4.0 Environmental Consequences
This chapter describes potential environmental consequences at each location that may be affected by the No-action Alternative, Alternative 1, and Alternative 2. The same resource areas addressed in Chapter 3.0 for each location are addressed in this chapter. The following sections address the potential for impacts on each environmental resource and its attributes by activity and subactivities identified in Chapter 2.0.

Environmental consequences are discussed according to location; the Open Ocean Areas is discussed first, followed by offshore and onshore discussion organized by island locations from west to east: Northwestern Hawaiian Islands, Kauai, Oahu, Maui, and Hawaii. For organizational purposes, discussions about Niihau and Kaula are included under the Kauai heading, because although they are separate islands, they are part of Kauai County. In addition, discussions about Molokai are included under the Maui heading, although it is a separate island, because it is part of Maui County. The last section discusses the Hawaiian Islands Humpback Whale National Marine Sanctuary. The page headers in this chapter identify which location is discussed. The rationale for not addressing certain resources for a given location is provided under each location. Table 4-1 lists each location and the section of each of the resources addressed.

Potential environmental effects described in this section focus on the continuation of ongoing operations in the Hawaii Range Complex (HRC) (No-action Alternative) and the effects of implementing Alternatives 1 and 2 to the No-action Alternative. The environmental consequences assessment in the Environmental Impact Statement (EIS)/Overseas EIS (OEIS) includes estimates of the potential direct and indirect effects, long- and short-term effects, and irreversible and irretrievable resource commitments.

The EIS/OEIS generally describes the measures required to mitigate adverse impacts. The EIS/OEIS also identifies those measures already committed to as part of current, ongoing operations, and additional mitigations (if any) which could reasonably be expected to reduce impacts if Alternative 1 or 2 is implemented.
### Table 4-1. Chapter 4.0 Locations and Resources

<table>
<thead>
<tr>
<th>Air Quality</th>
<th>Acreage</th>
<th>Biological Resources</th>
<th>Cultural Resources</th>
<th>Geology &amp; Soils</th>
<th>Hazardous Materials &amp; Waste</th>
<th>Health &amp; Safety</th>
<th>Land Use</th>
<th>Noise</th>
<th>Socioeconomics</th>
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</table>

*A review of the 13 environmental resources against program activities determined there would be no impacts from site activities under the No-action Alternative, Alternative 1, or Alternative 2.*
4.1 OPEN OCEAN AREA

Table 4.1-1 lists ongoing operations for the No-action Alternative and proposed operations for Alternatives 1 and 2 in the Open Ocean Area. Alternative 2 is the preferred alternative.

