Appendix F Military Expended Material and Direct Strike Impact Analyses

Supplemental Environmental Impact Statement/ Overseas Environmental Impact Statement Northwest Training and Testing

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APPENDIX F MILITARY EXPENDED MATERIAL AND DIRECT STRIKE IMPACT ANALYSES

F.1 Estimating The Impact of Military Expended Materials and Underwater Explosions on Abiotic Substrates as a Habitat for Biological Resources

This section describes the calculation of the disturbance footprint (i.e., military expended material footprint or explosive crater footprint) of an instantaneous impact of military expended materials or explosions on the substrate. The actual instantaneous impact 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 impacts on the bottom are far more difficult to quantify—refer to the Marine Habitats section (3.3) of Chapter 3 (Affected Environment and Environmental Consequences) for qualitative discussion. The approach described in this appendix is consistent with the approach taken in the 2015 Northwest Training and Testing (NWTT) Final Environmental Impact Statement (EIS)/Overseas Environmental Impact Statement (OEIS) (see Appendix H, Statistical Probability Analysis for Estimating Direct Air Strike Impact and Number of Potential Exposures).

The analysis requires a tabular summary of the military expended material or crater (underwater explosions) footprints expected in training and testing areas. The data comes from the NWTT action proponents and represents the most locational flexibility with regard to expenditure of military expended materials and underwater explosions. The data for both expended and recovered material are reported in Table F-1 below. Appendix A (Navy Activities Descriptions) of the 2015 NWTT Final EIS/OEIS provides basic descriptions of military expended materials, and Chapter 3 (Section 3.0.3.2, Explosive Stressors) provides basic descriptions of explosive categories. The data for number of military expended materials and underwater explosions are then multiplied by an estimate of the footprint size documented in Table F-1.

To determine the potential level of disturbance of military expended materials on marine substrates, it was assumed that the impact area (footprint) of the expended material on the seafloor is twice the size of its physical size (unless specified otherwise in Appendix F notes). By doubling the footprint, the results should more accurately reflect the potential disturbance to soft bottom habitats (i.e., to account for sediment plumes), but should overestimate disturbance to hard bottom habitats (i.e., because sediment plumes are not expected). These calculations do not consider the Navy's mitigation measures for seafloor resources, which are detailed in Appendix K (Geographic Mitigation Assessment). 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 (i.e., worst case), 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.

Additionally, highly explosive munitions that explode either at the surface or in the water column were treated in the same manner as non-explosive practice munitions, although in reality, the explosions would result in smaller fragments reaching the substrate than expected by the fully intact non-explosive practice munitions.

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] ($ft.^2$)*	*MEM Size ($ft.^2$)*	*MEM Footprint ($ft.^2$)*	*Material Specific Notes*
Bomb	Bombs (Explosive)	NA	NA	8.1203	112.9048	The MEM footprint was calculated using the bomb with the largest footprint in terms of material fragments.
	Bombs (Non-explosive)	NA	NA	8.1203	112.9048	
Countermeasure	Acoustic Countermeasures	NA	NA	0.31107	1.2432	Includes all type of non-recoverable Acoustic Countermeasures
	Chaff-Air Cartridge	NA	NA	0.0012	0.0022	Chaff is a radar reflector material made of thin, narrow, metallic strips cut in various lengths to elicit frequency responses, which deceive enemy radars. Chaff-Air is fired from an aircraft using a small cartridge.
	Chaff-Ship Cartridge	NA	NA	2.000	4.000	Chaff-ship serves the same purpose of chaff-air. It is fired from a ship in cartridges.
	Anti-torpedo Torpedo	NA	NA	4.5424	9.0847	The Countermeasure Anti-torpedo consists of an anti-torpedo torpedo enclosed within All Up Round Equipment canister. The anti-torpedo torpedo is a 6.75-inch diameter high-maneuverability hard-kill torpedo designed to rapidly intercept and engage an incoming threat torpedo. The All Up Round Equipment consists of a nose sabot, ram plate, launch tube, muzzle cover, and breech mechanism to encapsulate, protect, and ultimately launch the anti-torpedo torpedo. Anti-torpedo torpedoes are frequently recovered; assume all are non-recoverable for worst-case.
Missiles	Missiles (Explosive)	NA	NA	37.3669	74.7338	MEM size based on SM-6
	Missile (Non-explosive)	NA	NA	31.0011	62.0023	MEM size based on Tomahawk

