Appendix D

Acoustic Impact Analysis for EROS

Removal of Oil and Gas Structures Off of Southern California

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Abbreviations and Acronyms

AML	above the mud line
BML	below the mud line
BOEM	Bureau of Ocean Energy Management
BSEE	Bureau of Safety and Environmental Enforcement
DOI	U.S. Department of the Interior
EROS	explosive removal of structures
GOM	Gulf of Mexico
L_{PK}	peak level
MPS	marine protected species
NEW	net explosive weight
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
OCS	Outer Continental Shelf
PEIS	programmatic environmental impact statement
PTS	permanent threshold shift
SEL	energy source level
SoCal	southern California
TTS	temporary threshold shift
UWC	underwater calculator

1 Introduction

1.1 Background

The Bureau of Ocean Energy Management (BOEM), in the course of preparing this programmatic environmental impact statement (PEIS), has determined that the pressure wave and acoustic energy generated by the detonation of explosive-severance charges for the explosive removal of structures (EROS) are the primary impact-producing factors on marine protected species (MPS). To assess the impacts of these activities, BOEM estimated the annual number of potential impacts on all the appropriate marine mammal, sea turtle, and fish species potentially present in the vicinities of these activities.

Because this PEIS information will also be used to petition for incidental-take regulations under Subpart I of the Marine Mammal Protection Act, estimates were also projected over a standard rulemaking cycle of 5 years. However, many or the requisite specifics describing these activities currently are not known. These details include (but are not limited to): exactly which platforms will use explosive removal techniques, which year(s) these will occur, the explosive weight needed to successfully sever the pilings, and the precise date of the activities. To proceed without these details, this appendix will identify the range of these critical parameters and either present a representative range of these values or a conservative assumption that covers all possible known potential values for that parameter.

Historically, based on similar decommissioning activities in the Gulf of Mexico (GOM), explosive-severance activities as described under the proposed action can be grouped into five blasting categories: very small, small, standard, large, and specialty. The level of detonation pressure and energy is primarily related to the amount of explosives used; the categories were developed based upon the specific range of charge weights (net explosive weight [NEW]) needed to conduct current and future GOM Outer Continental Shelf (OCS) decommissionings. Depending on the design of the target and other variable marine conditions, the severance charges developed under each of these categories could be designed for use in either a below-the-mudline (BML) or above-the-mudline (AML) configuration. These factors, combined with an activity location within either on the shelf (<200 m) or slope (>200 m) zone, results in 20 separate severance scenarios (Table D-1).

For the 23 decommissionings off the coast of southern California, water depths ranged between 27 and 365 m, with 16 of the structures located in the slope region and 7 on the shelf. The number of removals AML and BML are not known at this time, nor are the size of the charges. However, for information purposes, Table D-2 provides the approximate percentages of historically proposed removals in the GOM for each charge size and configuration. Currently, no explosive removals are being allowed in the GOM AML. For this analysis, we assumed that that will also be the case in California; therefore no further analysis of AML scenarios will be included here.

Table D-1. Blasting Category Parameters and Associated Severance Scenario Numbers

Blasting Category	Net Explosive Weight of Charge Range (lb.)	Configuration	Species-Delineation Zone	Scenario Number
Very Small	0–10	BML	Shelf (<200 m)	A1
			Slope (>200 m)	A2
	0–5	AML	Shelf (<200 m)	A3
			Slope (>200 m)	A4
Small	>10–20	BML	Shelf (<200 m)	B1
			Slope (>200 m)	B2
	>5–20	AML	Shelf (<200 m)	B3
			Slope (>200 m)	B4
Standard	>20–80	BML	Shelf (<200 m)	C1
			Slope (>200 m)	C2
	>20–80	AML	Shelf (<200 m)	C3
			Slope (>200 m)	C4
Large	>80–200	BML	Shelf (<200 m)	D1
			Slope (>200 m)	D2
	>80–200	AML	Shelf (<200 m)	D3
			Slope (>200 m)	D4
Specialty	>200–500	BML	Shelf (<200 m)	E1
			Slope (>200 m)	E2
	>200–500	AML	Shelf (<200 m)	E3
			Slope (>200 m)	E4

Table D-2. Approximate Percentage of Removals in the GOM

Blasting Category	Net Explosive Weight of Charge Range (lb.)	Configuration	Approximate Percentage
Very Small	0–10	BML	14.0
	0–5	AML	9.2
Small	>10–20	BML	20.2
	>5–20	AML	8.9
Standard	>20–80	BML	27.2
	>20–80	AML	10.7
Large	>80–200	BML	7.3
	>80–200	AML	1.8
Specialty	>200–500	BML	0.7
	>200–500	AML	0.0

1.2 Acoustic and Non-Acoustic Thresholds

1.2.1 Auditory Behavior and Injury Thresholds for Marine Mammals, Sea Turtles, and Fish

Marine mammal auditory injury for impulsive signal is defined by NMFS (2018) and specified in Table D-3, with the source energy level (SEL) and peak level (L_{PK}) thresholds identified where appropriate. These permanent threshold shift (PTS) criteria have been incorporated into the latest version of the BOEM/Bureau of Safety and Environmental Enforcement (BSEE) underwater calculator (UWC), and the radii for exposures above these levels will be determined there. Due to the nature of explosive removal activities (i.e., they occur once per site, are separated by many days between events, and are very short in duration, typically much less than a second), the temporary threshold shift (TTS) criteria will be used to identify the onset of behavioral impacts.

For completeness, the current criteria for impulsive threshold for fish are included in Table D-4. However, they will not be used for any further calculations in this document.

Table D-3. Acoustic Injury Criteria and Metrics for Marine Mammals[a]

Faunal Group	TTS		PTS	
	SEL^b (weighted)	$L_{pk}{}^b$ (unweighted)	SEL^b (weighted)	$L_{pk}{}^b$ (unweighted)
Low-frequency cetaceans	168	213	183	219
Mid-frequency cetaceans	170	224	185	230
High-frequency cetaceans	140	196	155	202
Phocid pinnipeds in water	170	212	185	218
Other marine carnivores	188	226	203	232
Sirenians	175	220	190	226
Sea turtles[c]	189	226	204	232

[a] Source: NMFS (2018).

[b] Threshold units: SEL in dB re 1 $\mu Pa^2 \cdot s$; L_{pk} in dB re 1 μPa .

[c] Source: U.S. Department of the Navy (2017).

Table D-4. Mortality and Acoustic Thresholds for Impulsive Signal Potential Injury and TTS for Fish

Fish Group	Mortality[b] (dB Peak)	Injury		TTS
		SEL^a (unweighted)	$L_{pk}{}^a$ (unweighted)	SEL^a (unweighted)
Fish without swim bladder[b]	229–234	>216	>213	≫186
Fish with swim bladder not involved in hearing[b]	229–234	203	>207	>186
Fish with swim bladder involved in hearing[b]	229–234	203	>207	186

[a] Threshold units: SEL in dB re 1 $\mu Pa^2 \cdot s$; L_{pk} in dB re 1 μPa.

[b] Source: Popper et al. (2014).

1.2.2 Non-Auditory Injury and Mortality Thresholds for Marine Mammals and Sea Turtles

The explosive removal of marine structures has the potential to cause mortality and non-acoustic injury to marine animals. For marine mammals and sea turtles, these injuries include slight injury to the lungs and gastrointestinal injury. The critical explosive parameter tied to these criteria are peak pressure (L_{pk}) and positive impulse (sometimes just referred to as impulse) (J_0). Based on work by Goertner (1982) and Yelverton (1973), the U.S. Navy (2017) has identified the similitudes in Table D-5 as the threshold for the occurrence of these impacts. They also identified the corresponding similitudes in Table D-6 as the potential onset for these impacts for mitigation and planning purposes. Table D-6 will be used to calculate impacts in this document.

Table D-5. U.S. Navy Mortality and Non-Auditory Impulse and Peak Pressure Thresholds for Marine Mammals and Sea Turtles[a]

Impact Assessment Criteria	Threshold[b]
Mortality—Impulse	144 $M^{1/3}$ (1 + (D/10.1))$^{1/6}$ Pa-s
Injury—Impulse	65.8 $M^{1/3}$ (1 + (D/10.1))$^{1/6}$ Pa-s
Injury—Peak Pressure (non-auditory)	243 dB re 1 μPa peak

[a] Source: U.S. Department of the Navy (2017).

[b] Where *M* is animal mass (kg) and *D* is animal depth (m).

Table D-6. U.S. Navy Mortality and Non-Auditory Impulse and Peak Pressure Thresholds for Marine Mammals and Sea Turtles for Estimating Distances to Potential Onset for Mitigation Planning[a]

Impact Assessment Criteria	Threshold[b]
Mortality—Impulse	103 $M^{1/3}$ (1 + (D/10.1))$^{1/6}$ Pa-s
Injury—Impulse	47.5 $M^{1/3}$ (1 + (D/10.1))$^{1/6}$ Pa-s
Injury—Peak Pressure (non-auditory)	237 dB re 1 μPa peak

[a] Source: U.S. Department of the Navy (2017).

[b] Where *M* is animal mass (kg) and *D* is animal depth (m).

2 Theory and Background

2.1 Open Water Explosives Scenario

Open water explosions, or underwater explosions that occur in the water column, have been studied for decades. Arons and Yennie (1948) defined the general description of the shock pulse before it interacts with any of the ocean's boundaries was defined as an exponentially decaying function by the equations using International System of Units (SI) of meter, kilogram, and second (MKS) units:

$$P(t) = P_0\, e^{(-t/\tau)} \qquad (1)$$

where: $P(t)$ is the pressure time series in Pa,
P_0 is the maximum pressure of the shock wave in Pa,
t is time (seconds), and
τ is the decay constant (seconds).

The P_0 and τ terms are a scalar value derived based on empirical data. They are found using equations (2) and (3):

$$P_0 = (5.24 \times 10^7)\ (W^{1/3}/R)^{K1} \qquad (2)$$

in Pa, and

$$\tau = (9.25 \times 10^{-5})\, W^{1/3}\, (W^{1/3} / R)^{K2} \qquad (3)$$

in seconds, where: W is the NEW of the charge in kg TNT,
R is the slant range (meters),
$K1$ is 1.12, a correction factor for attenuation for TNT, and
$K2$ is -0.22, a spreading correction factor for TNT.

These equations were found by Rogers (1977) to only apply very close to the source, and he developed a weak shock theory to correct for longer ranges. Gaspin (1983) identified this transition range as defined by the equation:

$$R0 = 4.76\, W^{1/3} \qquad [\mathrm{m}] \qquad (4)$$

in meters. So, for a weight of 1,000 kg, that transition range is 47.6 m.

Since the UWC, version 3 (UWC 3) relies on empirical measurements and data to correct for other attenuating factors in the EROS process—such as the energy absorption in cutting the structure, the shape of the charges themselves, and any attenuation from transmission through sediment—the effects of the weak shock are included in these calibrations and will not be further developed in this theory section.

One other quantification of underwater explosions needs to be discussed, since it is critical to estimating non-auditory physical impacts on marine animals. This quantity is called “positive impulse,” or sometimes just “impulse.” Its symbol is J_0, and it has units of Pa-s. Impulse is the integration of the positive pressure of the shock wave from its inception until the time the initial pressure becomes a negative pressure. Solving that integration, the effective impulse is defined as:

$$J_0 = P_0(R)\, \tau(R)\, (1 - e^{(T/\tau)}) \qquad [\text{Pa s}] \qquad (5)$$

where:
P_0 is defined by equation (2),
τ is defined by equation (3),
R is the slant range in m,
e = 2.718, and
T is the cutoff time (i.e., the lesser of T_{surf} or T_{osc}; see below).

Figure D-1 provides the geometry of the impulsive signal. Figure D-2 provides a visual representation of an explosive pressure signal.

