In the HCTT, the 2009–2025 16.6-year total is 36,306 at-sea days, or 2,187 days per year. This was used as the starting point for an annual estimate contributing to the cumulative total of future at-sea days over the pending HCTT authorization. In addition, a new category of vessel type is soon to be transferred to HCTT for testing during the upcoming permit period. These are larger sized USVs longer than 61 m (200 ft.) in length. Although there has not been a whale ship strikes from USVs, out of an abundance of caution for this newer larger class of USVs, the Navy is adding large USV annual at-sea days with the manned annual at-sea days above (final annual at-sea days 2,187+728=2,915). Therefore, the cumulative total for the December 2025–December 2032 period for Navy manned and large USV at-sea days is 20,345 (2,915 times 7).

The Coast Guard 16.6-year average at-sea days was 262. Therefore, 262 days per year is used for the annual at-sea days between December 2025 and December 2032. To account for limitations in data availability particular to Coast Guard vessel size classes, future new vessel or repositioning home port assignments, in consideration of documented strikes from Coast Guard medium sized vessels <100 m, and out of an abundance of caution, the Coast Guard has elected to add an extra 60 at-sea days per year for the 2026–2032 period. The cumulative total for this period including the annual supplemental addition is 2,534.

I.4.3.4 Calculations Series for Estimated Strike Probabilities

The probability of a vessel strike to whales is influenced by the amount of time at-sea for Navy or Coast Guard surface vessels within the HCTT Study Area and the number of strikes over those years. This generates a specific strike rate. For the period 2009–2025, there were seven Navy strikes over 36,306 at-sea days. Dividing the Navy reported strikes by ship at-sea days (i.e., 7 divided by 36,306) results in a strike rate of 0.000193 strikes per day. For the period 2009–2025, there was one Coast Guard strike over 4,351 at-sea days. Dividing the Coast Guard reported strikes by ship at-sea days (i.e., 1 divided by 4,351) results in a strike rate of 0.000230 strikes per day.

Navy. Estimated Navy cumulative ship at-sea days within HCTT for the period from December 2025 to December 2032 is 20,345 days. The previously calculated strike rate (0.000193 strikes per day) can be multiplied by the estimated at-sea days from December 2025 to December 2032 to estimate the number of predicted whale strikes anticipated over this period (0.000193 strikes per day times 20,345 days). This formula calculates up to 3.9226 strikes from December 2025 to December 2032.

During previous consultations, the National Marine Fisheries Service and Navy agreed to using a Poisson distribution as the most appropriate statistical approach for calculating future strike probabilities. A Poisson distribution is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time. It is often used to describe random occurrences when the probability of an occurrence is small; for example, count data such as cetacean sighting data or in this case vessel strike data, often described as a Poisson or over-dispersed Poisson distribution. Therefore, the probabilities of a specific number of strikes over the period from December 2025 to December 2032 can be derived from the Poisson distribution.

The formula for a Poisson distribution is: $$P\langle n \mid \mu \rangle = \frac{e^{-\mu} \bullet \mu^{n}}{n!}$$

P(*n*|*μ*) is the probability of observing n events in some time interval, when the expected number of events in that time interval is *μ*. For this analysis, *μ* is the estimated December 2025–December 2032 strike rate of 3.9226. Using this strike rate (3.9226), the Poisson distribution can estimate the probability of *n* where *n*=0 (no strikes), 1 strike, 2 strikes, 3 strikes, 4 strikes, or 5 strikes, as well as the probability of *n* where *n* is greater than a number from 1 to 5. The probability of *n*>x is presented below:

P(*n*>0) is 0.980 or a 98.0 percent chance of more than zero strikes

P(*n*>1) is 0.903 or a 90.3 percent chance of more than one strike

P(*n*>2) is 0.750 or a 75.0 percent chance of more than two strikes

P(*n*>3) is 0.551 or a 55.1 percent chance of more than three strikes

P(*n*>4) is 0.356 or a 35.6 percent chance of more than four strikes

P(*n*>5) is 0.203 or a 20.3 percent chance of more than five strikes

P(*n*>6) is 0.103 or a 10.3 percent chance of more than six strikes

P(*n*>7) is 0.047 or a 4.7 percent chance of more than seven strikes

(percentages above rounded to nearest whole value)