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions (continued)

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] (ft.^{2})*	*MEM Size (ft.^{2})*	*MEM Footprint (ft.^{2})*	*Material Specific Notes*
Other	Air-launched Lightweight (Explosive) Torpedo	NA	NA	19.1199	38.2399	MEM size based on MK50/MK54
	Air-launched Lightweight (Non-explosive) Torpedo	NA	NA	19.1199	38.2399	MEM size based on MK50/MK54. Typically recovered
	AMNS/EMNS Neutralizer (Explosive)	50%	430.5564	1.6286	3.2572	AMNS is air deployed whereas EMNS is ship deployed
	AMNS Neutralizer (Non-explosive)	NA	NA	0.1513	0.3026	The neutralizer itself is recovered, but the associated fiber optic cable and the can that holds the fiber optic cable is not.
	Anchor (Expendable)	NA	NA	6.2495	12.5001	Associated primarily with mine shapes.
	Anchor (Recoverable)	NA	NA	6.2495	12.5001	Associated primarily with mine shapes and ships.
	Biodegradable Polymer	NA	NA	NA	NA	A substance composed of molecules that degrade as a result of microorganisms and/or enzymes. Footprint is not applicable because the material breaks up within a couple of hours, depending on the material composition of the polymer. Reference: Karlsson and Albertsson (1998).
	Bottom Placed Instruments	NA	NA	2.0000	4.000	Usually a moored tracking beacon, typically weighing around 50 pounds covering approximately 2 ft.^{2} of seafloor.
	Buoy (Explosive)	NA	NA	0.9752	3.8987	Explosive buoys including mini-sound source and SUS. MEM-size based on Marine Marker.

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions (continued)

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] ($ft.^2$)*	*MEM Size ($ft.^2$)*	*MEM Footprint ($ft.^2$)*	*Material Specific Notes*
Other (continued)	Buoy (Non-explosive)	NA	NA	0.9752	3.8987	These buoys are separate from sonobuoys, and are included for DWADS (expendable). MEM size based on Marine Marker. Can be expended or recovered.
	Concrete Slugs	NA	NA	0.0011	0.0022	Assume similar in dimensions to a chaff cartridge
	Endcaps & Pistons – Non Chaff & Flare	NA	NA	0.0043	0.0086	Applies only to where it cannot be associated to another object (e.g., endcaps and pistons associated with chaff would be covered by chaff). Used for testing.
	Endcaps – Chaff & Flare	NA	NA	0.00215	0.0043	Applies only to Chaff-Air and Flares. 1 Endcap is expended per chaff-air or flare.
	Flare O-Ring	NA	NA	0.0043	0.0086	Assumed similar 2-dimensional footprint as endcaps and pistons. Associated with flares. Assumed 1 Flare O-Ring per flare.
	Fiber Optic Can	NA	NA	0.0011	0.0022	Assumed similar 2-dimensional footprint as chaff-air cartridge. Associated with AMNS Neutralizer fiber optic cable. Can that holds fiber optic cable is expended.
	Bathythermograph – Expended	NA	NA	0.0258	0.0516	An instrument that is deployed from a ship to record temperature and depth measurements. Small wires transmit the temperature data from the probe to the ship. This item is fairly standard in terms of footprint; these are off the shelf Commercial products. Reference: NOAA 2015. http://www.aoml.noaa.gov/goos/uot/xbt-what-is.php. Accessed November 3, 2015.
	Fiber Optic Cables	NA	NA	NA	NA	Associated with some rockets and AMNS neutralizers, security, underwater communication, power transmission (e.g., with UUVs, torpedoes, UAVs)
	Guidance Wires	NA	NA	0	0	Fragments created for relatively small portion associated with explosive devices (associated with heavyweight torpedoes).