For the combined signal—that is, the combination of the direct path and the surface reflected path—a portion of the positive impulse is cut off or cancelled out due because the reflected signal is 180° out of phase with the direct signal. Note that since this signal travels farther and loses some energy during its interaction with the ocean surface, its maximum amplitude is less than that of the direct signal. The time of the cutoff after the arrival of the direct path signal is governed by this equation:

$$T_{surf} = ((X^2 + (D_s + D_r)2)^{1/2} - (X^2 + (D_s - D_r)^2)^{1/2})/C_0 \qquad (6)$$

in seconds, where:
T_{surf} is the cutoff time of the reflected signal in seconds,
X is the horizontal distance from the explosion (meters),
D_s is the depth of the source (meters),
D_r is the depth of the receiver (meters), and
C_0 is the speed of sound in water, an estimated 1,500 m/s.

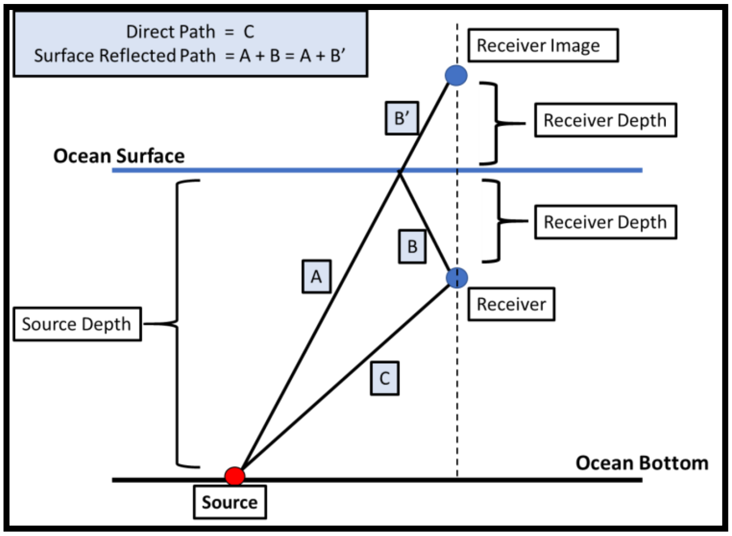

Figure D-1. Geometry of Direct and Reflected Signals

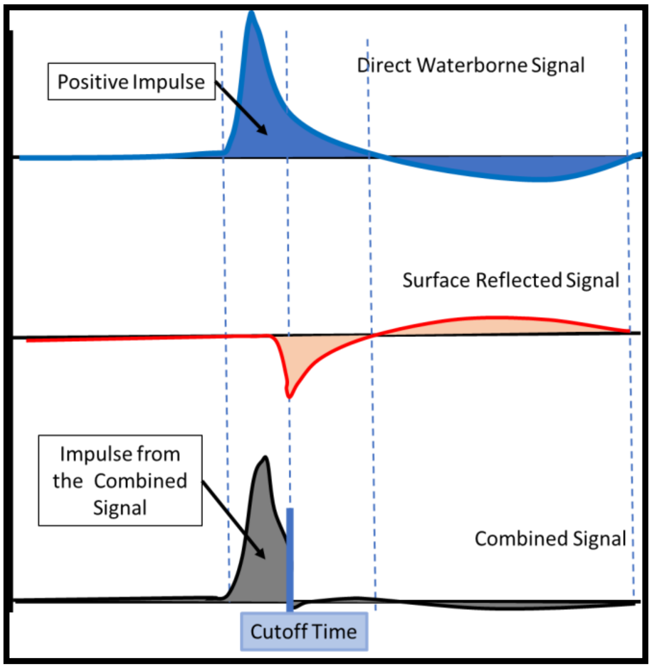

Figure D-2. Combined Direct and Reflected Signal

The U.S. Navy (U.S. Department of the Navy 2017) also examines the oscillation time (T_{osc}) of an animal's lungs to determine if that cutoff time is less than the surface reflection time. For positive impulse, the lesser of T_{surf} or 20% of T_{osc} is used as the cutoff time. The equation governing T_{osc} is:

$$T_{osc} = 29.7(1.83\ M\ (P_{atm}/P_{hyd})\ /\ (4\ \pi/3))^{1/3})\ /\ (P_{hyd})^{1/2} \quad (7)$$

In seconds, where: M is the mass of the animal in kilograms,
P_{atm} is the atmospheric pressure at sea level (assume 14.7 psi),
P_{hyd} is the hydrostatic pressure at that depth (psi),
$P_{hyd} = (P_{atm} + (D_r\ \upsilon_{sw}\ /144))$,
υ_{sw} is the specific weight of salt water (64 lb./ft^3), and
D_r is receiver depth in feet.

A necessary component for these calculations is the masses of the animals being examined. For the purposes of this analysis, Table D-6 provides a range of the masses of both adult individuals and calves/pups for the species shown. These are intended to be representative values and not specific for all possible animal weights. This is a simplifying assumption, and animals with lesser weights than those used here will have proportionately larger impact radii since smaller animals are more susceptible to these impacts. The plots in Figures D-3 and D-4 roughly cover the full range of masses in Table D-7, and are plotted to show the general comparison for T_{surf} and 20% T_{osc} for this range of masses.

Table D-7. Representative Weight for Various Species

Species or Species Group	Calf/pup Mass (kg)[a]	Adult Mass (kg)[a]
Low-Frequency (Baleen) Cetaceans and Sperm Whales	650	16,000
Pilot and Minke Whales	200	4,000
Beaked Whales	49	366
Dolphins, Kogia, Pinnipeds	8	60
Porpoises	8	40
Sea Otters	5	45

[a] Found in Hannay and Zykov (2022).

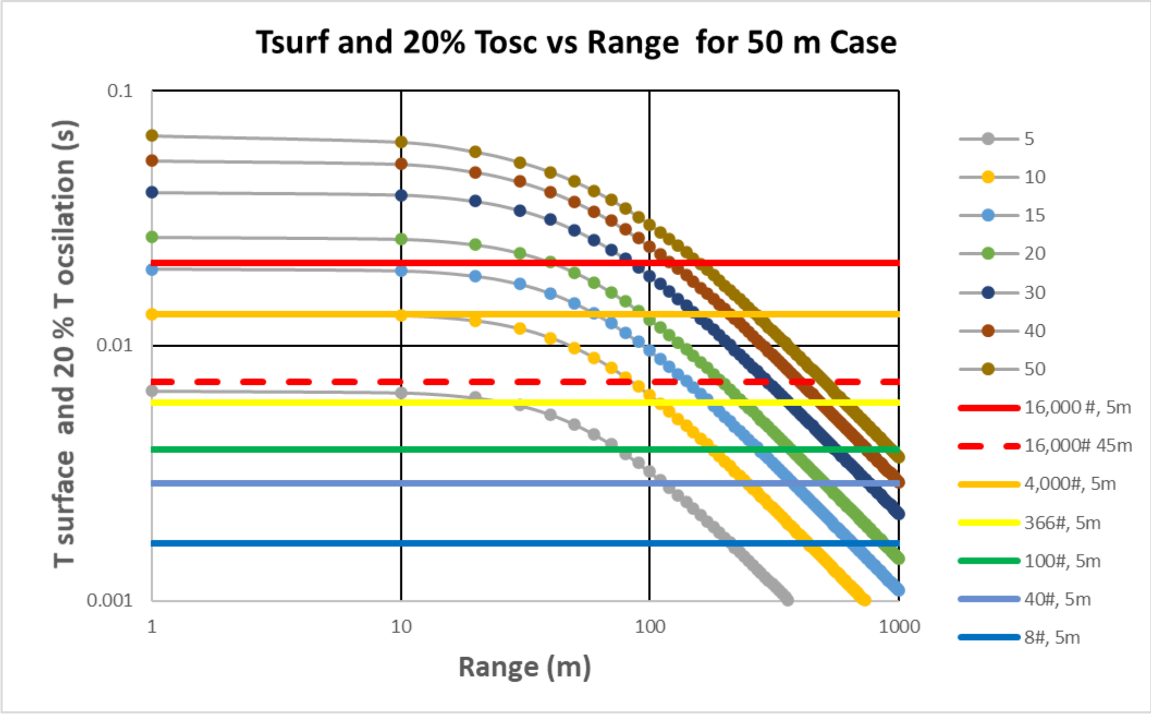

Figure D-3. T_{surf} and T_{osc} as a Function of Depth for the 50-m Water Depth Cases (T_{surf}: data points; T_{osc}: solid lines)

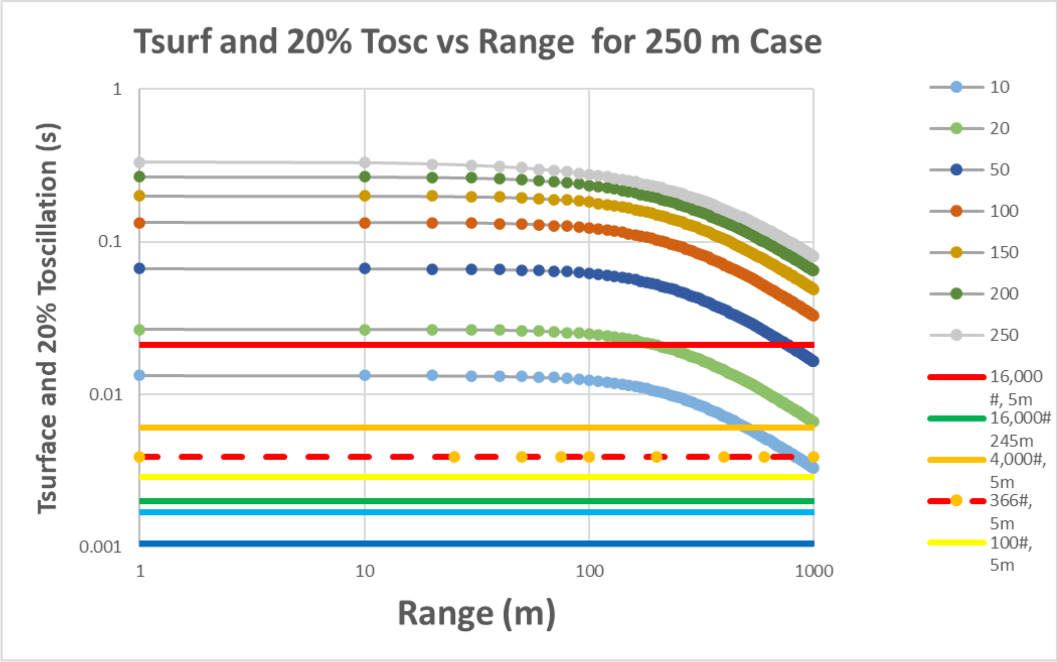

Figure D-4. T_{surf} and T_{osc} as a Function of Depth for 250-m Water Depth Cases (T_{surf}: data points; T_{osc}: solid lines)

Figures D-3 and D-4 show how T_{surf} and T_{osc} vary as a function of depth for the two water depth cases of 50 and 250 m, respectively. These figures only show T_{osc} as a function of receiver depth, not horizontal range from the source. Figures D-5 and D-6 show how horizontal range affects these T_{surf} values. In general, an examination of these figures demonstrates that the T_{surf} cutoff time determines the impulse, except in the case of large baleen whales when they are very close to the source (i.e., they have horizontal ranges of 50 m or less) and they are very shallow (i.e., less than 10 m deep). This is due to the relative depth of the explosive sources in relation to the water column. The 20% T_{osc} cutoff will be dominant at farther ranges, especially for the larger species.