Table 4.1-1. Training and RDT&E Operations Occurring in the Open Ocean Area

<table>
<thead>
<tr>
<th>Training Operations</th>
<th>Research, Development, Test, and Evaluation (RDT&amp;E) Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Air Combat Maneuver (ACM)</td>
<td>• Anti-Air Warfare RDT&amp;E</td>
</tr>
<tr>
<td>• Air-to-Air Missile Exercise (A-A MISSILEX)</td>
<td>• Anti-Submarine Warfare</td>
</tr>
<tr>
<td>• Surface-to-Air Gunnery Exercise (S-A GUNEX)</td>
<td>• Combat System Ship Qualification Trial</td>
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<tr>
<td>• Surface-to-Air Missile Exercise (S-A MISSILEX)</td>
<td>• Electronic Combat/Electronic Warfare (EC/EW)</td>
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<tr>
<td>• Chaff Exercise (CHAFFEX)</td>
<td>• High Frequency</td>
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<tr>
<td>• Naval Surface Fire Support Exercise (NSFS)</td>
<td>• Missile Defense</td>
</tr>
<tr>
<td>• Visit, Board, Search, and Seizure (VBSS)</td>
<td>• Shipboard Electronic Systems Evaluation Facility (SESEF) Quick Look</td>
</tr>
<tr>
<td>• Surface-to-Surface Gunnery Exercise (S-S GUNEX)</td>
<td>• SESEF System Performance Test</td>
</tr>
<tr>
<td>• Surface-to-Surface Missile Exercise (S-S MISSILEX)</td>
<td>• Additional Chemical Simulant (Alternative 1)</td>
</tr>
<tr>
<td>• Air-to-Surface Gunnery Exercise (A-S GUNEX)</td>
<td>• Intercept Targets Launched into Pacific Missile Range Facility (PMRF) Controlled Area</td>
</tr>
<tr>
<td>• Air-to-Surface Missile Exercise (A-S MISSILEX)</td>
<td>(Alternative 1)</td>
</tr>
<tr>
<td>• Bombing Exercise (BOMBEX) (Sea)</td>
<td>• Launched SM-6 from Sea-Based Platform (AEGIS) (Alternative 1)</td>
</tr>
<tr>
<td>• Sink Exercise (SINKEX)</td>
<td>• Test Unmanned Surface Vehicles (Alternative 1)</td>
</tr>
<tr>
<td>• Anti-Surface Warfare (ASUW) Torpedo Exercise (TORPEX) (Submarine-Surface)</td>
<td>• Test Unmanned Aerial Vehicles (Alternative 1)</td>
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<td>• Anti-Submarine Warfare (ASW) Tracking Exercise (TRACKEX)</td>
<td>• Test Hypersonic Vehicles (Alternative 1)</td>
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<td>• ASW TORPEX</td>
<td>• Portable Undersea Tracking Range (Alternative 1)</td>
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<td>• Major Integrated ASW Training Exercise</td>
<td>• Large Area Tracking Range Upgrade (Alternative 1)</td>
</tr>
<tr>
<td>• Electronic Combat Operations</td>
<td>• Enhanced Electronic Warfare Training (Alternative 1)</td>
</tr>
<tr>
<td>• Mine Countermeasures Exercise (MCM)</td>
<td>• Expanded Training Capability for Transient Air Wings (Alternative 1)</td>
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<tr>
<td>• Mine Neutralization</td>
<td>• Directed Energy (Alternative 2)</td>
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<td>• Swimmer Insertion/Extraction</td>
<td>• Advanced Hypersonic Weapon (Alternative 2)</td>
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<td>• Command and Control (C2) (Sea)</td>
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<tr>
<td>• Demolition Exercises (Sea)</td>
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</table>

Notes: 1. Modeled for explosives  
2. Modeled for sonar
4.1.1 AIRSPACE—OPEN OCEAN

The potential impacts on airspace in the Open Ocean Area are discussed in terms of conflicts with the use of controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields.

4.1.1.1 NO-ACTION ALTERNATIVE (AIRSPACE—OPEN OCEAN)

4.1.1.1.1 HRC Training Operations

The ongoing, continuing HRC Training Operations that could affect airspace include mine laying, Surface-to-Surface Gunnery Exercises (S-S GUNEX), Surface-to-Surface Missile Exercises (S-S MISSILEX), Air-to-Surface Gunnery Exercises (A-S GUNEX), Air-to-Surface Missile Exercises (A-S MISSILEX), Bombing Exercises (BOMBEX), Sink Exercises (SINKEX), Air Combat Maneuvers (ACM), Air-to-Air Missile Exercises (A-A MISSILEX), Electronic Countermeasures (ECM), Surface-to-Air Gunnery Exercises (S-A GUNEX), Surface-to-Air Missile Exercises (S-A MISSILEX), Naval Surface Fire Support (NSFS), Flare Exercises, and Chaff Exercises (CHAFFEX).

Controlled and Uncontrolled Airspace

The Navy can accomplish the No-action Alternative without modifications or need for additional airspace to accommodate continuing training operations.

Special Use Airspace

Ongoing, continuing operations identified above will continue to use the existing Open Ocean Area special use airspace including Warning Areas and Air Traffic Control Assigned Airspace (ATCAA) shown on Figure 3.1.1-1. Although the nature and intensity of use varies over time and by individual special use airspace area, the continuing training operations represent precisely the kinds of operations for which the special use airspace was created. The Warning Areas are designed and set aside by the Federal Aviation Administration (FAA) to accommodate operations that present a hazard to other aircraft. As such, the continuing training operations do not conflict with any airspace use plans, policies, and controls. The ATCAA has been developed by the FAA to facilitate the management of aircraft moving between and adjacent to other special use airspace areas.

En Route Airways and Jet Routes

Numerous instrument flight rules (IFR), en route low altitude air traffic service routes, and IFR en route high altitude oceanic routes are used by commercial aircraft that pass through the region of influence (see Figure 3.1.1-1). However, the region of influence is relatively remote from the majority of jet routes that crisscross the northern Pacific Ocean. The Navy coordinates closely with the FAA to avoid conflicts with commercial aviation.