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions (continued)

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] ($ft.^2$)*	*MEM Size ($ft.^2$)*	*MEM Footprint ($ft.^2$)*	*Material Specific Notes*
Other (continued)	Bathythermograph – Expended Wire	NA	NA	NA	NA	Single vertical wire
	Heavyweight (Explosive) Torpedo	NA	NA	39.6155	79.2299	MEM size based on MK-48
	Heavyweight Torpedo Accessories	NA	NA	0.1615	3.2367	MEM includes ballast weights, flex tubing
	Heavyweight (Non-explosive) Torpedo	NA	NA	NA	NA	Typically recovered
	Illumination Flares	NA	NA	1.2196	4.8782	Flares that have a large parachute; MEM size based on half the surface area of an 18 ft. diameter parachute used with an LUU-2 illumination flare.
	Lightweight Torpedo Accessories	NA	NA	1.0107	2.0215	MEM includes ballast weights, flex tubing (parachute size not included)
	Marine Marker	NA	NA	0.9752	3.8987	MEM footprint based on two Navy marine markers (MK25 and MK58
	Parachute (Large)	NA	NA	353.4289	706.8578	MEM size based on diameter of drone main parachute (30 ft. diameter).
	Parachute (Medium)	NA	NA	283.9961	567.9932	Associated with Illumination flares (18 ft. diameter)
	Small Decelerator/ Parachute	NA	NA	2.8438	5.6876	Associated with launched sonobuoys, lightweight torpedoes, and drones (drag parachute)
	Sabot	NA	NA	1.2195	4.8782	An accessory used during projectile firing. Footprint similar in size to the projectile.

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions (continued)

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] ($ft.^2$)*	*MEM Size ($ft.^2$)*	*MEM Footprint ($ft.^2$)*	*Material Specific Notes*
Other (continued)	Sonobuoys (Non-explosive)	NA	NA	1.2206	2.4413	Sonobuoys have an extra item footprint (half the dimensions of the sonobuoy) added in addition to the actual sonobuoy and casing to account for the items that are discarded from the sonobuoy following its release. MEM size does not include the associated Small Decelerator/Parachute (noted in table above)
	Sonobuoys (Explosive)	0%	NA	1.2206	2.4413	
	Sonobuoy Wires	NA	NA	NA	NA	One wire is associated with each sonobuoy
	Surface-Launched Lightweight (Explosive) Torpedo	0%	NA	10.0782	20.1576	MEM size based on MK50/MK54
	Surface-Launched Lightweight (Non-Explosive) Torpedo	NA	NA	10.0782	20.1576	Typically recovered
Projectile	Grenades (Explosive)	0	NA	0.1044	0.2088	None
	Large Caliber (Explosive)	NA	NA	1.0097	4.0386	Item assumed to have a projectile and casing
	Large Caliber (Non-explosive)	NA	NA	1.0097	4.0386	Item assumed to have a projectile and casing
	Large caliber (Casing Only)	NA	NA	0.5048	1.0097	Used when the target is on land; no MEM from projectile
	Medium Caliber (Explosive)	NA	NA	0.0560	0.2239	Item assumed to have a projectile and casing
	Medium Caliber (Non-explosive)	NA	NA	0.0560	0.2239	Item assumed to have a projectile and casing
	Small Caliber (Non-explosive)	NA	NA	0.0301	0.1216	Item assumed to have a projectile and casing

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions (continued)