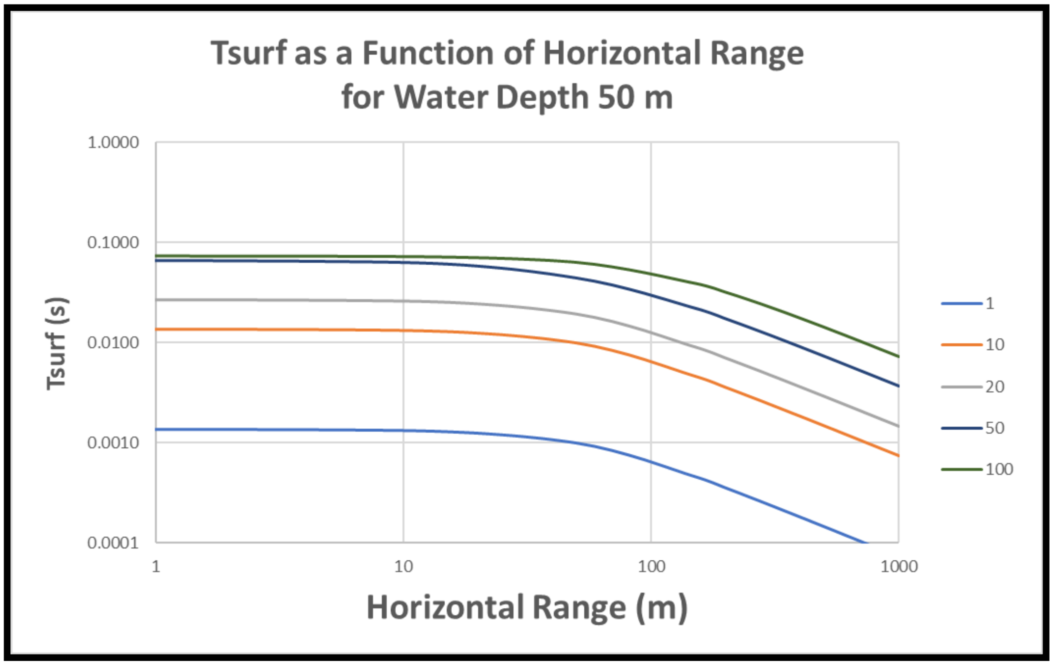

Figure D-5. T_{surf} as a Function of Range for 50-m Water Depth Cases, for Various Depths in the Water Column

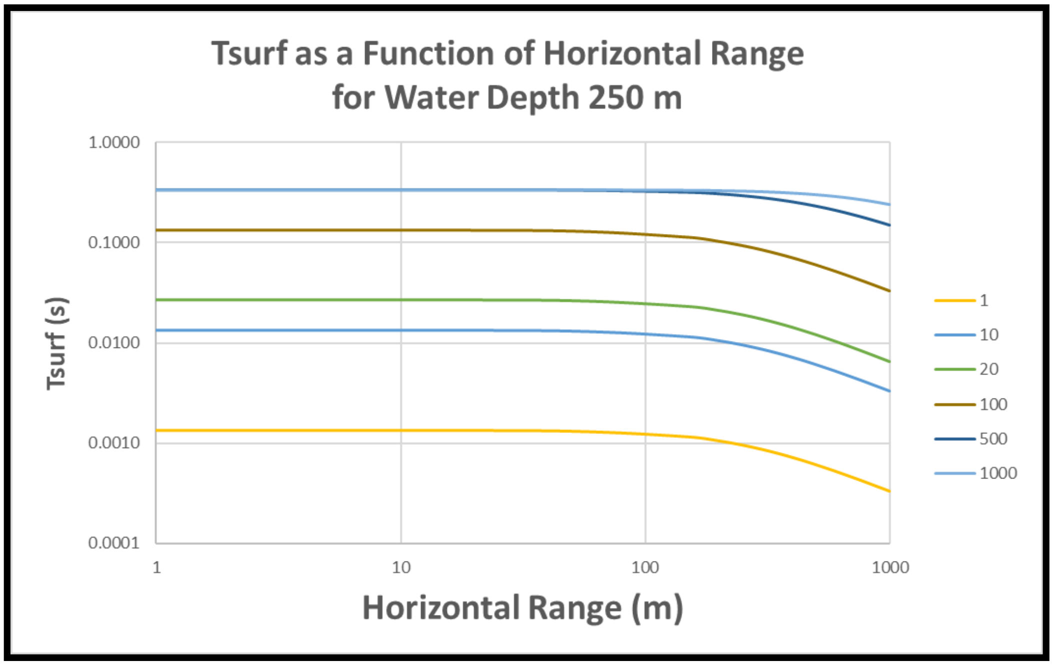

Figure D-6. T_{surf} as a Function of Range for the 250-m Water Depth Cases for Various Depths in the Water Column

The final characteristic of the open water shockwave that needs to be discussed is the frequency content of the acoustic energy of the impulsive signal. As described in Urick (1971, 1983) and using the first bubble oscillation equation identified in Chapman (1985), the energy source level (SEL) can be quantified for an open water explosion. This SEL can be provided as a function of frequency, as an SEL spectral density, whose levels are dependent on the size and the explosion and the depth where it occurs. Here the source scales as the NEW of the charge to the one-third power. Following the U.S. Navy's approach, species frequency-weighted SEL values are used to assess the presence of injury per the thresholds identified above.

The effects of the ocean bottom interface, other structures, and other phenomena in and around the explosive source are not considered in this investigation. The ocean bottom interface is not a perfect reflector and it absorbs shock energy. Typically, the amplitude of the wave reflected from the bottom surface is less than the direct shock wave. We are considering the amplitude of this wave to be in the same positive sense (i.e., it does not have the 180° phase shift of the ocean surface interface) as the direct shock but much lower invalue. Therefore, we are considering the ocean bottom reflections to be negligible for this study. The other shock interactions caused by the explosive event are much later in time. This study does not show possible multiple reflections between the air surface and the bottom, nor arriving bubble sphere radiations which occur later than the shockwave. We are only considering the shock interactions within the five or so time constants of the direct shock pulse.

2.2 Description of the Shock Pulse and Impulsive Function for the EROS Scenario

An idealized simulation of the physics of EROS scenario is demonstrated in Figures D-7 and D-8. These figures are loosely based on physical configuration and the shock physics calculation modeled for one of the field tests from TAR570 (Dzwilewski 2014) (see Sub-Appendix D1 for the complete report on the UWC 3). The configuration is shown in Figure D-7 (explosive shown in red). The resulting pressure field from the numerical simulation at 15.5 ms is shown in Figure D-8. The top of the mudline is at zero and the explosive is at 5 m (15 ft.) BML.

The resulting wave structure is complex and consists of several distinct components. One component is produced by the vibration from the explosion propagating up the steel pile and radiating outward. This produces a radiated wave the is subsequently reflect off of the ocean's surface. It is identified in this figure by the label "free surface reflected wave." A second component is the direct pressure from the explosion propagating outward from the explosion point, through the sediment and then into the water column. A final component visible at this time after the explosion is the wave produced by the vibration travel down the pile from the explosion. This wavefront propagates downward and eventually encounters and is reflected off of the "basement." This "basement" is the transition from sediment to rock and is labeled here as "reflection." These elements can be modeled quite adequately. The difficulty, however, is that the actual *in situ* sediment conditions and properties and their variability with depth and range are generally not known. In particular, the energy losses in the sediment due the presence of air or gasses in the voids have a significant impact on the attenuation and shock environment in the water. Hence, there is a great need to base the models on field data.

In addition, three other factors necessitate the use of an empirical approach to model the EROS physics. The first of these is the use of distributed shape charges to "cut," rather than damage the structure with a physical force. This probably has some directionality to it, which is not easily measured. The second factor is the loss of energy due to the absorption in the cutting process and the transmission the structure as a whole. Finally, the oscillatory bubble present in open water explosions is not seriously impacted, because the explosive removal charge is by the containment of much of the explosion internal to the structure itself and then at least partially directing the bubble to remain inside the structure, where it oscillation energy is not easily propagated into the water column.

To properly account for all of these factors, the UWC1 and 2 were developed after measuring the sound fields on numerous EROS events (Dzwilewski and Fenton 2003; Dzwilewski 2014). Subsequent to these reports, additional EROS measurements were taken, typically with different water depths, pile diameters and thickness, and *in situ* sediment situations. The resulting UWC3 report was not previously released, but is included in the PEIS as Sub-Appendix D1. Additional discussion of the details of the involving the calculations made by the UWC3 and the assumption embedded in the model can be found in Section 4.2 of this sub-appendix.

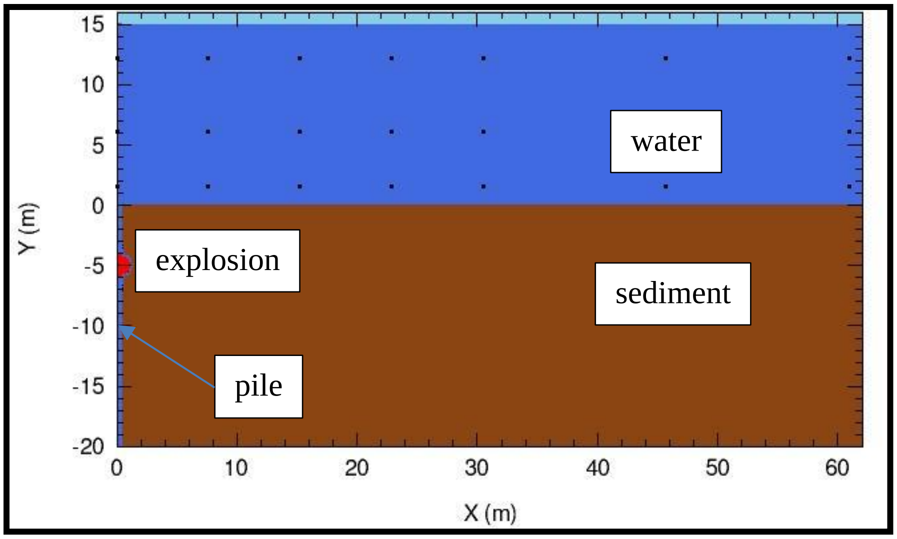

Figure D-7. Modeled Physical Configuration for a TAR570 Experiment (Dzwilewski 2014)

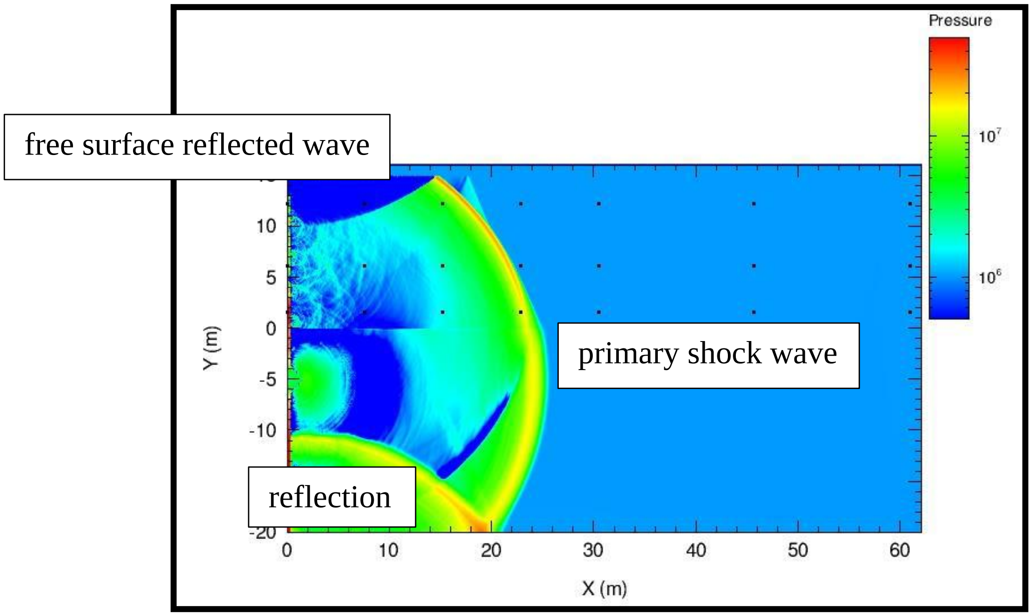

Figure D-8. Numerical Simulation Pressure Plot at 15.5 ms (Dzwilewski 2014)

3 Impact Analysis Approach

3.1 Input Parameters and Associated Assumptions

3.1.1 Offshore Structure Locations and Depths

Table D-8 lists the current structures located in the water off of southern California (SoCal). Their locations and depths (in meters) are included. This information is derived from the BOEM/BSEE Technical Information Management System, a computerized and secure, proprietary government tool used to automate and track business and regulate functions for those operations that either BOEM/BSEE has authorized or permitted.