Coast Guard. Estimated Coast Guard cumulative ship at-sea days within HCTT for the period from December 2025–December 2032 is 2,534 days. The previously calculated strike rate (0.000230 strikes per day) can be multiplied by the estimated at-sea days from December 2025 to December 2032 to estimate the number of predicted whale strikes anticipated over this period (0.000230 strikes per day times 2,534 days). This calculation estimates up to 0.5824 strikes from December 2025 to December 2032. Using this strike rate (0.5824), the Poisson distribution can estimate the probability of *n* where n=0 (no strikes), 1 strike, or 2 strikes for December 2025–December 2032:

P(*n*>0) is 0.441 or a 44.1 percent chance of more than zero strikes

P(*n*>1) is 0.116 or a 11.6 percent chance of more than one strike

P(*n*>2) is 0.021 or a 2.1 percent chance of more than two strikes

(percentages above rounded to nearest whole value)

References

Ellison, W. T., B. L. Southall, C. W. Clark, and A. S. Frankel. (2012). A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds. *Conservation Biology 26* (1): 21–28. DOI:10.1111/j.1523-1739.2011.01803.x

Fonseca, C. T., S. Pérez-Jorge, R. Prieto, C. Oliveira, M. Tobeña, A. Scheffer, and M. A. Silva. (2022). Dive behavior and activity patterns of fin whales in a migratory habitat. *Frontiers in Marine Science 9*. DOI:10.3389/fmars.2022.875731

Gorodilov, L. V. and A. P. Sukhotin. (1996). Experimental investigation of craters generated by explosions of underwater surface charges on sand. *Combustion, Explosion, and Shock Waves 32* (3): 344–346.

Hochscheid, S. (2014). Why we mind sea turtles' underwater business: A review on the study of diving behavior. *Journal of Experimental Marine Biology and Ecology 450* 118–136. DOI:10.1016/j.jembe.2013.10.016

Irvine, L., D. M. Palacios, J. Urbán, and B. Mate. (2017). Sperm whale dive behavior characteristics derived from intermediate-duration archival tag data. *Ecology and Evolution 7* (19): 7822–7837. DOI:https://doi.org/10.1002/ece3.3322

Lagerquist, B. A., K. M. Stafford, and B. R. Mate. (2000). Dive characteristics of satellite-monitored blue whales (*Balaenoptera musculus*) off the central California coast. *Marine Mammal Science 16* (2): 375–391. DOI:https://doi.org/10.1111/j.1748-7692.2000.tb00931.x

Mate, B. R., K. A. Rossbach, S. L. Nieukirk, R. S. Wells, A. Blair Irvine, M. D. Scott, and A. J. Read. (1995). Satellite-monitored movements and dive behavior of a bottlenose dolphin (*Tursiops truncatus*) in Tampa Bay, Florida. *Marine Mammal Science 11* (4): 452–463. DOI:https://doi.org/10.1111/j.1748-7692.1995.tb00669.x

O'Hara, J. and J. R. Wilcox. (1990). Avoidance responses of loggerhead turtles, *Caretta caretta*, to low frequency sound. *Copeia 1990* (2): 564–567.

O'Keeffe, D. J. and G. A. Young. (1984). *Handbook on the Environmental Effects of Underwater Explosions*. Silver Spring, MD: U.S. Navy, Naval Surface Weapons Center (Code R14).

Samuel, Y., S. J. Morreale, C. W. Clark, C. H. Greene, and M. E. Richmond. (2005). Underwater, low-frequency noise in a coastal sea turtle habitat. *The Journal of the Acoustical Society of America 117* (3): 1465–1472. DOI:10.1121/1.1847993

U.S. Department of the Navy. (2024). *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase IV Training and Testing* (Technical Report prepared by Naval Information Warfare Center Pacific). San Diego, CA: Naval Undersea Warfare Center.