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] ($ft.^2$)*	*MEM Size ($ft.^2$)*	*MEM Footprint ($ft.^2$)*	*Material Specific Notes*
Projectile	Small Caliber (Casing Only)	NA	NA	0.0151	0.0301	Used only for small caliber blanks. All other small caliber rounds are included under NEPM.
	Kinetic Energy Round	NA	NA	0.5048	1.0097	Item assumed to only have a projectile (no casing) – size of Large Caliber round.
Target	Aerial Drones – Expendable	NA	NA	294.6082	589.2164	MEM when specifically known it is an aerial drone; MEM size based on Firebee.
	Aerial Drones – Recovered	NA	NA	294.6082	589.2164	MEM when specifically known it is an aerial drone; MEM size based on Firebee. Typically recovered.
	Air Target – Expended (Non-Drone)	NA	NA	42.1622	84.3244	MEM when specifically known it is an air launched decoy. MEM size based on dimensions of Tactical Air Launched Decoy or Miniature Air-Launched Decoy.
	Metal Plates	NA	NA	2.7782	5.5563	Charges are secured to a 20" X 20" X 1/2" ferrous metal plate The target unit (concrete blocks, metal plate, and any debris) is brought to the surface and analyzed.
	Surface Target – Expended	NA	NA	5.7522	11.5034	Includes remote controlled or towed targets
	Surface Target – Recovered	NA	NA	NA	NA	Reported as recovered.
	Surface Target (Mobile) – Expended	NA	NA	5.7522	11.5034	Includes remote controlled or towed targets
	Surface Target (Stationary) – Expended	NA	NA	96.8752	193.7504	MEM when specifically known it is a stationary surface target. MEM size based on Killer Tomato.
	Subsurface Target (Mobile) – Expended	NA	NA	1.2206	2.4412	MEM when specifically known it is a sub-surface Motorized Autonomous Target

Table F-1: Categories and Footprints for Various Materials and Underwater Explosions (continued)

Material Group	*Material Category*	*Bottom Frequency[1]*	*Crater Footprint[2] ($ft.^2$)*	*MEM Size ($ft.^2$)*	*MEM Footprint ($ft.^2$)*	*Material Specific Notes*
Target	Mine Shape – Expended	NA	NA	25.7903	51.5807	Mine shapes that were specifically identified as non-recoverable; footprint based on size of explosive mine; size not including anchor
	Mine Shape – Expended	NA	NA	25.7903	51.5807	Mine shape and associated anchor block that are recovered. The vast majority of practice mines have built-in anchors for placing on the bottom; relatively few are moored/floating, and none are drifting.

[1]Bottom frequencies (%) are only listed for underwater explosions;

[2]Crater footprints are only listed for material that may be detonated on the bottom.

Notes: MEM = Military Expended Materials, AMNS/EMNS = Airborne Mine Neutralization System/Expendable Mine Neutralization System, NA = Not Applicable, DWADS = Deep Water Active Distributed System, NEPM = Non-explosive Practice Munitions, UAV = Unmanned Aerial Vehicle, UUV = Unmanned Underwater Vehicle

F.1.1 Military Expended and Recovered Material – Training Activities

Table F-2 shows military expended and recovered materials and impact footprints within the NWTT Study Area for a single year.

Table F-2: Number and Impacts[1] of Military Expended Materials Proposed for Use During Training Activities in a Single Year Under Alternatives 1 and 2

