Environmental Impact Statement/
Overseas Environmental Impact Statement
Point Mugu Sea Range
TABLE OF CONTENTS

List of Figures

There are no figures in this appendix.

List of Tables

This page intentionally left blank.

Appendix E Underwater Range to Effects for Explosives at or Near the Surface in the Point Mugu Sea Range

Ongoing and proposed Navy activities at the Point Mugu Sea Range include the use of explosives detonating at or near the ocean surface; there are no proposed activities involving explosives purposefully placed underwater or involving underwater targets. The acoustic effects modeling supporting the impact analysis in this Environmental Impact Statement/Overseas Environmental Impact Statement conservatively overestimates the impacts from the use of explosives by modeling all detonations occurring at or near the ocean surface, as if they detonate 0.1 meters below the surface, and with all pressure and acoustic energy from the detonation contained below the surface (i.e., no "surface blow-off" expending acoustic energy into the air) (U.S. Department of the Navy, 2018).

The following section provides the range (distance) over which specific physiological or behavioral effects are expected to occur based on explosive impact criteria as detailed in U.S. Department of the Navy (2017); in regulations recently promulgated by National Marine Fisheries Service (Federal Register 83 29872, Thursday, December 27, 2018); in National Marine Fisheries Service guidance and Biological Opinions (National Marine Fisheries Service, 2018a, 2018b); and the explosive propagation calculations from the Navy Acoustic Effects Model (U.S. Department of the Navy, 2018). The underwater range to effects are shown for the explosive bins represented in ongoing and proposed activities with detonations at or near the ocean surface, ranging from E1 (up to 0.25 pound [lb.] net explosive weight) to E10 (up to 500 lb. net explosive weight); for introduction to the explosive bins, see Section 3.0.5.7, (Explosive Stressors).

Under the assumption that all acoustic energy is contained underwater, ranges are determined by modeling the distance that noise from an explosion will need to propagate to reach exposure level thresholds specific to a marine mammal hearing group that may result in a behavioral response, temporary threshold shift (TTS), permanent threshold shift (PTS), and non-auditory injury. Range to effects is also important in the consideration of the level of impact that will be mitigated within applicable mitigation zones.

Table E-1 shows the average, minimum, and maximum ranges to non-auditory injury. The ranges to effects represent the range to gastrointestinal tract injury for representative animal masses between 5 and 72,000 kilograms and explosive bins between 0.25 and 500 lb. net explosive weight. Animals within these distances from the explosive source would be expected to receive minor injuries farther from the source and increasingly more substantial injuries closer as the animal approaches the detonation point. Ultimately, if the animal is close enough to the detonation point mortality occurs. Ranges to mortality, based on animal mass, are shown in Table E-2. The modeling and analysis predicts that there would be no non-auditory injuries or mortality as a result of the ongoing or proposed activities at the Point Mugu Sea Range due to the use of explosives.

Table E-1: Ranges to Non-Auditory Injury for All Marine Mammal Hearing Groups

Bin	Range		
	Average (m)	*Minimum (m)*	*Maximum (m)*
E1	12	11	13
E3	25	25	30
E5	40	35	140
E6	52	40	120
E8	117	75	400
E9	120	90	290
E10	174	100	480

Note: All ranges to non-auditory injury within this table are driven by the gastrointestinal tract injury threshold regardless of animal mass. Explosive bins not shown on this table (i.e., E2, E4, E7, E11, and E12) and subsequent tables are not used at PMSR and so have been excluded from presentation.
m = meter(s)

Table E-2: Ranges to Mortality Risk for All Marine Mammal Hearing Groups as a Function of Animal Mass

Bin	Animal Mass Intervals (kg)[1]					
	10	250	1,000	5,000	25,000	72,000
E1	3 (2–3)	0 (0–3)	0 (0–0)	0 (0–0)	0 (0–0)	0 (0–0)
E3	8 (6–10)	4 (2–8)	1 (0–2)	0 (0–0)	0 (0–0)	0 (0–0)
E5	13 (11–45)	7 (4–35)	3 (3–12)	2 (0–8)	0 (0–2)	0 (0–2)
E6	18 (14–55)	10 (5–45)	5 (3–15)	3 (2–10)	0 (0–3)	0 (0–2)
E8	50 (24–110)	27 (9–55)	13 (0–20)	9 (4–13)	4 (0–6)	3 (0–5)
E9	32 (30–35)	20 (13–30)	10 (8–12)	7 (6–9)	4 (3–4)	3 (2–3)
E10	56 (40–190)	25 (16–130)	13 (11–16)	9 (7–11)	5 (4–5)	4 (3–4)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Note: kg = kilogram(s)

The following tables (Table E-3 through Table E-12) show the average, minimum, and maximum ranges to onset of auditory and behavioral effects for the various marine mammal hearing groups based on the criteria and thresholds and modeling as cited above. For events with multiple explosions, sound from successive clusters of explosions within a bin (i.e., 25 millimeter [mm] rounds, bin E1; 76 mm rounds, bin E3; and 127 mm (5") rounds, bin E5) are predicted to accumulate and increase the range to the onset of each type of effect based on the sound exposure level criteria thresholds. Ranges to TTS and PTS are based on the sound pressure level (SPL), or peak pressure, for a single explosion, which generally exceeds the corresponding sound exposure level threshold. Ranges to peak pressure thresholds are estimated using the best available science from peer reviewed publications; however, data on peak pressure far from an explosion are very limited. For additional information on how ranges to effects from explosions were estimated, see the technical report *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). For additional information on the criteria and thresholds for determining behavioral, TTS, or PTS exposures, see the technical report *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)* (U.S. Department of the Navy, 2017).