Table D-8. Oil and Gas Structures Offshore of California

Structure Name	Latitude (°N)	Longitude (°W)	Water Depth (ft.)	Water Depth (m)
Hogan	34.3376716	119.5424427	154	46.9
Houchin	34.3349884	119.5530739	163	49.7
A	34.3318836	119.6134301	188	57.3
B	34.3323393	119.6224973	190	57.9
Hillhouse	34.3313419	119.6042073	190	57.9
Hondo	34.3907226	120.1215075	842	256.6
C	34.3329227	119.6317284	192	58.5
Grace	34.1795724	119.4687796	318	96.9
Henry	34.3332524	119.5613549	173	52.7
Ellen	33.5823890	118.1291206	265	80.8
Gina	34.1175018	119.2772020	90	27.4
Gilda	34.1823428	119.4195137	205	62.5
Habitat	34.2866148	119.5890526	290	88.4
Edith	33.5958082	118.1415850	161	49.1
Eureka	33.5638034	118.1173923	700	213.4
Gail	34.1250830	119.4011658	739	225.2
Harmony	34.3766667	120.1685034	1198	365.2
Heritage	34.3503825	120.2801661	1075	327.7
Irene	34.6104033	120.7304352	242	73.8
Harvest	34.4691227	120.6818212	675	205.7
Hermosa	34.4550701	120.6473920	603	183.8
Hidalgo	34.4950001	120.7032945	430	131.1
Elly	33.5834251	118.1279872	265	80.8

The structural locations are plotted in the body of this PEIS and will not be repeated here. However, those locations are a critical input to the identification of the local sediment character and the local marine species densities throughout the year.

The depth parameter for these structures span water depths of 27 to 365 m. For this analysis, two representative depths at the higher and low range of these depths were selected to reasonably represent both the range and statistical distribution of the water depths being examined. Those representative values are 50 and 250 m.

3.1.2 Explosive Charge Size and Explosive Depth

The range of NEWs for the five explosive weight bins shown in Table D-9 vary from 0 to 500 lb. equivalent weight of TNT. For each of these five bins, the largest weight in that bin's weight range was used to identify the bin. For example, bins A1 and A2 range from 0 to 10 lb., so a value of 10 lb. is used to represent those bins. Table D-2 shows the typical distribution of explosive weights in the GOM. For the purpose of completeness, all five weight bins will be examined in this analysis; however, note that over 90% of the charges used are 200 lb. or less. Less than 1% are in the 500-lb. bin, so the use of charges that large is fairly rare. For representative analysis in Section 5 of this appendix, only NEW of 200 lb. will be examined. Tables covering the impacts of the other four NEW bins appear in Sub-Appendix D2.

The positioning of the explosive in relation to the ocean floor, or mudline, is also identified in Table D-1. However, removals at or above the mudline (AML) as shown in that table are currently very rarely allowed. For this appendix, we assume that all explosive charges will be BML. In addition, the current standard depth that is used is 15 ft, or approximately 5 m. This analysis will use that nominal value for all calculations.

Table D-9, from the UWC3 report (Sub-Appendix D1) is repeated here for comparison. It delineates the experiments that were included in the development of the UWC3. It also provides examples of recent explosive weights, depths, water depths, and structural wall thickness. Sub-Appendix D1 details how these recent measurements were incorporated into the similitudes used in the UWC-3. Note that these values are consistent with the assumptions made concerning explosive weight and vertical placement.

Table D-9. Comparison of Parameters of Past and Current Studies

Experiment	Water Depth (ft)	Charge Size (lb.)	Depth BML (ft)	Wall Thickness (in.)
TAR118 (Connor 1990)	53	25–50	8–26	1.0
TAR429	38–50	50	15	1.0
TAR570	50	75–145	15–30	0.625–1.5
PWAP	92	75–200	15–25	1.0–2.25

3.1.3 Structural Specifications

The structural diameters and wall thicknesses for the rigs covered in this PEIS have not been specified, but they are expected to be consistent with those used in the GOM rigs. The California rigs are contemporaneous with the Gulf rigs and use similar technology. Table D-9 provides some representative values for those Gulf rigs, and the charge size used to cut them. Table D-10 provides an historic perspective on the specifications typical structural wall thickness, pile diameters and explosive weights used in the GOM. The inclusion in this analysis of charge weights up to 500 lb. should cover any thickness greater than 2.5 in. that may exist, and which would require charges greater than 200 lb. In addition, Table D-9 includes structures situated in 250 m of water; therefore the full range of water depth and structural specifications that may be encountered in SoCal have been included in this analysis.

Table D-10. Pile Numerical Simulations

Pile Wall Thickness (inches)	Pile Diameter (inches)			
	24	**36**	**48**	**72**
¾	25 lb.	—	—	—
1½	50 lb.	50, 100 lb.	100 lb.	100 lb.
1½	—	50 lb. (soft clay)	—	—
1½	—	50 lb. (water)	—	—
1½	—	50 lb. (toroid)	—	—
2½	—	50 lb., 100 lb.	100 lb.	100 lb.

3.1.4 Sediment Present at Sites

One of the potentially important parameters identified by the development of the UWC-3 is the sediment present at the structure's location. Unfortunately, the analysis of the measured data to date has not succeeded in allowing this parameter to be incorporated into the UWC-3 code as a specifically called-out parameter. Rather, all of the data is incorporated into the algorithm, and mean values are used in the coding. For this analysis, the 23 locations are spread out over an area approximately 90 km by 200 km and covering water depths between 27 and 365 m deep. In addition, these structures can be from less than 18 km to more than 150 km offshore. Therefore, there is not a single sediment type or structure present throughout this area. This variety can clearly be seen in Figure D-9 and Table D-11 (Gillett et al. 2021). The use of the UWC-3 mean values to capture this variability both in the model and this analysis is reasonable.

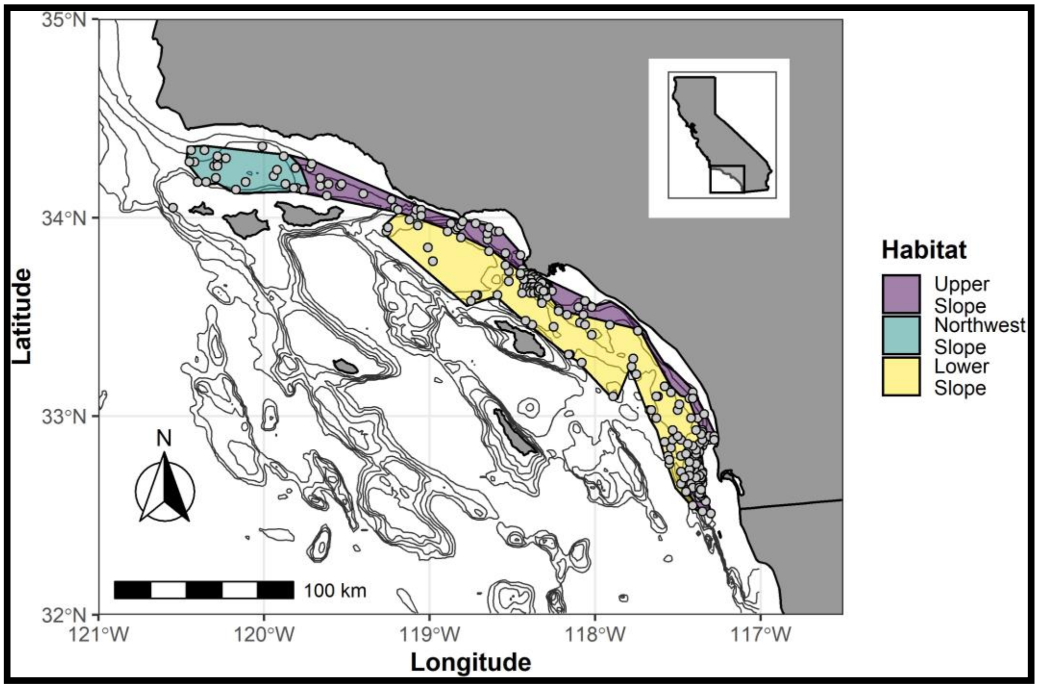

Figure D-9. Map of SoCal Bight Sediments and Distribution (Gillett et al. 2021)

Table D-11. Summary of Sediments for Figure D-9 (Gillett et al. 2021, Table 2)

Sediment	Upper Slope (%)	Northwest Slope (%)	Lower Slope (%)
Sand	0.28	0.67	0.36
Silt	0.41	0.62	0.45
Clay	0.45	0.15	0.13

3.1.5 Species Present in the Proposed Sites and Their Densities

The densities of marine mammals potentially present in the SoCal region are provided in Table D-12, in units of animals per square kilometer. Here the species are separated by hearing group, with the densities provided for each month throughout the year. The shaded boxes indicate that those values were found on the NOAA website (https://cetsound.noaa.gov/cda), while the unshaded values are derived from the U.S. Navy's *Hawaii and Southern California Training and Testing Final Environmental Impact Statement* Overseas Environmental Impact Statement (U.S. Department of the Navy 2018). The NOAA data was used as the primary source, and the U.S. Navy data was used to fill in gaps in the NOAA data. When no density was specified by either source, a value of "0" was used. When the values varied within a single month, such as when gray whales were migrating past the area, the largest density identified for that month was used.

Table D-12. Marine Mammal Densities (animals/km^2) By Month for the SoCal Area[a]

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.000342	0.000342	0.000342	0.000342	0.000342	0.008431	0.008431	0.008431	0.008431	0.008431	0.008431	0.008431
Bryde's whale	0.000037	0.000037	0.000037	0.000037	0.000037	0.000037	0.000006	0.000006	0.000006	0.000006	0.000006	0.000037
Fin whale	0.006223	0.006223	0.006223	0.006223	0.006223	0.027164	0.027164	0.027164	0.027164	0.027164	0.027164	0.027164
Humpback whale	0.007055	0.007055	0.007055	0.007055	0.007055	0.006613	0.006613	0.006613	0.006613	0.006613	0.006613	0.006613
Minke whale	0.000276	0.000276	0.000276	0.000276	0.000448	0.000448	0.001616	0.001616	0.001616	0.001616	0.001616	0.001616
Sei whale	0.00006	0.00006	0.00006	0.00006	0.00006	0.00006	0.000086	0.000086	0.000086	0.000086	0.000086	0.00006
Gray whale	0.01791	0.01791	0.01791	0.01791	0.01791	0.01791	0.00059	0.00059	0.00059	0.00059	0.00059	0.01791
Mid-Frequency Cetaceans												
Sperm whale	0.003375	0.003375	0.003375	0.003375	0.005364	0.001453	0.001453	0.001453	0.001453	0.001453	0.001453	0.005364
Small sperm whales (general)	0.002497	0.002497	0.002497	0.002497	0.002497	0.002497	0.001083	0.001083	0.001083	0.001083	0.001083	0.002497
Beaked Whale (general)	0.001483	0.001483	0.001483	0.001483	0.002497	0.002497	0.002497	0.002497	0.002497	0.002497	0.002497	0.002497
False killer whale	0	0	0	0	0	0	0	0	0	0	0	0
Killer whale	0.000246	0.000246	0.000246	0.000246	0.009188	0.009188	0.000709	0.000709	0.000709	0.000709	0.000709	0.00024
Short-finned pilot whale (general)	0.002402	0.002402	0.002402	0.002402	0.002402	0.002402	0.000307	0.000307	0.000307	0.000307	0.000307	0.002402
Northern Pacific right whale	0.000061	0.000061	0.000061	0.000061	0	0	0	0	0	0	0	0
Bottlenose (general)	0.042192	0.042192	0.042192	0.042192	0.118101	0.171153	0.171153	0.171153	0.171153	0.171153	0.171153	0.191421
Bottlenose coastal stock	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576	0.041576
Bottlenose offshore stock	0.000616	0.000616	0.000616	0.000616	0.076525	0.076525	0.149845	0.149845	0.149845	0.149845	0.149845	0.149845