Military Expended Materials	*Size ($ft.^2$)*	*Impact Footprint ($ft.^2$)*	*Offshore Area*				*Inland Waters*			
			Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
			Number	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*
Bombs										
Bombs (Explosive)	8.1203	112.9048	2	0.00518	2	0.00518	0	0	0	0
Bombs (Non-Explosive)	8.1203	112.9048	84	0.21772	90	0.23327	0	0	0	0
Grenade (Explosive)	0.1044	0.2088	130	0.00062	130	0.00062	0	0	0	0
Projectiles										
Small-Caliber (Non-Explosive)	0.0301	0.1216	121,000	0.33778	121,000	0.33778	0	0	0	0
Small-Caliber (Casing Only)	0.0151	0.0301	3,036	0.00210	6,057	0.00419	0	0	0	0
Medium-Caliber (Explosive)	0.056	0.2239	250	0.00129	6,490	0.03336	0	0	0	0
Medium-Caliber (Non-Explosive)	0.056	0.2239	26,410	0.13575	43,112	0.22160	0	0	0	0
Large-Caliber (Explosive)	1.0097	4.0386	112	0.01038	390	0.03656	0	0	0	0
Large-Caliber (Non-Explosive)	1.0097	4.0386	2,800	0.25960	9,520	0.88263	0	0	0	0
Large-Caliber (Casing only)	0.5048	1.0097	9,562	0.22164	9,910	0.22971	0	0	0	0
Missiles (Explosive)	37.6691	74.7338	14	0.02402	27	0.04632	0	0	0	0
Missiles (Non-Explosive)	37.6691	74.7338	4	0.00686	15	0.02573	0	0	0	0
Countermeasures										
Chaff- Air Cartridge	0.0011	0.0022	5,000	0.00025	5000	0.00025	0	0	0	0
Flares	1.2196	4.8782	700	0.07839	700	0.07839	0	0	0	0
Targets										
Air Target- Expended Decoy	42.1622	84.3245	35	0.06775	43	0.08324	0	0	0	0
Air Targets- Recovered Drone	NA	NA	98	0	145	0	0	0	0	0
Sub-Surface Targets (Mobile) - Expended	1.2206	2.4412	373	0.02090	373	0.02090	0	0	0	0
Sub-Surface Targets (Mobile) - Recovered	NA	NA	96	0	107	0	0	0	0	0
Surface Targets (Stationary) - Expended	96.8752	193.7504	374	0.09877	370	0.09771	0	0	0	0

Table F-2: Number and Impacts[1] of Military Expended Materials Proposed for Use During Training Activities in a Single Year Under Alternatives 1 and 2 (continued)

Military Expended Materials	*Size ($ft.^2$)*	*Impact Footprint ($ft.^2$)*	*Offshore Area*				*Inland Waters*			
			Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
			Number	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*
Targets (continued)										
Mine Shapes - Recovered	NA	NA	0	0	0	0	112	0	120	0
Mine Shapes - Expended	25.7903	51.5807	0	0	0	0	0	0	0	0
Other										
Anchor - Recovered	6.2495	12.5001	0	0	0	0	40	0.01148	40	0.01148
Sonobuoys (Non-Explosive)	1.2207	2.4413	9,338	0.52334	9,378	0.52559	0	0	0	0
Endcaps	0.0021	0.0043	5,700	0.00056	5,700	0.00057	0	0	0	0
Compression Pad/Piston	0.0043	0.0086	700	0.00014	700	0.00014	0	0	0	0
Fiber Optic Can	0.0011	0.0022	170	0.00001	164	0.00001	0	0	0	0
Flare O-Ring	0.0043	0.0086	704	0.00014	724	0.00014	0	0	0	0
Illumination Flare	1.2196	4.8782	4	0.00045	24	0.00269	0	0	0	0
Heavyweight Torpedo (Non-Explosive)	39.6155	79.2299	2	0.00364	0	0	0	0	0	0
Heavyweight Torpedo (Explosive)	39.6155	79.2299	0	0	2	0.00364	0	0	0	0
Heavyweight Torpedo Accessories	0.1615	3.2367	2	0.00015	2	0.00015	0	0	0	0
Lightweight Torpedo (Non-Explosive)	19.1199	38.2398	16	0.01405	16	0.01405	0	0	0	0
Lightweight Torpedo Accessories	1.1011	2.0215	16	0.00074	16	0.00074	0	0	0	0
Marine Marker	0.9752	3.8987	230	0.02059	232	0.02076	40	0.00358	50	0.00448
Small Decelerator/Parachute	2.8438	5.6876	9,354	1.22135	9,394	1.22657	0	0	0	0
Sonobuoy Wires	0.0000	0.0000	9,338	0	9,378	0	0	0	0	0
Parachutes - Medium	9.0417	18.0834	4	0.00166	24	0.00996	0	0	0	0
Parachutes - Large	283.9961	567.9932	98	1.27785	145	1.89070	0	0	0	0
Total			**205,546**	**6.10074**	**239,114**	**7.56672**	**3,076**	**0.00568**	**6,107**	**0.00866**