The low altitude airways that pass through a Warning Area include V7 (through W-190), V15 (through W-188), and V16 (through W-186). There are no oceanic routes that pass through a Warning Area. Several low altitude airways pass below the Pali ATCAA near Oahu. The floor of the Pali ATCAA is above the ceiling of the low altitude routes. Two low altitude airways pass above the ceiling of the Mela North ATCAA. Navy training involving aircraft in the Open Ocean...
4.0 Environmental Consequences, Open Ocean Area

Area is conducted away from en route airways and jet routes to minimize potential airspace conflicts.

Use of the low altitude airways and high-altitude jet routes comes under the control of the Honolulu and Oakland Air Route Traffic Control Center (ARTCC). In addition, the Navy surveys the airspace involved in each training operation either by radar or patrol aircraft. Safety regulations dictate that hazardous operations will be suspended by the Navy when it is known that any non-participating aircraft has entered any part of a training activity danger zone. The suspension lasts until the non-participating entrant has left the area or a thorough check of the suspected area has been performed. Consequently, there are no impacts to non-military aircraft.

In terms of potential airspace use impacts to en route airways and jet routes in the Open Ocean Area, the continuing training operations will be conducted in compliance with Department of Defense (DoD) Directive 4540.1, as directed by Office of the Chief of Naval Operations Instruction (OPNAVINST) 3770.4A, which specifies procedures for conducting aircraft operations and for missile/projectile firing. Namely, that missile and projectile firing areas shall be selected so that trajectories are clear of established oceanic air routes or areas of known surface or air activity. In addition, before conducting an operation that is hazardous to non-participating aircraft, Notices to Airmen (NOTAMs) published by the FAA will be sent in accordance with the conditions of the directive specified in OPNAVINST 3721.20A. The increasing adoption of “Free Flight” by commercial aircraft could make the airspace coordination task somewhat more difficult, but this will still be handled by the issuance of NOTAMs. As noted in Chapter 3.0, with the full implementation of this program, the amount of airspace in the region of influence that is likely to be clear of traffic may decrease as pilots, whenever practical, choose their own route and file a flight plan that follows the most efficient and economical route.

All airspace outside the territorial limits is located in international airspace. Because the Open Ocean Area airspace use region of influence is in international airspace, the procedures outlined in International Civil Aviation Authority (ICAO) Document 444, Rules of the Air and Air Traffic Services are followed. The FAA acts as the U.S. agent for aeronautical information to the ICAO, and air traffic in the over-water region of influence is managed by the Honolulu ARTCC, and to a lesser extent, the Oakland ARTCC.

As noted above, continuing training operations will use the existing Open Ocean Area special use airspace and will not require either: (1) a change to an existing or planned IFR minimum flight altitude, a published or special instrument procedure, or an IFR departure procedure; or (2) a visual flight rules (VFR) operation to change from a regular flight course or altitude. Consequently, there are no airspace conflicts.

Airports and Airfields
There are no airports and airfields in the Open Ocean Area region of influence.

HRC RDT&E Operations
The ongoing research, development, test, and evaluation (RDT&E) operations that could affect airspace include missile defense ballistic missile target flights, Terminal High Altitude Area Defense (THAAD) interceptor operations, A-S MISSILEX, A-A MISSILEX, S-A MISSILEX, and
Controlled and Uncontrolled Airspace

No new airspace proposal or any modification to the existing controlled airspace has been identified to accommodate continuing training operations. Typically target and interceptor missiles will be above flight level (FL) 600 within minutes of the rocket motor firing. As such, all other local flight activities will occur at sufficient distance and altitude that the target missile and interceptor missiles will be little noticed. However, activation of the proposed stationary altitude reservation (ALTRV) procedures, where the FAA provides separation between non-participating aircraft and the missile flight test activities in the TOA for use of the airspace identified in Figure 3.1.1-1, will impact the controlled airspace available for use by non-participating aircraft for the duration of the ALTRV—usually for a matter of a few hours, with a backup day reserved for the same hours. The airspace in the TOA is not heavily used by commercial aircraft, and is far removed from the en route airways and jet routes crossing the North Pacific Ocean. The relatively sparse use of the area by commercial aircraft and the advance coordination with the FAA regarding ALTRV requirements results in minimal impacts on controlled and uncontrolled airspace from RDT&E operations.