Table D-12. Marine Mammal Densities (animals/km²) By Month for the SoCal Area (cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Common Dolphin, long-beaked	2.529041	2.529041	2.529041	2.529041	2.529041	6.567737	6.567737	6.567737	6.567737	6.567737	6.567737	2.529041
Common dolphin, short-beaked	0.77	0.77	0.77	0.77	0.77	0.333981	2.831187	2.831187	2.831187	2.831187	2.831187	0.333981
Northern right whale dolphin	0.034061	0.034061	0.034061	0.034061	0.030014	0.067837	0.067837	0.067837	0.067837	0.067837	0.067837	0.030014
Pacific white-sided dolphin	0.621757	0.621757	0.621757	0.621757	0.1005	0.193141	0.193141	0.193141	0.193141	0.193141	0.193141	0.1005
Risso's dolphin	0.202937	0.202937	0.202937	0.202937	0.147165	0.192595	0.192595	0.192595	0.192595	0.192595	0.192595	0.147165
Rough-toothed dolphin	0	0	0	0	0	0	0	0	0	0	0	0
Striped dolphin	0.003724	0.003724	0.003724	0.003724	0.003724	0.021632	0.021632	0.021632	0.021632	0.021632	0.021632	0.003724
High-Frequency Cetaceans												
Dall's porpoise	0.16	0.16	0.16	0.16	0.16	0.079686	0.079686	0.079686	0.079686	0.079686	0.079686	0.200437
Harbor porpoise	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
Dwarf sperm whale	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159	0.00159
Pygmy sperm whale	0	0	0	0	0	0	0.000797	0.000797	0.000797	0.000797	0.000797	0
Otaridae												
California sea lion	0.062738	0.062738	0.062738	0.062738	0.062738	0.062738	0.062874	0.062874	0.062874	0.062874	0.062874	0.062738
Guadalupe fur seal	0.0083	0.0083	0.0083	0.0083	0.0083	0.0083	0.0287	0.0287	0.0287	0.0287	0.0287	0.0083
Northern fur seal	0.022564	0.022564	0.022564	0.022564	0.022564	0.022564	0.0063	0.0063	0.0063	0.0063	0.0063	0.022564
Southern sea otter	Unkn.[b]	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0183	0.0183	0.0183	0.0183	0.0183	0.0183	0.0083	0.0083	0.0083	0.0083	0.0083	0.0183
Northern elephant seal	0.05755	0.05755	0.05755	0.05755	0.05755	0.05755	0.08628	0.08628	0.08628	0.08628	0.08628	0.05755

[a] No data were available for sea turtles, so they are not included in this table.

[b] No reliable density data exist for sea otters, so this is noted by “Unkn.”

3.1.6 Animal Depth in the Water Column

Each explosive removal is a separate event in time and space, potentially separated by many days or even months, and large distances—miles, or even tens of miles. This impact analysis considers them in this light and assumes that there is no significant addition of acoustic energy from multiple events. In addition, this analysis did not use detailed animal movement modelling and animals were assumed to be evenly distributed throughout the water column. For the shallow water structures (i.e., approximately in 50 m water) this is a reasonable assumption; for deeper scenarios (i.e., water approximately 250 m deep) this is probably conservative, except for the deeper diving species.

It is expected that mitigation steps will be included in the guidance for actually conducting these removals; however, no mitigation has been applied in this analysis. This includes any seasonal time selection for these events. However, monthly estimates of marine mammal densities throughout the year and the estimated potential impact presented here facilitate examining these temporal scenarios.

3.1.7 Prorated Volume Correction in the Calculations

Due to the range of representative water depth (50 and 250 m) and the range of impact radii (from tens to thousands of meters), the physical volume actually ensonified compared to the water column should be examined. This is necessary because the hemisphere surrounding the explosion is at the bottom of the water column; potentially, the entire water column would not be completely ensonified to a threshold level. When potential takes are calculated, implicit in that calculation is the assumption that the entire water column has been ensonified out to the radius of a cylinder defined by the impact radius or slant range calculated in the UWC-3. Figure D-10 visually represents this configuration. Here the source (a red star) is identified at some distance BML and the ensonified volume, up to the level of a particular threshold is shown by the red hemisphere. The water column cylinder is represented here by two vertical dashed lines.

For impact radii less than the water depth, the scenario remains a hemisphere at the bottom of a cylinder. However, as the radius increases in size it eventually will meet the ocean's surface. In that configuration, the ensonified volume assumes the volume of a spherical segment, whose value is governed by equation (8):

$$V_{seg} = (1/6)\,\pi\, h\,(3a^2 + 3a_1^2 + h^2) \tag{8}$$

in cubic meters, where:

V_{seg} = volume of the spherical segment;
h = height of the segment, or effectively the depth of the water (m);
a = radius of the sphere, effectively the radius to the threshold (m); and
a_1 = the radius of the circle of the intersection of the sphere with the ocean's surface (m).

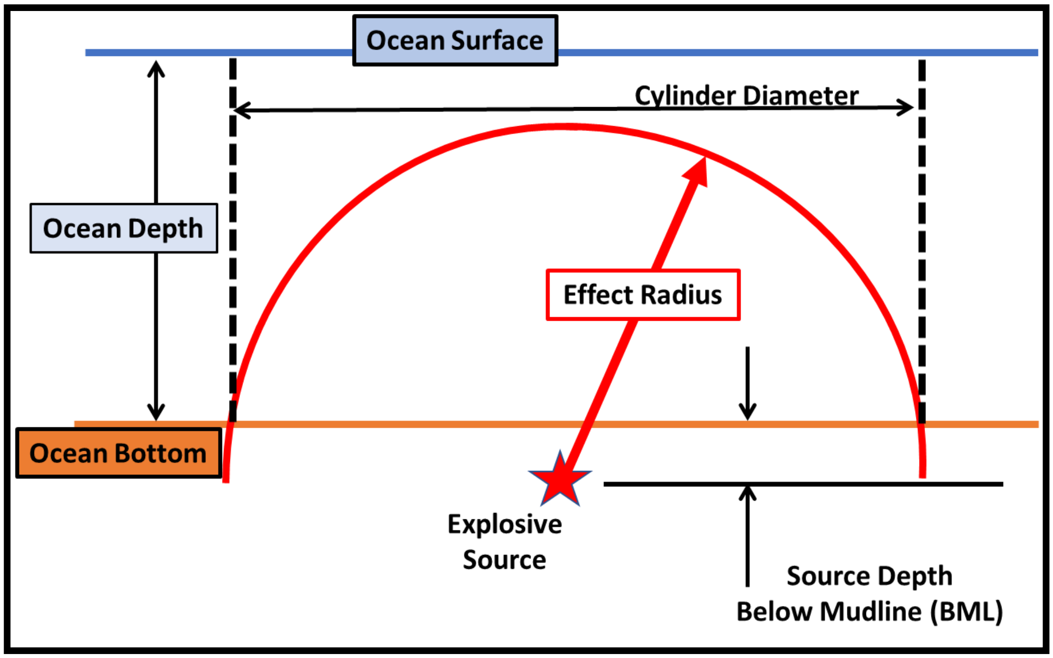

Figure D-10. Configuration of the Ensonified Hemispherical Volume within the Water Column

Figure D-11 provides a plot of these volume correction values for the 50 and 250 m depth cases. Effectively, as the radius continues to increase the hemisphere gradually approaches the volume of the cylinder its radius inscribes. Note that by the time the radius reaches the ocean's surface, over 60% of the cylinder is ensonified; this number increases to over 90% for radii that are twice the water depth.

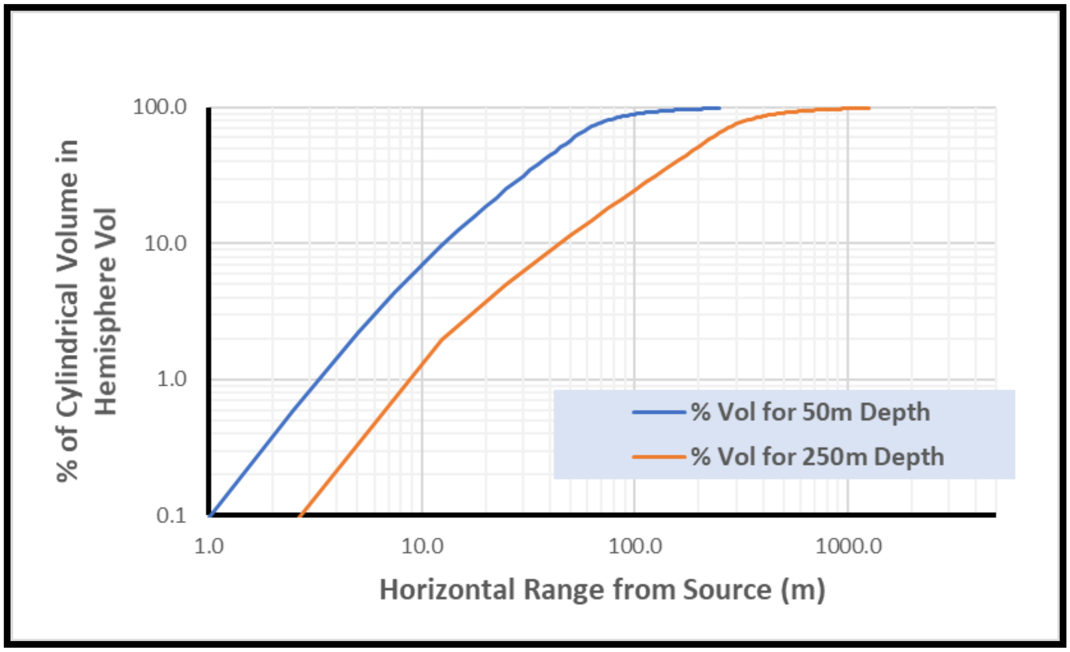

Figure D-11. Volume Correction Factor for a Hemisphere at the Bottom of a Cylinder, for the 50- and 250-m Cases

3.1.8 Impact Radius Calculations

3.1.8.1 Non-Auditory Injury Ranges

The non-auditory injury ranges are calculated directly by the UWC-3. The requisite inputs include the type of explosive, the scenario type, the NEW of the explosive, the number of events, the animal mass, and the animal depth. For this analysis it is assumed the main pile is being removed by TNT, with the larger of the ranges of NEWs for each weight bin from Table D-1; there is only one event; and the animal masses are per Table D-7. The animal depth of maximum impulse is used. The depth of maximum impulse was identified by repeated runs of the UWC-3 and selecting the depth of maximum impact. A value of 5 m was used here. The resulting non-auditory injurious radii are presented in Tables D-13 and D-14 for calves/pups and adults, respectively, for the species based on hearing group and the animal masses from Table D-7. Note that in this Tables D-13 and D-14, “severe lung injury” is equivalent to mortality.