[1]Calculations for "Impact (Acre) Column = [(Impact Footprint) x (Number)]/43,560 sq. ft. per acre; Blue shading indicates numbers and impacts of MEM that differ between Alternatives 1 & 2

F.1.2 Military Expended and Recovered Materials – Testing Activities

Table F-3 shows military expended and recovered materials and impact footprints within the NWTT Study Area for a single year.

Table F-3: Number and Impacts[1] of Military Expended Materials Proposed for Use During Testing Activities in a Single Year Under Alternatives 1 and 2

Military Expended Materials	*Size ($ft.^2$)*	*Impact Footprint ($ft.^2$)*	*Offshore Area*				*Inland Waters*			
			Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
			Number	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*
Projectiles										
Kinetic Energy Round	0.5048	1.0097	80	0.00185	80	0.00185	0	0	0	0
Large-Caliber (Non-Explosive)	1.0097	4.0386	160	0.01483	160	0.01483	0	0	0	0
Large-Caliber (Casing only)	0.5048	1.0097	160	0.00371	160	0.00371	0	0	0	0
Sabot – Kinetic Energy Round	1.2196	4.8782	80	0.00896	80	0.00896	0	0	0	0
Countermeasures										
Acoustic Countermeasures	0.3311	1.2432	751	0.02143	791	0.02258	720	0.02055	720	0.02055
Anti-Torpedo Torpedo	4.524	9.0847	58	0.01210	58	0.01210	176	0.03671	184	0.03837
Targets										
Air Targets - Expended Drone	294.6082	589.2164	162	0.31360	162	0.31360	0	0	0	0
Mine Shapes (Non-Explosive) – Expended	25.7903	51.5807	280	0.33156	280	0.33156	336	0.39787	336	0.39787
Mine Shapes (Non-Explosive) – Recovered	25.7903	51.5807	181	0.21433	181	0.21433	3,776	4.47127	5,266	6.23563
Mines (Explosive)	25.7903	51.5807	5	0.00592	5	0.00592	0	0	0	0
Sub-Surface Target (Mobile) – Recovered	NA	NA	185	0	188	0	1,127	0	1,159	0
Sub-Surface Target (Stationary) – Expended	96.8752	193.7504	4	0.01779	4	0.01779	0	0	0	0
Sub-Surface Target (Stationary) – Recovered	NA	NA	3,331	0	3,331	0	7,317	0	7,317	0
Surface Target (Mobile) – Expended	5.7522	11.5034	162	0.04278	162	0.04278	0	0	0	0
Surface Target (Stationary) – Expended	96.8752	193.7504	172	0.76504	172	0.76504				
Surface Target (Stationary) – Recovered	NA	NA	81	0	81	0	542	0	542	0
Other										
Air-Launched Lightweight Torpedo (Explosive)	19.1199	38.2399	2	0.00176	2	0.00176	0	0	0	0
Air-Launched Lightweight Torpedo (Non-Explosive)	19.1199	38.2399	42	0.03687	42	0.03687	0	0	0	0
AMNS Neutralizer (Explosive)	1.6286	3.2572	36	0.00269	36	0.00269	0	0	0	0
Anchor – Expended	6.2495	12.5001	445	0.12770	445	0.12770	720	0.20661	720	0.20661
Anchor – Recovered	6.2495	12.5001	0	0	0	0	2,527	0.72516	3,107	0.89159
Bathythermograph - Expended	0.2771	0.5554	604	0.00770	1,130	0.01441	0	0	0	0
Bottom Placed Instruments	2.0000	4.0000	0	0.00000	0	0.00000	19	0.00174	19	0.00174
Buoy (Explosive)	0.9752	3.8987	80	0.00716	80	0.00716	0	0	0	0