Special Use Airspace

Ongoing RDT&E operations identified above will continue to utilize the existing Open Ocean Area special use airspace including PMRF Warning Areas shown on Figure 3.1.1-1. Missile intercepts will continue to be conducted within either the existing special use airspace in Warning Area W-188 and W-186 controlled by PMRF or within the TOA shown in the inset on Figure 3.1.1-1. Similarly, intercept impact debris will be contained within these same areas. Missiles coming into the TOA from various locations can overfly the Papahanaumokuakea Marine National Monument. At this point in their flight, the boosters follow a ballistic trajectory and will not impact the monument. For select intercept missions, the potential exists for limited debris to fall into the Open Ocean Area off of Necker and Nihoa in the Papahanaumokuakea Marine National Monument. Although the nature and intensity of use varies over time and by individual special use airspace area, the proposed operations do not represent a direct special use airspace impact due to the nature of the special use airspace and the planning and coordination between Navy and the FAA, as described below.

Warning Areas consist of airspace over international waters in which hazardous activity may be conducted. The Warning Areas are designed and set aside by the FAA to accommodate activities that present a hazard to other aircraft. Similarly, the use of ALTRV procedures as authorized by the Central Altitude Reservation Function, an air traffic service facility, or appropriate ARTCC (the Oakland ARTCC for the TOA) for airspace use under prescribed conditions in the TOA will not impact special use airspace. According to the FAA Handbook, 7610.44, ALTRVs may encompass certain rocket and missile operations and other special operations as may be authorized by FAA approval procedures.

PMRF will coordinate with the Honolulu or Oakland ARTCC military operations specialist assigned to handle such matters and the airspace coordinator at the Honolulu Center Radar.
Approach using ALTRV request procedures. After receiving the proper information on each test flight, a hazard pattern will be constructed and superimposed on a chart depicting the area of operations. Ensuring that the hazard pattern will not encroach any land mass, this area is then plotted using minimum points (latitude-longitude) to form a rectangular area. This plotted area is then faxed to the military operations specialist at Honolulu or Oakland ARTCC requesting airspace with the following information: area point (latitude-longitude); date and time for primary and backup (month, day, year, Zulu time); and altitude. A copy is sent to the Honolulu Center Radar Approach Control. A follow-up phone call is made after 48 hours to verify receipt of the fax. When approval of the request of the airspace is received from the military operations specialist at Honolulu or Oakland ARTCC, PMRF will submit an ALTRV request to Central Altitude Reservation Function, which publishes the ALTRV 72 hours prior to the flight test. With these coordination and planning procedures in place, the RDT&E operations do not conflict with any airspace use plans, policies, and controls.

**En Route Airways and Jet Routes**

Two IFR en route low altitude airways are used by commercial aircraft that pass through the PMRF Warning Areas. The two low altitude airways are V15 (through W-188), and V16 (through W-186). Use of these low altitude airways comes under the control of the Honolulu ARTCC. In addition, during a training operation, provision is made for surveillance of the affected airspace either by radar or patrol aircraft. Safety regulations dictate that hazardous operations will be suspended when it is known that any non-participating aircraft has entered any part of the training operation danger zone until the non-participating entrant has left the area or a thorough check of the suspected area has been performed. Therefore, potential impacts on civilian aircraft are avoided.

The airways and jet routes that crisscross the Open Ocean Area airspace region of influence have the potential to be affected by RDT&E operations. However, target and defensive missile launches and missile intercepts will be conducted in compliance with DoD Directive 4540.1, as enclosed by OPNAVINST 3770.4A. DoD Directive 4540.1 specifies procedures for conducting missile and projectile firing, namely “firing areas shall be selected so that trajectories are clear of established oceanic air routes or areas of known surface or air activity” (DoD Directive 4540.1, § E5).

Before conducting a missile launch and/or intercept test, NOTAMs will be sent in accordance with the conditions of the directive specified in OPNAVINST 3721.20. In addition, to satisfy airspace safety requirements, the responsible commander will obtain approval from the Administrator, FAA, through the appropriate Navy airspace representative. Provision is made for surveillance of the affected airspace either by radar or patrol aircraft. In addition, safety regulations dictate that hazardous operations will be suspended when it is known that any non-participating aircraft have entered any part of the danger zone until the non-participating entrant has left the area or a thorough check of the suspected area has been performed.