Table E-3: SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Reaction for High-Frequency Cetaceans

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	353 (130–825)	1,234 (290–3,025)	2,141 (340–4,775)
	25	1,188 (280–3,025)	3,752 (490–8,525)	5,196 (675–12,275)
E3	1	654 (220–1,525)	2,294 (350–4,775)	3,483 (490–7,775)
	12	1,581 (300–3,525)	4,573 (650–10,275)	6,188 (725–14,775)
E5	25	2,892 (440–6,275)	6,633 (725–16,025)	8,925 (800–22,775)
E6	1	1,017 (280–2,525)	3,550 (490–7,775)	4,908 (675–12,275)
E8	1	1,646 (775–2,525)	4,322 (1,525–9,775)	5,710 (1,525–14,275)
E9	1	2,105 (850–4,025)	4,901 (1,525–12,525)	6,700 (1,525–16,775)
E10	1	2,629 (875–5,275)	5,905 (1,525–13,775)	7,996 (1,525–20,025)

[1]Average distance in meters is depicted above the minimum and maximum distances, which are in parentheses.

Notes: SEL = Sound Exposure Level, PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-4: Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for High-Frequency Cetaceans

Bin	PTS	TTS
E1	660 (170–1,025)	1,054 (270–1,775)
E3	1,261 (290–6,025)	2,068 (480–9,025)
E5	1,869 (410–7,775)	2,751 (600–13,275)
E6	2,177 (525–9,275)	3,136 (625–14,025)
E8	2,986 (925–5,775)	3,806 (1,525–9,775)
E9	3,365 (1,275–8,025)	4,409 (1,525–13,525)
E10	3,791 (1,275–9,775)	5,540 (1,775–26,025)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-5: SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Reaction for Low-Frequency Cetaceans

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	51 (40–70)	227 (100–320)	124 (70–160)
	25	205 (95–270)	772 (270–1,275)	476 (190–725)
E3	1	109 (65–150)	503 (190–1,000)	284 (120–430)
	12	338 (130–525)	1,122 (320–7,775)	761 (240–6,025)
E5	25	740 (220–6,025)	2,731 (460–22,275)	1,414 (350–14,275)
E6	1	250 (100–420)	963 (260–7,275)	617 (200–1,275)
E8	1	460 (170–950)	1,146 (380–7,025)	873 (280–3,025)
E9	1	616 (200–1,275)	1,560 (450–12,025)	1,014 (330–5,025)
E10	1	787 (210–2,525)	2,608 (440–18,275)	1,330 (330–9,025)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: SEL = Sound Exposure Level, PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-6: Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Low-Frequency Cetaceans

Bin	PTS	TTS
E1	126 (55–140)	226 (90–270)
E3	264 (100–320)	453 (140–600)
E5	404 (130–525)	679 (180–1,025)
E6	496 (150–700)	797 (210–6,025)
E8	830 (260–1,275)	1,045 (360–1,775)
E9	966 (310–1,525)	1,240 (420–2,525)
E10	1,057 (330–1,775)	1,447 (450–6,025)

[1]Average distance in meters to PTS and TTS is depicted above the minimum and maximum distances, which are in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-7: SEL-Based Ranges[1] for Explosives to Onset PTS, Onset TTS, and Behavioral Reaction for Mid-Frequency Cetaceans

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	25 (25–25)	118 (80–210)	178 (100–320)
	25	107 (75–170)	476 (150–1,275)	676 (240–1,525)
E3	1	50 (45–65)	233 (110–430)	345 (130–600)
	12	153 (90–250)	642 (220–1,525)	897 (270–2,025)
E5	25	318 (130–625)	1,138 (280–3,025)	1,556 (310–3,775)
E6	1	98 (70–170)	428 (150–800)	615 (210–1,525)
E8	1	160 (150–170)	676 (500–725)	942 (600–1,025)
E9	1	215 (200–220)	861 (575–950)	1,147 (650–1,525)
E10	1	275 (250–480)	1,015 (525–2,275)	1,424 (675–3,275)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: SEL = Sound Exposure Level, PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-8: Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Mid-Frequency Cetaceans

Bin	PTS	TTS
E1	43 (35–45)	81 (45–95)
E2	57 (40–65)	102 (50–110)
E3	96 (50–110)	174 (65–210)
E5	149 (65–160)	272 (95–300)
E6	188 (70–230)	338 (110–400)
E8	337 (300–370)	580 (400–750)
E9	450 (350–525)	757 (450–1,025)
E10	534 (240–700)	902 (410–1,275)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-9: SEL Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Otariids