Table F-3: Number and Impacts[1] of Military Expended Materials Proposed for Use During Testing Activities in a Single Year Under Alternatives 1 and 2 (continued)

Military Expended Materials	*Size (ft.²)*	*Impact Footprint (ft.²)*	*Offshore Area*				*Inland Waters*			
			Alternative 1		*Alternative 2*		*Alternative 1*		*Alternative 2*	
			Number	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*	*Number*	*Impact (Acre)*
Other (Continued)										
Buoy (Non-Explosive)	0.9752	3.8987	232	0.02076	392	0.03508	0	0	0	0
Fiber Optic Can	0.0011	0.0022	36	0.00000	36	0.00000	197	0.00001	197	0.00001
Guidance Wire	0.0000	0.0000	152	0	192	0	230	0	230	0
Heavyweight Torpedo (Explosive)	39.6155	79.2299	4	0.00728	4	0.00728	0	0	0	0
Heavyweight Torpedo (Non-Explosive)	39.6155	79.2299	148	0.26919	188	0.34195	230	0.41834	230	0.41834
Heavyweight Torpedo Accessories	0.1615	3.2367	152	0.01129	192	0.01427	230	0.01709	230	0.01709
Lightweight Torpedo Accessories	1.1011	2.0215	82	0.00381	85	0.00394	48	0.00223	48	0.00223
Parachutes (Medium)	9.0417	18.0834	102	0.04234	102	0.04234	176	0.07306	184	0.07639
Decelerator/Parachute (Small)	2.8438	5.6876	1,711	0.22340	1,711	0.22340	48	0.00627	48	0.00627
Sonobuoy (Non-Explosive)	1.2207	2.4413	4,233	0.23724	6,599	0.36984	48	0.00269	48	0.00269
Surface-Launched Lightweight Torpedo (Explosive)	10.0782	20.1576	2	0.00093	2	0.00093	0	0	0	0
Surface-Launched Lightweight Torpedo (Non-Explosive)	10.0782	20.1576	36	0.01666	39	0.01805	48	0.02221	48	0.02221
Total			**13,796**	**2.23364**	**19,137**	**2.39152**	**2,996**	**0.76483**	**3,012**	**0.76982**

[1]Calculations for "Impact (Acre) Column = [(Impact Footprint) x (Number)]/43,560; Blue shading indicates numbers and impacts of MEM that differ between Alternatives 1 and 2

F.2 STATISTICAL PROBABILITY ANALYSIS 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 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 available only 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 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, 2018).

F.2.1 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 on the sea surface within the specified training or testing area (R) 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 training or testing 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, 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 training or testing activity.

- A = length*width, where the individual animal's width (breadth) is assumed to be 20 percent of its length for marine mammals and 112 percent of its length for sea turtles. This product for A is multiplied by the number of animals N_a in the specified training or testing area (i.e., product of the highest average month animal density [D] and training or testing area [R]: $N_a = D*R$) to obtain the total animal footprint area ($A*N_a = A*D*R$) in the training or testing area. As a conservative scenario, the total animal footprint area is calculated for the species with the highest average month density in the training or testing 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 training or testing activity uses one or more different types of military items, each with a specific number and dimensions, and several training and testing 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 training or testing area in a given year.

As a conservative scenario, the total impact footprint area is calculated for the training or testing area with the highest use of military items within the entire Study Area.