In addition to the reasons cited above, there is a scheduling agency identified for each piece of special use airspace that will be used. The procedures for scheduling each piece of airspace are performed in accordance with letters of agreement with the controlling FAA facility, and the Honolulu and Oakland ARTCCs. Schedules are provided to the FAA facility as agreed among the agencies involved. Aircraft transiting the Open Ocean Area region of influence on one of the low-altitude airways and/or high-altitude jet routes that will be affected by flight test activities will be notified of any necessary rerouting before departing their originating airport and will be able...
to take on additional fuel before takeoff. Real-time airspace management involves the release of airspace to the FAA when the airspace is not in use or when extraordinary events occur that require drastic action, such as weather requiring additional airspace.

The FAA ARTCCs are responsible for air traffic flow control or management to transition air traffic. The ARTCCs provide separation services to aircraft operating on IFR flight plans and principally during the en route phases of the flight. They also provide traffic and weather advisories to airborne aircraft. Hazardous military operations are contained within the over-water Warning Areas or by using ALTRV procedures in the TOA to ensure non-participating traffic is advised or separated accordingly.

Continuing RDT&E operations will use the existing Open Ocean Area special use airspace and will not require either: (1) a change to an existing or planned IFR minimum flight altitude, a published or special instrument procedure, or an IFR departure procedure; or (2) a VFR operation to change from a regular flight course or altitude. Consequently, there are no airspace conflicts.

Airports and Airfields

There are no airports and airfields in the Open Ocean Area region of influence.

4.1.1.3 Major Exercises

Major Exercises such as Rim of the Pacific (RIMPAC) and Undersea Warfare Exercise (USWEX), include combinations of ongoing training operations and, in some cases, RDT&E operations. Therefore, potential impacts from a Major Exercise on the open ocean airspace will be similar to those described above for the training operations and RDT&E operations. The No-action Alternative includes one RIMPAC exercise (with a single aircraft carrier) and up to six USWEX exercises. RIMPAC planning conferences, which include coordination with the FAA, are conducted beginning in March of the year prior to each RIMPAC. Each of the USWEX training operations, up to six per year, will include coordination with the FAA well in advance of each 3- or 4-day exercise.

The advance planning and coordination with the FAA regarding ALTRV requirements for missile tests, scheduling of special use airspace, and coordination of Navy training operations relative to en route airways and jet routes, results in minimal impacts on airspace from Major Exercises.

4.1.1.2 ALTERNATIVE 1 (AIRSPACE—OPEN OCEAN)

4.1.1.2.1 Increased Tempo and Frequency of Training Operations

Alternative 1 would include increases in the number of training operations including mine laying, S-S GUNEX, A-S GUNEX, S-S MISSILEX, A-S MISSILEX, BOMBEX, SINKEX, ACM, A-A MISSILEX, ECM, S-A GUNEX, S-A MISSILEX, NSFS, Flare Exercises, and CHAFFEX. Training operations would occur in the same locations as identified for the No-action Alternative.

The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to those described in Section 4.1.1.1 for the No-action Alternative. The total number of training operations that affect airspace...
would increase by approximately 16 percent above the No-action Alternative. No new airspace proposal or any modification to the existing controlled airspace would be required. The training operations would continue to utilize the existing Open Ocean Area special use airspace including the PMRF and Oahu Warning Areas and ATCAA shown on Figure 3.1.1-1. By appropriately containing hazardous military operations within the over-water Warning Areas or coordinating the use of the ATCAA areas, non-participating traffic is advised or separated accordingly. Therefore, potential impacts to all airspace users are minimized.

As noted above, continuing training operations will use the existing Open Ocean Area special use airspace and will not require either: (1) a change to an existing or planned IFR minimum flight altitude, a published or special instrument procedure, or an IFR departure procedure; or (2) a VFR operation to change from a regular flight course or altitude. The increase in training operations under Alternative 1 would require an increase in coordination and scheduling by the Navy and the FAA. The increase in training operations would be readily accommodated within the existing airspace. Consequently, there are no airspace conflicts.

4.1.1.2.2 Enhanced and Future RDT&E Operations

The proposed operations include interceptor targets launched from Wake Island, Kwajalein Atoll, or Vandenberg AFB into the TOA; Standard Missile-6 (SM-6) launches from a sea-based platform; and high speed and unmanned aerial vehicle testing. The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes would be similar to that described above for missile launches in Section 4.1.1.1.2. The intercept areas would be in the Broad Ocean Area and TOA.