Table D-13. Non-Auditory Injurious Radii by Hearing Group and Animal Mass for Calves/Pups

Species Group	Injury Type	Explosive NEW (lb.)				
		10	20	80	200	500
Low-frequency and sperm whale	Severe lung	14	20	40	64	101
	Slight lung	22	31	62	98	155
	Gastrointestinal tract	45	57	90	123	167
Pilot and minke whales	Severe lung	17	25	49	78	123
	Slight lung	27	38	76	119	189
	Gastrointestinal tract	45	57	90	123	167
Beaked whales	Severe lung	22	31	62	99	156
	Slight lung	34	48	96	151	239
	Gastrointestinal tract	45	57	90	123	167
Dolphins, pinnipeds, kogia	Severe lung	30	42	85	134	212
	Slight lung	46	65	129	205	324
	Gastrointestinal tract	45	57	90	123	167
Porpoise	Severe lung	32	46	91	145	229
	Slight lung	50	70	140	222	351
	Gastrointestinal tract	45	57	90	123	167

Table D-14. Non-Auditory Injurious Radii by Hearing Group and Animal Mass for Adults

Species Group	Injury Type	Explosive NEW (lb.)				
		10	20	80	200	500
Low-frequency and sperm whale	Severe lung	8	12	24	37	59
	Slight lung	13	18	36	57	91
	Gastrointestinal tract	45	57	90	123	167
Pilot and minke whales	Severe lung	11	15	30	47	75
	Slight lung	16	23	46	72	115
	Gastrointestinal tract	45	57	90	123	167
Beaked whales	Severe lung	16	22	45	71	112
	Slight lung	24	34	68	108	171
	Gastrointestinal tract	45	57	90	123	167
Dolphins, pinnipeds, kogia	Severe lung	21	30	60	95	151
	Slight lung	33	46	92	146	231
	Gastrointestinal tract	45	57	90	123	167
Porpoise	Severe lung	23	32	65	102	162
	Slight lung	35	49	99	156	248
	Gastrointestinal tract	45	57	90	123	167

3.1.8.2 Auditory Injury and Behavior Ranges

Similarly, the ranges to the isopleth that cause PTS and behavior impacts are provided in Table D-15 for the five hearing groups identified above. Both the SPL and SEL injury radii are provided for information, but the SPL radius is always larger and will be used for all subsequent take calculations. Two values for behavior radii are also provided. The first labelled "Behavior (UWC-3)" comes directly from the UWC number and is based on NMFS (2018) thresholds. Since that publication, the U.S. Navy (U.S. Department of the Navy 2018) has subsequently used TTS as the onset for behavioral impacts. Here the maximum TTS radius from the UWC-3 is used. Based on the species hearing group thresholds, the maximum TTS value can vary between the SPL and the SEL values.

Table D-15. Auditory Injurious and Behavioral Radii by Hearing Group for Calves/Pups and Adults

Species Group	Injury Type	Explosive NEW (lb.)				
		10	20	80	200	500
Low-frequency whale	PTS (SPL)	168	211	335	454	617
	PTS (SEL)	142	191	342	503	739
	Behavior (UWC 3)	814	1,088	1,941	2,846	4,272
	Behavior (U.S. Navy [USN]: TTS)	626	704	1,257	1,845	2,707
Mid-frequency cetacean	PTS (SPL)	75	95	150	204	277
	PTS (SEL)	49	61	97	131	178
	Behavior (UWC 3)	246	310	493	669	909
	Behavior (USN: TTS)	164	207	328	445	605
High-frequency cetacean	PTS (SPL)	577	727	1,153	1,565	2,124
	PTS (SEL)	469	597	971	1,338	1,846
	Behavior (UWC 3)	2,320	2,982	4,926	6,865	9,570
	Behavior (USN: TTS)	1,555	1,995	3,282	4,562	6,342
Otaridae	PTS (SPL)	65	82	130	177	240
	PTS (SEL)	10	13	20	26	36
	Behavior (UWC 3)	50	63	100	156	184
	Behavior (USN: TTS)	101	127	201	273	371
Phocidae	PTS (SPL)	180	227	360	489	663
	PTS (SEL)	49	61	97	131	178
	Behavior (UWC 3)	246	310	493	669	909
	Behavior (USN: TTS)	279	351	557	756	1,026

4 Results

The results presented in this chapter will cover both non-auditory injuries and auditory injury and behavior take estimates for the representative explosive charge size of 200 lb., representative structure water depths of 50 and 250 m, and for both calf/pup and adult animal masses throughout the year. The volume correction will be applied, but no mitigation is included.

4.1 Non-Auditory Injury Takes

The non-auditory injury take estimates will be for the largest of the three passible non-auditory radii as identified in Table D-15. Table D-16 covers calves/pups for 50-m structures; Table D-17 covers adults for 50-m structures; Table D-18 covers calves/pups for 250-m structures; and Table D-20 covers adults for 250-m structures.

A review of these results shows that for all baleen and endangered species, the estimated takes are 0.002 or less, while for almost all other species the estimated takes are 0.08 or less. The exceptions to this are the common dolphin species, where the take estimates can be as high as 0.82 in some months. This is because these species have the highest density values by far. Also note that this only occurs for the shallow-water structure scenario. For the deep structure, with all other factors being the same, take estimates for the common dolphins are approximately one-fourth those of the shallow-water case. This is because non-auditory injury radii are typically about 50 m; in the deep-water case, this represents only about one-fifth of the water column. In addition, these deep-water cases are also more conservative because, realistically, these dolphin species do not dive that deep in the water column.

Table D-16. Non-Auditory Injury Takes for Calves/Pups, 200-lb. NEW, 50-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Bryde's whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
Fin whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Humpback whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Minke whale	0.0000	0.0000	0.0000	0.0000	0.0012	0.0012	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Sei whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Gray whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Mid-Frequency Cetaceans												
Sperm whale	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Small sperm whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
Beaked whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0000	0.0000	0.0000	0.0000	0.0012	0.0012	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Short-finned pilot whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0053	0.0053	0.0053	0.0053	0.0148	0.0214	0.0214	0.0214	0.0214	0.0214	0.0214	0.0240
coastal stock	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
offshore stock	0.0001	0.0001	0.0001	0.0001	0.0096	0.0096	0.0188	0.0188	0.0188	0.0188	0.0188	0.0188
Common dolphin, long-beaked	0.3169	0.3169	0.3169	0.3169	0.3169	0.8229	0.8229	0.8229	0.8229	0.8229	0.8229	0.3169
Common dolphin, short-beaked	0.0965	0.0965	0.0965	0.0965	0.0965	0.0418	0.3547	0.3547	0.3547	0.3547	0.3547	0.0418

Table D-16. Non-Auditory Injury Takes for Calves/Pups, 200-lb. NEW, 50-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0043	0.0043	0.0043	0.0043	0.0038	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0038
Pacific white-sided dolphin	0.0779	0.0779	0.0779	0.0779	0.0126	0.0242	0.0242	0.0242	0.0242	0.0242	0.0242	0.0126
Risso's dolphin	0.0254	0.0254	0.0254	0.0254	0.0184	0.0241	0.0241	0.0241	0.0241	0.0241	0.0241	0.0184
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0005	0.0005	0.0005	0.0005	0.0005	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0005
High-Frequency Cetaceans												
Dall's porpoise	0.0237	0.0237	0.0237	0.0237	0.0237	0.0118	0.0118	0.0118	0.0118	0.0118	0.0118	0.0296
Harbor porpoise	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092
Dwarf sperm whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Otaridae												
California sea lion	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146
Guadalupe fur seal	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0067	0.0067	0.0067	0.0067	0.0067	0.0019
Northern fur seal	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0015	0.0015	0.0015	0.0015	0.0015	0.0053
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0011	0.0011	0.0011	0.0011	0.0011	0.0024
Northern elephant seal	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0111	0.0111	0.0111	0.0111	0.0111	0.0074

Table D-17. Non-Auditory Injury Takes for Adult, 200-lb. NEW, 50-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Bryde's whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fin whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
Humpback whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Minke whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sei whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gray whale	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
Mid-Frequency Cetaceans												
Sperm whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Small sperm whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Beaked whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Short-finned pilot whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0011	0.0011	0.0011	0.0011	0.0030	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0049
coastal stock	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
offshore stock	0.0000	0.0000	0.0000	0.0000	0.0019	0.0019	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
Common dolphin, long-beaked	0.0642	0.0642	0.0642	0.0642	0.0642	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.0642
Common dolphin, short-beaked	0.0195	0.0195	0.0195	0.0195	0.0195	0.0085	0.0719	0.0719	0.0719	0.0719	0.0719	0.0085

Table D-17. Non-Auditory Injury Takes for Adult, 200-lb. NEW, 50-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0009	0.0009	0.0009	0.0009	0.0008	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0008
Pacific white-sided dolphin	0.0158	0.0158	0.0158	0.0158	0.0026	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0026
Risso's dolphin	0.0052	0.0052	0.0052	0.0052	0.0037	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0037
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001
High-Frequency Cetaceans												
Dall's porpoise	0.0047	0.0047	0.0047	0.0047	0.0047	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0059
Harbor porpoise	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Dwarf sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Otaridae												
California sea lion	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
Guadalupe fur seal	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0047	0.0047	0.0047	0.0047	0.0047	0.0014
Northern fur seal	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0010	0.0010	0.0010	0.0010	0.0010	0.0037
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005
Northern elephant seal	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0022	0.0022	0.0022	0.0022	0.0022	0.0014

Table D-18. Non-Auditory Injury Takes for Calves/Pups, 200-lb. NEW, 250-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
Bryde's whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fin whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Humpback whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
Minke whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Sei whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gray whale	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008
Mid-Frequency Cetaceans												
Sperm whale	0.0001	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Small sperm whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
Beaked whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0000	0.0000	0.0000	0.0000	0.0012	0.0012	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Short-finned pilot whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0053	0.0053	0.0053	0.0053	0.0148	0.0214	0.0214	0.0214	0.0214	0.0214	0.0214	0.0240
coastal stock	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052	0.0052
offshore stock	0.0001	0.0001	0.0001	0.0001	0.0096	0.0096	0.0188	0.0188	0.0188	0.0188	0.0188	0.0188
Common dolphin, long-beaked	0.3169	0.3169	0.3169	0.3169	0.3169	0.8229	0.8229	0.8229	0.8229	0.8229	0.8229	0.3169
Common dolphin, short-beaked	0.0965	0.0965	0.0965	0.0965	0.0965	0.0418	0.3547	0.3547	0.3547	0.3547	0.3547	0.0418

Table D-18. Non-Auditory Injury Takes for Calves/Pups, 200-lb. NEW, 250-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0043	0.0043	0.0043	0.0043	0.0038	0.0085	0.0085	0.0085	0.0085	0.0085	0.0085	0.0038
Pacific white-sided dolphin	0.0779	0.0779	0.0779	0.0779	0.0126	0.0242	0.0242	0.0242	0.0242	0.0242	0.0242	0.0126
Risso's dolphin	0.0254	0.0254	0.0254	0.0254	0.0184	0.0241	0.0241	0.0241	0.0241	0.0241	0.0241	0.0184
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0005	0.0005	0.0005	0.0005	0.0005	0.0027	0.0027	0.0027	0.0027	0.0027	0.0027	0.0005
High-Frequency Cetaceans												
Dall's porpoise	0.0237	0.0237	0.0237	0.0237	0.0237	0.0118	0.0118	0.0118	0.0118	0.0118	0.0118	0.0296
Harbor porpoise	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092	0.0092
Dwarf sperm whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Otaridae												
California sea lion	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146	0.0146
Guadalupe fur seal	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0067	0.0067	0.0067	0.0067	0.0067	0.0019
Northern fur seal	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0015	0.0015	0.0015	0.0015	0.0015	0.0053
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0011	0.0011	0.0011	0.0011	0.0011	0.0024
Northern elephant seal	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074	0.0111	0.0111	0.0111	0.0111	0.0111	0.0074