Though marine mammals and sea turtles 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 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.

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 training or testing 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 training or testing 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. The results of the following four scenarios were averaged to determine the probability:

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 training or testing activities occurring in the area per year, and is given by the ratio of total area (A_{tot}) to training or testing area (R): $P = A_{tot}/R$. Number of exposures is $T = N*P = N*A_{tot}/R$, where N = number of animals in the training or testing 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 and 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 potential number of exposures (t) are reported in Table F-4, Table F-5, and Table F-6.

F.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 the two action alternatives.
2. One training and testing area: The NWTT Offshore Area.
3. The following types of non-explosive items:
    - Small-caliber projectiles: up to and including .50 caliber rounds
    - Medium-caliber projectiles: larger than .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 lb.
    - Torpedoes: includes all aircraft-released lightweight torpedoes
    - Sonobuoys: includes all sonobuoys
    - Targets: includes expended, airborne and surface targets, as well as mine shapes
    - Lightweight torpedo accessories: includes all accessories that are dropped along with the torpedo (e.g., nose cap, air stabilizer)
    - Expended bathythermographs: small sensors deployed from ships
4. High-energy lasers: includes high-energy laser weapons that are directed at a surface target.

5. Animal species of interest: the eight species of ESA-listed marine mammals and the non-ESA listed marine mammal species with the highest average month density in the training and testing area of interest (harbor porpoise and California sea lion), and the only sea turtle species with a possible occurrence in the training and testing area of interest.

F.2.3 INPUT DATA

Input data for the direct strike analysis include animal species likely to be in the area and military items proposed for use under each of the two action alternatives. Animal species data include: (1) species identification and status (i.e., threatened, endangered, or neither), (2) highest average month density estimate for the species of interest, and (3) adult animal dimensions (length and width) for the species with the highest density. 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. Military items data include: (1) military items category (e.g., projectile, bomb, rocket, target), (2) military items dimensions (length and width), and (3) total number of military items used annually.

Military items input data, specifically the quantity (e.g., numbers of bombs and rockets), are different in magnitude between the two action alternatives. All animal species input data, the military items' identification and category, and the military items' dimensions are the same for the two alternatives; only the quantities (i.e., total number of military items) are different.

F.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 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 Tables F-4 through F-6.

Table F-4: Estimated Exposures from Direct Strike of a High-Energy Laser by Area and Alternative in a Single Year

NWTT Offshore Area				
Species	Training		Testing	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
All Marine Mammals Species	0.000000	0.000000	0.000619	0.000619
Leatherback Sea Turtle	0.000000	0.000000	0.000000	0.000000

Table F-5: Estimated Representative Marine Mammal Exposures from Direct Strike of Military Expended Materials by Area and Alternative in a Single Year

NWTT Offshore Area				
Species	Training		Testing	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Humpback Whale	0.000463	0.000534	0.000353	0.000372
Sei Whale	0.000006	0.000007	0.000004	0.000005
Fin Whale	0.000230	0.000265	0.000177	0.000186
Blue Whale	0.000064	0.000073	0.000049	0.000052
Sperm Whale	0.000054	0.000062	0.000041	0.000043
Killer Whale (Southern Resident)	0.000012	0.000014	0.000009	0.000010
Gray Whale	0.000215	0.000249	0.000164	0.000173
Harbor Porpoise	0.010810	0.012568	0.008129	0.008576
California Sea Lion	0.004216	0.004902	0.003170	0.003345
Guadalupe Fur Seal	0.000216	0.000251	0.000162	0.000171

Table F-6: Estimated Leatherback Sea Turtle Exposures from Direct Strike of Military Expended Materials by Area and Alternative in a Single Year

NWTT Offshore Area				
Species	Training		Testing	
	Alternative 1	Alternative 2	Alternative 1	Alternative 2
Leatherback Sea Turtle	0.000001	0.000002	0.000001	0.000001

REFERENCES

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