Alternative 1 would include increases in the number of RDT&E operations including missile defense ballistic missile target flights, THAAD interceptor operations, A-S MISSILEX, A-A MISSILEX, S-A MISSILEX, and S-S MISSILEX. RDT&E operations would occur in the same locations as for the No-action Alternative.

The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described in Section 4.1.1.1 for the No-action Alternative. The total number of RDT&E operations that may affect airspace would increase by approximately 6 percent above the No-action Alternative. No new airspace proposal or any modification to the existing controlled airspace would be required. The RDT&E operations would continue to utilize the existing Open Ocean Area special use airspace including the PMRF Warning Areas and ATCAA and TOA shown on Figure 3.1.1-1. By appropriately containing hazardous military operations within the over-water Warning Areas or coordinating the use of the ATCAA areas, or using ALTRV procedures in the TOA, non-participating traffic is advised or separated accordingly. The relatively sparse use of the area by commercial aircraft and the advance coordination with the FAA regarding ALTRV requirements results in minimal impacts on controlled and uncontrolled airspace from RDT&E operations. The small increase in RDT&E operations under Alternative 1 would require a minor increase in coordination and scheduling by the Navy and the FAA. The increased RDT&E operations would be readily accommodated within the existing airspace.
4.1.1.2.3 HRC Enhancements

Range safety for high-energy lasers at PMRF could affect airspace. Depending on the intensity of the lasers, nomenclature would need to be added to aeronautical charts, and certain test events could require NOTAMs and Notices to Mariners (NOTMARs).

The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described above for missile launches. The establishment of laser range operational procedures, including horizontal and vertical buffers, would minimize potential impacts to aircraft. All operations would be in accordance with American National Standards Institute (ANSI) Z136.1, *Safe Use of Lasers*, which has been adopted by DoD as the governing standard for laser safety. Additional information on range safety for high-energy lasers is in Section 4.1.5, Health and Safety.

4.1.1.2.4 Major Exercises

Major Exercises, such as RIMPAC and USWEX, include combinations of ongoing training operations and, in some cases, RDT&E operations. Therefore, potential impacts from a Major Exercise on the open ocean airspace would be similar to those described above for the training operations and RDT&E Operations. RIMPAC planning conferences, which include coordination with the FAA, are conducted beginning in March of the year prior to each RIMPAC. Each of the USWEX training operations, up to six per year, would include coordination with the FAA well in advance of each 3- or 4-day exercise.

The advance planning and coordination with the FAA regarding ALTRV requirements for missile tests, scheduling of special use airspace, and coordination of Navy training operations relative to en route airways and jet routes, results in minimal impacts on airspace from Major Exercises. The increase from one aircraft carrier to two during RIMPAC under Alternative 1 would require a minor increase in coordination and scheduling by the Navy and the FAA. The increased training operations would be readily accommodated within the existing airspace.

4.1.1.3 ALTERNATIVE 2 (AIRSPACE—OPEN OCEAN)

4.1.1.3.1 Increased Tempo and Frequency of Training Operations

Alternative 2 would include increases in the number of training operations including mine laying, S-S GUNEX, A-S GUNEX, S-S MISSILEX, A-S MISSILEX, BOMBEX, SINKEX, ACM, A-A MISSILEX, ECM, S-A GUNEX, S-A MISSILEX, NSFS, Flare Exercises, and CHAFFEX. Training operations would occur in the same locations as for the No-action Alternative.

The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described in Section 4.1.1.1 for the No-action Alternative. The total number of training operations that affect airspace would increase by approximately 22 percent above the No-action Alternative. No new airspace proposal or any modification to the existing controlled airspace would be required. The training operations would continue to use the existing Open Ocean Area special use airspace including the PMRF and Oahu Warning Areas and ATCAA shown on Figure 3.1.1-1. By appropriately containing hazardous military operations within the over-water Warning Areas or coordinating the use of the ATCAA areas, non-participating traffic is advised or separated accordingly, thus

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avoiding substantial adverse impacts to the low altitude airways and high-altitude jet routes in the region of influence.