Table D-19. Non-Auditory Injury Takes for Adult, 200-lb. NEW, 250-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Bryde's whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fin whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007	0.0007
Humpback whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Minke whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sei whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Gray whale	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005
Mid-Frequency Cetaceans												
Sperm whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Small sperm whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Beaked whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0000	0.0000	0.0000	0.0000	0.0002	0.0002	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Short-finned pilot whale	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0011	0.0011	0.0011	0.0011	0.0030	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0049
coastal stock	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011
offshore stock	0.0000	0.0000	0.0000	0.0000	0.0019	0.0019	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038
Common dolphin, long-beaked	0.0642	0.0642	0.0642	0.0642	0.0642	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	0.0642
Common dolphin, short-beaked	0.0195	0.0195	0.0195	0.0195	0.0195	0.0085	0.0719	0.0719	0.0719	0.0719	0.0719	0.0085

Table D-19. Non-Auditory Injury Takes for Adult, 200-lb. NEW, 250-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0009	0.0009	0.0009	0.0009	0.0008	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0008
Pacific white-sided dolphin	0.0158	0.0158	0.0158	0.0158	0.0026	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0026
Risso's dolphin	0.0052	0.0052	0.0052	0.0052	0.0037	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0037
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001
High-Frequency Cetaceans												
Dall's porpoise	0.0047	0.0047	0.0047	0.0047	0.0047	0.0023	0.0023	0.0023	0.0023	0.0023	0.0023	0.0059
Harbor porpoise	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018
Dwarf sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Otaridae												
California sea lion	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
Guadalupe fur seal	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0047	0.0047	0.0047	0.0047	0.0047	0.0014
Northern fur seal	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0010	0.0010	0.0010	0.0010	0.0010	0.0037
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005
Northern elephant seal	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0022	0.0022	0.0022	0.0022	0.0022	0.0014

4.2 Auditory Injury

Auditory take estimates are provided in Tables D-20 and D-21 for the 50- and 250-m cases, respectively. A review of these results shows that for all baleen and endangered species, the estimated takes are 0.02 or less, while for almost all other species the estimated takes are 0.03 or less.

The exceptions to this are the common dolphin species, where the take estimates can be as high as 0.83 in some months, and the Dall and harbor porpoises, for which estimated takes can be about 1.5 and 0.5, respectively. For the dolphins, this is due to their high densities, while for the porpoises it is due to the large radii for their thresholds. Also note that this only occurs for the shallow-water structure scenario. For the deep structure, with all other factors being the same, those take estimates for the common dolphins are approximately half those of the shallow-water case. This is because the auditory injury radius is typically about 200 m, and in the deep-water case this represents only about 80% of the water column. In addition, the deep-water cases are also more conservative because, realistically, these dolphin species do not dive that deep in the water column.

Table D-20. Auditory Injury Takes, 200-lb. NEW, 50-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067	0.0067
Bryde's whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fin whale	0.0049	0.0049	0.0049	0.0049	0.0049	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216
Humpback whale	0.0056	0.0056	0.0056	0.0056	0.0056	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053
Minke whale	0.0002	0.0002	0.0002	0.0002	0.0004	0.0004	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Sei whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Gray whale	0.0142	0.0142	0.0142	0.0142	0.0142	0.0142	0.0005	0.0005	0.0005	0.0005	0.0005	0.0142
Mid-Frequency Cetaceans												
Sperm whale	0.0027	0.0027	0.0027	0.0027	0.0043	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0043
Small sperm whale	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0003
Beaked whale	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003	0.0003
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0000	0.0000	0.0000	0.0000	0.0012	0.0012	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Short-finned pilot whale	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0002	0.0002	0.0002	0.0002	0.0002	0.0019
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0054	0.0054	0.0054	0.0054	0.0150	0.0218	0.0218	0.0218	0.0218	0.0218	0.0218	0.0244
coastal stock	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053
offshore stock	0.0001	0.0001	0.0001	0.0001	0.0097	0.0097	0.0191	0.0191	0.0191	0.0191	0.0191	0.0191
Common dolphin, long-beaked	0.3217	0.3217	0.3217	0.3217	0.3217	0.8355	0.8355	0.8355	0.8355	0.8355	0.8355	0.3217
Common dolphin, short-beaked	0.0980	0.0980	0.0980	0.0980	0.0980	0.0425	0.3602	0.3602	0.3602	0.3602	0.3602	0.0425

Table D-20. Auditory Injury Takes, 200-lb. NEW, 50-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0040	0.0040	0.0040	0.0040	0.0036	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081	0.0036
Pacific white-sided dolphin	0.0739	0.0739	0.0739	0.0739	0.0119	0.0230	0.0230	0.0230	0.0230	0.0230	0.0230	0.0119
Risso's dolphin	0.0241	0.0241	0.0241	0.0241	0.0175	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0175
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0004	0.0004	0.0004	0.0004	0.0004	0.0026	0.0026	0.0026	0.0026	0.0026	0.0026	0.0004
High-Frequency Cetaceans												
Dall's porpoise	1.2299	1.2299	1.2299	1.2299	1.2299	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	1.5407
Harbor porpoise	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766
Dwarf sperm whale	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0061	0.0061	0.0061	0.0061	0.0061	0.0000
Otaridae												
California sea lion	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
Guadalupe fur seal	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0027	0.0027	0.0027	0.0027	0.0027	0.0008
Northern fur seal	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0006	0.0006	0.0006	0.0006	0.0006	0.0021
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0137	0.0137	0.0137	0.0137	0.0137	0.0137	0.0062	0.0062	0.0062	0.0062	0.0062	0.0137
Northern elephant seal	0.0432	0.0432	0.0432	0.0432	0.0432	0.0432	0.0648	0.0648	0.0648	0.0648	0.0648	0.0432

Table D-21. Auditory Injury Takes, 200-lb. NEW, 250-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061	0.0061
Bryde's whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fin whale	0.0045	0.0045	0.0045	0.0045	0.0045	0.0197	0.0197	0.0197	0.0197	0.0197	0.0197	0.0197
Humpback whale	0.0051	0.0051	0.0051	0.0051	0.0051	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
Minke whale	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Sei whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.0000
Gray whale	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0004	0.0004	0.0004	0.0004	0.0004	0.0130
Mid-Frequency Cetaceans												
Sperm whale	0.0025	0.0025	0.0025	0.0025	0.0039	0.0011	0.0011	0.0011	0.0011	0.0011	0.0011	0.0039
Small sperm whale	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002
Beaked whale	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0000	0.0000	0.0000	0.0000	0.0006	0.0006	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Short-finned pilot whale	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0002	0.0002	0.0002	0.0002	0.0002	0.0017
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0028	0.0028	0.0028	0.0028	0.0080	0.0115	0.0115	0.0115	0.0115	0.0115	0.0115	0.0129
coastal stock	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
offshore stock	0.0000	0.0000	0.0000	0.0000	0.0052	0.0052	0.0101	0.0101	0.0101	0.0101	0.0101	0.0101
Common dolphin, long-beaked	0.1706	0.1706	0.1706	0.1706	0.1706	0.4431	0.4431	0.4431	0.4431	0.4431	0.4431	0.1706
Common dolphin, short-beaked	0.0519	0.0519	0.0519	0.0519	0.0519	0.0225	0.1910	0.1910	0.1910	0.1910	0.1910	0.0225

Table D-21. Auditory Injury Takes, 200-lb. NEW, 250-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0023	0.0023	0.0023	0.0023	0.0020	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0020
Pacific white-sided dolphin	0.0419	0.0419	0.0419	0.0419	0.0068	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0068
Risso's dolphin	0.0137	0.0137	0.0137	0.0137	0.0099	0.0130	0.0130	0.0130	0.0130	0.0130	0.0130	0.0099
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0003	0.0003	0.0003	0.0003	0.0003	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0003
High-Frequency Cetaceans												
Dall's porpoise	1.2299	1.2299	1.2299	1.2299	1.2299	0.6125	0.6125	0.6125	0.6125	0.6125	0.6125	1.5407
Harbor porpoise	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766	0.4766
Dwarf sperm whale	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122	0.0122
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0061	0.0061	0.0061	0.0061	0.0061	0.0000
Otaridae												
California sea lion	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028
Guadalupe fur seal	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0013	0.0013	0.0013	0.0013	0.0013	0.0004
Northern fur seal	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0003	0.0003	0.0003	0.0003	0.0003	0.0010
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0125	0.0125	0.0125	0.0125	0.0125	0.0125	0.0057	0.0057	0.0057	0.0057	0.0057	0.0125
Northern elephant seal	0.0393	0.0393	0.0393	0.0393	0.0393	0.0393	0.0589	0.0589	0.0589	0.0589	0.0589	0.0393

4.3 Behavior Injury

Behavior take estimates by month are provided in Tables D-22 and D-23 for the 50- and 250-m water depths, respectively. In general, the threshold radii for the all species have doubled or tripled in size from those for PTS. This corresponds to a roughly four- to nine-fold increase in the number of behavioral takes compared to equivalent auditory injury takes for these species.

A review of these results shows that for all baleen and endangered species, the estimated takes are 0.3 or less, primarily due to their low densities. All of the take estimates grew as expected, but for almost all other species the estimated takes are 0.05 or less. The exceptions to this extend beyond the common dolphin species, where the take estimates can be as high as 4.0 in some months, to other more common dolphin species like bottlenose and Pacific white-sided dolphins, which have take estimates of 0.1 to 0.5. The porpoise radii have also increased, and their estimated takes are between 3.0 and 13.0 in some months. Because the HF species radii are approximately four times the depth of even the deep-water case (i.e., 250 m), even the deep-water case shows significant take levels since the entire water column is ensonified out to these radii.

Table D-22. Behavioral Takes, 200-lb. NEW, 50-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0037	0.0037	0.0037	0.0037	0.0037	0.0901	0.0901	0.0901	0.0901	0.0901	0.0901	0.0901
Bryde's whale	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004
Fin whale	0.0665	0.0665	0.0665	0.0665	0.0665	0.2902	0.2902	0.2902	0.2902	0.2902	0.2902	0.2902
Humpback whale	0.0754	0.0754	0.0754	0.0754	0.0754	0.0706	0.0706	0.0706	0.0706	0.0706	0.0706	0.0706
Minke whale	0.0029	0.0029	0.0029	0.0029	0.0048	0.0048	0.0173	0.0173	0.0173	0.0173	0.0173	0.0173
Sei whale	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0009	0.0009	0.0009	0.0009	0.0009	0.0006
Gray whale	0.1913	0.1913	0.1913	0.1913	0.1913	0.1913	0.0063	0.0063	0.0063	0.0063	0.0063	0.1913
Mid-Frequency Cetaceans												
Sperm whale	0.0021	0.0021	0.0021	0.0021	0.0033	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0033
Small sperm whale	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0007	0.0007	0.0007	0.0007	0.0007	0.0016
Beaked whale	0.0009	0.0009	0.0009	0.0009	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0002	0.0002	0.0002	0.0002	0.0057	0.0057	0.0004	0.0004	0.0004	0.0004	0.0004	0.0001
Short-finned pilot whale	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0002	0.0002	0.0002	0.0002	0.0002	0.0015
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0262	0.0262	0.0262	0.0262	0.0734	0.1064	0.1064	0.1064	0.1064	0.1064	0.1064	0.1190
coastal stock	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258	0.0258
offshore stock	0.0004	0.0004	0.0004	0.0004	0.0476	0.0476	0.0931	0.0931	0.0931	0.0931	0.0931	0.0931
Common dolphin, long-beaked	1.5718	1.5718	1.5718	1.5718	1.5718	4.0818	4.0818	4.0818	4.0818	4.0818	4.0818	1.5718
Common dolphin, short-beaked	0.4785	0.4785	0.4785	0.4785	0.4785	0.2076	1.7596	1.7596	1.7596	1.7596	1.7596	0.2076