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	7 (7–7)	34 (30–40)	56 (45–70)
	25	30 (25–35)	136 (80–180)	225 (100–320)
	10	25 (25–30)	115 (70–150)	189 (95–250)
E3	1	16 (15–19)	70 (50–95)	115 (70–150)
	12	45 (35–65)	206 (100–290)	333 (130–450)
	12	55 (50–60)	333 (280–750)	544 (440–1,025)
E5	25	98 (60–120)	418 (160–575)	626 (240–1,000)
E6	1	30 (25–35)	134 (75–180)	220 (100–320)
E8	1	50 (50–50)	235 (220–250)	385 (330–450)
E9	1	68 (65–70)	316 (280–360)	494 (390–625)
E10	1	86 (80–95)	385 (240–460)	582 (390–800)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: SEL = Sound Exposure Level, PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-10: Peak Pressure Based Ranges[1] for Explosives to Onset PTS and Onset TTS for Otariids

Bin	PTS	TTS
E1	35 (30–40)	64 (40–95)
E2	45 (35–50)	82 (45–95)
E3	77 (45–95)	133 (60–150)
E5	117 (55–130)	212 (80–250)
E6	148 (65–170)	263 (95–310)
E8	272 (260–280)	482 (370–525)
E9	368 (320–400)	610 (420–800)
E10	442 (230–525)	715 (330–1,025)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-11: SEL-Based Ranges[1] for Explosives to PTS, TTS, and Behavioral Reaction for Phocids

Bin	Cluster Size	PTS	TTS	Behavioral
E1	1	45 (40–65)	210 (100–290)	312 (130–430)
	25	190 (95–260)	798 (280–1,275)	1,050 (360–2,275)
E2	1	58 (45–75)	258 (110–360)	383 (150–550)
	10	157 (85–240)	672 (240–1,275)	934 (310–1,525)
E3	1	96 (60–120)	419 (160–625)	607 (220–900)
	12	277 (120–390)	1,040 (370–2,025)	1,509 (525–6,275)
E5	25	569 (200–850)	2,104 (725–9,275)	2,895 (825–11,025)
E6	1	182 (90–250)	767 (270–1,275)	1,011 (370–1,775)
E8	1	311 (290–330)	1,154 (625–1,275)	1,548 (725–2,275)
E9	1	416 (350–470)	1,443 (675–2,025)	1,911 (800–3,525)
E10	1	507 (340–675)	1,734 (725–3,525)	2,412 (800–5,025)

[1]Average distance (in meters) to PTS, TTS, and behavioral thresholds are depicted above the minimum and maximum distances, which are in parentheses. Values depict the range produced by SEL hearing threshold criteria levels.

Notes: SEL = Sound Exposure Level, PTS = permanent threshold shift, TTS = temporary threshold shift

Table E-12: Peak Pressure Based Ranges[1] to Onset PTS and Onset TTS for Phocids

Range to Effects for Explosives: Phocids[1]		
Bin	**PTS**	**TTS**
E1	144 (60–160)	258 (95–300)
E2	180 (70–220)	323 (110–370)
E3	303 (100–350)	533 (150–675)
E5	469 (140–600)	815 (190–6,025)
E6	582 (160–775)	910 (230–6,025)
E8	987 (500–1,275)	1,472 (625–2,025)
E9	1,207 (550–1,525)	1,790 (700–3,025)
E10	1,407 (450–3,275)	2,043 (775–5,275)

[1]Average distance in meters to mortality is depicted above the minimum and maximum distances, which are in parentheses.
Notes: PTS = permanent threshold shift, TTS = temporary threshold shift

REFERENCES

National Marine Fisheries Service. (2018a). *Biological Opinion on U.S. Navy Hawaii-Southern California Training and Testing and the National Marine Fisheries Service's Promulgation of Regulations Pursuant to the Marine Mammal Protection Act for the Navy to "Take" Marine Mammals Incidental to Hawaii-Southern California Training and Testing*. Silver Spring, MD: National Marine Fisheries Service, Office of Protected Resources.

National Marine Fisheries Service. (2018b). *2018 Revision to: Technical Guidance for Assessing the Effects of Anthropogenic Sound on Marine Mammal Hearing (Version 2.0): Underwater Thresholds for Onset of Permanent and Temporary Threshold Shifts*. Silver Spring, MD: National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources.

U.S. Department of the Navy. (2017). *Criteria and Thresholds for U.S. Navy Acoustic and Explosive Effects Analysis (Phase III)*. San Diego, CA: Space and Naval Warfare System Command, Pacific.

U.S. Department of the Navy. (2018). *Quantifying Acoustic Impacts on Marine Mammals and Sea Turtles: Methods and Analytical Approach for Phase III Training and Testing* (Technical Report prepared by NUWC Division Newport, Space and Naval Warfare Systems Center Pacific, G2 Software Systems, and the National Marine Mammal Foundation). Newport, RI: Naval Undersea Warfare Center.