Table D-22. Behavior Takes, 200-lb. NEW, 50-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0212	0.0212	0.0212	0.0212	0.0187	0.0422	0.0422	0.0422	0.0422	0.0422	0.0422	0.0187
Pacific white-sided dolphin	0.3864	0.3864	0.3864	0.3864	0.0625	0.1200	0.1200	0.1200	0.1200	0.1200	0.1200	0.0625
Risso's dolphin	0.1261	0.1261	0.1261	0.1261	0.0915	0.1197	0.1197	0.1197	0.1197	0.1197	0.1197	0.0915
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0023	0.0023	0.0023	0.0023	0.0023	0.0134	0.0134	0.0134	0.0134	0.0134	0.0134	0.0023
High-Frequency Cetaceans												
Dall's porpoise	10.4507	10.4507	10.4507	10.4507	10.4507	5.2048	5.2048	5.2048	5.2048	5.2048	5.2048	13.0919
Harbor porpoise	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497
Dwarf sperm whale	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0521	0.0521	0.0521	0.0521	0.0521	0.0000
Otaridae												
California sea lion	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147	0.0147
Guadalupe fur seal	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0067	0.0067	0.0067	0.0067	0.0067	0.0019
Northern fur seal	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0015	0.0015	0.0015	0.0015	0.0015	0.0053
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0328	0.0328	0.0328	0.0328	0.0328	0.0328	0.0149	0.0149	0.0149	0.0149	0.0149	0.0328
Northern elephant seal	0.1032	0.1032	0.1032	0.1032	0.1032	0.1032	0.1548	0.1548	0.1548	0.1548	0.1548	0.1032

Table D-23. Behavioral Takes, 200-lb. NEW, 250-m Structure

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Low-Frequency Cetaceans												
Blue whale	0.0033	0.0033	0.0033	0.0033	0.0033	0.0812	0.0812	0.0812	0.0812	0.0812	0.0812	0.0812
Bryde's whale	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0001	0.0001	0.0001	0.0001	0.0001	0.0004
Fin whale	0.0600	0.0600	0.0600	0.0600	0.0600	0.2617	0.2617	0.2617	0.2617	0.2617	0.2617	0.2617
Humpback whale	0.0680	0.0680	0.0680	0.0680	0.0680	0.0637	0.0637	0.0637	0.0637	0.0637	0.0637	0.0637
Minke whale	0.0027	0.0027	0.0027	0.0027	0.0043	0.0043	0.0156	0.0156	0.0156	0.0156	0.0156	0.0156
Sei whale	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	0.0008	0.0008	0.0008	0.0008	0.0008	0.0006
Gray whale	0.0033	0.0033	0.0033	0.0033	0.0033	0.0812	0.0812	0.0812	0.0812	0.0812	0.0812	0.0812
Mid-Frequency Cetaceans												
Sperm whale	0.0019	0.0019	0.0019	0.0019	0.0030	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0030
Small sperm whale	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0006	0.0006	0.0006	0.0006	0.0006	0.0014
Beaked whale	0.0008	0.0008	0.0008	0.0008	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
False killer whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Killer whale	0.0001	0.0001	0.0001	0.0001	0.0051	0.0051	0.0004	0.0004	0.0004	0.0004	0.0004	0.0001
Short-finned pilot whale	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0002	0.0002	0.0002	0.0002	0.0002	0.0013
N. Pacific right whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Bottlenose (genera)	0.0233	0.0233	0.0233	0.0233	0.0651	0.0943	0.0943	0.0943	0.0943	0.0943	0.0943	0.1055
coastal stock	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229	0.0229
offshore stock	0.0003	0.0003	0.0003	0.0003	0.0422	0.0422	0.0826	0.0826	0.0826	0.0826	0.0826	0.0826
Common dolphin, long-beaked	1.3940	1.3940	1.3940	1.3940	1.3940	3.6201	3.6201	3.6201	3.6201	3.6201	3.6201	1.3940
Common dolphin, short-beaked	0.4244	0.4244	0.4244	0.4244	0.4244	0.1841	1.5605	1.5605	1.5605	1.5605	1.5605	0.1841

Table D-23. Behavior Takes, 200-lb. NEW, 250-m Structure (Cont.)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Northern right whale dolphin	0.0188	0.0188	0.0188	0.0188	0.0165	0.0374	0.0374	0.0374	0.0374	0.0374	0.0374	0.0165
Pacific white-sided dolphin	0.3427	0.3427	0.3427	0.3427	0.0554	0.1065	0.1065	0.1065	0.1065	0.1065	0.1065	0.0554
Risso's dolphin	0.1119	0.1119	0.1119	0.1119	0.0811	0.1062	0.1062	0.1062	0.1062	0.1062	0.1062	0.0811
Rough-toothed dolphin	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Striped dolphin	0.0021	0.0021	0.0021	0.0021	0.0021	0.0119	0.0119	0.0119	0.0119	0.0119	0.0119	0.0021
High-Frequency Cetaceans												
Dall's porpoise	10.4507	10.4507	10.4507	10.4507	10.4507	5.2048	5.2048	5.2048	5.2048	5.2048	5.2048	13.0919
Harbor porpoise	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497	4.0497
Dwarf sperm whale	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039	0.1039
Pygmy sperm whale	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0521	0.0521	0.0521	0.0521	0.0521	0.0000
Otaridae												
California sea lion	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104	0.0104
Guadalupe fur seal	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0047	0.0047	0.0047	0.0047	0.0047	0.0014
Northern fur seal	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0010	0.0010	0.0010	0.0010	0.0010	0.0037
Southern sea otter	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.	Unkn.
Phocidae												
Harbor seal	0.0316	0.0316	0.0316	0.0316	0.0316	0.0316	0.0143	0.0143	0.0143	0.0143	0.0143	0.0316
Northern elephant seal	0.0993	0.0993	0.0993	0.0993	0.0993	0.0993	0.1489	0.1489	0.1489	0.1489	0.1489	0.0993

5 Conclusions

5.1 Non-auditory Injury Impacts

Overall, the estimated non-auditory injury takes indicate that the likelihood of any marine mammals receiving sufficient exposure for these types of injuries is very low (less than 0.02 takes per event in any month), except for the common dolphins and other similar very high-density cetaceans—and their take estimate is only 0.8 for the shallow-water case. These values for take are based on the calves/pups analysis, which is for the most vulnerable portion of those populations. The adult levels of estimated takes are generally 1/4th of these levels or lower. This is due the relatively short radii for these injuries, the position of the source in the water column and the generally (with a few dolphin exceptions) relatively low densities of the marine mammals.

Mitigation can be applied to further reduce these levels of potential injury, but all of the presented results include no mitigation.

5.2 Auditory Injury Impacts

Auditory injury results are similar in number and patterns to those identified for the non-auditory impacts, except that the large radii for the HF species causes the Dall's and Harbor porpoises to be at the approximately same or slightly higher levels than common dolphins. Similar summary conclusions are applicable.

5.3 Behavioral Impacts

The behavioral radii sizes increased significantly (i.e., they are approximately 4–9 times larger) for all species due to the behavior threshold levels. Some mitigation measures may still be effective for most species, since their behavioral radii are typically less than 1 km, but this is more problematic for the HF porpoises, whose behavioral radii are more than 4 km.

6 References

Arons, A.B., and D.R. Yennie. 1948. “Energy Partition in Underwater Explosion Phenomena.” *Review of Modern Physics* 20(3): 519–536.

Chapman, N.R. 1985. “Measurements of the waveform parameters of shallow explosive charges.” *Journal of the Acoustical Society of America* 78:672–681.

Connor, Jr., J.G. 1990. *Underwater Blast Effects from Explosive Severance of Offshore Platform Legs and Well Conductors*, NAVSWCTR 90-532. Naval Surface Warfare Center, Silver Spring, MD.

Dzwilewski, P., and G. Fenton. 2003. *Shock Wave/Sound Propagation Modeling Results for Calculating Marine Protected Species Impact Zones during Explosive Removal of Offshore Structures*, MMS 2003-059. U.S. Department of the Interior, Minerals Management Service, Gulf of Mexico OCS Region, New Orleans, LA.

Dzwilewski, P.T. 2014. *Water Shock Prediction for Explosive Removal of Offshore Structures: Underwater Calculator (UWC) Version 2.0 Update Based upon Field Data*.

Gaspin, J.B.1983. *Safe swimmer ranges from bottom explosions*. NSWC/WOL TR-83-84. Naval Surface Warfare Center, White Oak Lab, and Defense Technical Information Center, Silver Springs, MD.

Gillet, D.J., L. Gilbane, and K.C. Schiff. 2021. "Characterizing Community Structure of Benthic Infauna from the Continental Slope of Southern California Bight,” in *Marine Science* Volume 8, article 605805. June.

Goertner, J.F. 1982. *Prediction of Underwater Explosion Safe Ranges for Sea Mammals*, NSWC TR 82-188. NavalSurface Weapons Center, Silver Spring, MD.

Hannay, D.E., and M. Zykov. 2022. *Underwater Acoustic Modelling of Detonations of Unexploded Ordnance (UXO) for Ørsted Wind Farm Construction, US East Coast*, Document 02604, Version 4.45. Prepared by JASCO Applied Sciences for Ørsted.

NMFS (National Marine Fisheries Service). 2018. *Marine Mammal Acoustic Technical Guidance*, NOAA-TM-NMFS-OPR-59, Office of Protected Resources, April.

Popper, A.N., A.D. Hawkins, R.R. Fay, D.A. Mann, S. Bartol, T.J. Coombs, W.T. Ellison, R.L. Gentry, et.al. 2014. *Sound Exposure Guidelines for Fish and Sea Turtles: A Technical Report*. Prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI.ASA S3/SC1.4 TR-2014. Springer Briefs in Oceanography. ASA Press and Springer. Available at https://doi.org/10 1007/978-3-319-06659-2.

Rogers, P.H. 1977. “Weak-shock solution for underwater explosive shock waves.” *Journal of the Acoustical Society of America* 62(6):1412–1419.

Urick, R.J. 1971. “Handy curves for finding the source level of an explosive charge fired at depth in the sea.” *Journal of the Acoustical Society of America* 49:935–936.

Urick, R. J.1983. Principles of Underwater Sound, 3rd Edition ed. McGraw-Hill, New York.

U.S. Department of Commerce. 2018. *2018 Revisions 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*, NOAA-TM-NMFS-OPR-59, National Marine Fisheries Service.

U.S. Department of the Navy. 2017). *Request for Regulations and Letter of Authorization for the Incidental Taking of Marine Mammals Resulting from U.S. Navy Training and Testing in the Atlantic Fleet Training and Testing Study Area*. Prepared for U.S. Department of Commerce, National Marine Fisheries Service, Office of Protected Resources by U.S. Department of the Navy, Commander, Fleet Forces Command. 15June 2017, Updated 4 August 2017. 560 p.

U.S. Department of the Navy. 2018. *Hawaii–Southern California Training and Testing Final Environmental Impact Statement/Overseas Environmental Impact Statement*. Naval Facilities Engineering Command, Pacific/EV21, Pearl Harbor, HI. Available at: https://www.hstteis.com/Documents/2018-Hawaii-Southern-California-Training-and-Testing-Final-EIS-OEIS/Final-EIS-OEIS.

Yelverton, J.T., D.R. Richmond, E.R. Fletcher, and R.K. Jones. 1973. *Safe Distances from Underwater Explosions for Mammals and Birds*, Technical Report No. 3114 T. Prepared by Lovelace Foundation forMedical Education and Research, Albuquerque, NM, for Defense Nuclear Agency, Washington, DC.