Alternative 2 would also include increases in the number of RDT&E operations including missile defense ballistic missile target flights, THAAD interceptor operations, A-S MISSILEX, A-A MISSILEX, S-A MISSILEX, and S-A MISSILEX. RDT&E operations would occur in the same locations as for the No-action Alternative.

The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described in Section 4.1.1.1 for the No-action Alternative. The total number of RDT&E operations that may affect airspace would increase by approximately 16 percent above the No-action Alternative. No new airspace proposal or any modification to the existing controlled airspace would be required. The RDT&E operations would continue to use the existing Open Ocean Area special use airspace including the PMRF Warning Areas, ATCAA and TOA shown on Figure 3.1.1-1. By appropriately containing hazardous military operations within the over-water Warning Areas or coordinating the use of the ATCAA areas, or using ALTRV procedures in the TOA, non-participating traffic would be advised or separated accordingly, thus avoiding substantial adverse impacts to the low altitude airways and high-altitude jet routes in the region of influence. Due to the planning and coordination required for the use of special use airspace, the small increase in the tempo and frequency of training operations would be readily accommodated within the existing special use airspace.

As noted above, continuing training operations will use the existing Open Ocean Area special use airspace and will not require either: (1) a change to an existing or planned IFR minimum flight altitude, a published or special instrument procedure, or an IFR departure procedure; or (2) a VFR operation to change from a regular flight course or altitude. The increase in training operations under Alternative 1 would require an increase in coordination and scheduling by the Navy and the FAA. The increase in training operations would be readily accommodated within the existing airspace. Consequently, there are no airspace conflicts.

### 4.1.1.3.2 Enhanced and Future RDT&E Operations

Future RDT&E Operations include a Maritime Directed Energy Test Center at PMRF and the Advanced Hypersonic Weapon test program.

The Directed Energy Test Center, which may include a High Energy Laser Program, would have minimal impacts on airspace due to the required electromagnetic radiation/electromagnetic interference (EMR/EMI) coordination process. As discussed in Section 4.1.1.2.3, high-energy lasers at PMRF could affect airspace. Depending on the intensity of the lasers, nomenclature would need to be added to aeronautical charts, and certain test events could require NOTAMs and NOTMARs. The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described earlier for missile launches. The establishment of laser range operational procedures, including horizontal and vertical buffers, would minimize potential impacts to aircraft. All operations would be in accordance with ANSI Z136.1, Safe Use of Lasers, which has been adopted by DoD as the governing standard for laser safety. Additional information on range safety for high-energy lasers is in Section 4.1.5, Health and Safety.
The Advanced Hypersonic Weapon tests would be similar to a ballistic missile test. Potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described earlier for missile launches.

4.1.1.3.3 Additional Major Exercises—Multiple Strike Group Training

In addition to RIMPAC and USWEX, Alternative 2 includes a Multiple Strike Group Exercise consisting of operations that involve Navy assets engaging in a schedule of events battle scenario, with U.S. forces (blue forces) pitted against a notional opposition force (red force). Participants use and build upon previously gained training skill sets to maintain and improve the proficiency needed for a mission-capable, deployment-ready unit. The exercise would occur over a 5- to 10-day period. The Multiple Strike Group training would involve many of the training operations identified and evaluated under Section 4.1.1.1, No-action Alternative, including mine laying, S-S GUNEX, A-S GUNEX, S-S MISSILEX, A-S MISSILEX, BOMBEX, SINKEX, ACM, A-A MISSILEX, ECM, S-A GUNEX, S-A MISSILEX, NSFS, Flare Exercises, and CHAFFEX.

Additional training operations include Maritime Interdiction and Air Interdiction of Maritime Targets. These operations would include a red force surface action group consisting of Navy surface combatants, Military Sea-Lift Command ships, and a Coast Guard Cutter. Blue forces would consist of Navy frigates, cruisers, and destroyers, carrier air wing aircraft from the three Navy aircraft carriers and Air Force F-15 aircraft. All coordinated operations would take place within the PMRF and Oahu Warning Areas and areas as required. The exercise may include Air Force aircraft that would operate from Hickam Air Force Base (AFB), and carrier air wing aircraft that would operate from their respective aircraft carriers. The aircraft would coordinate efforts with blue force surface ships to locate, target, and simulate strikes against the red force surface action group.

During Defensive Counter Air Operations, Air Force F-15 aircraft would simulate red force aircraft and anti-ship missiles. These red force aircraft would attempt simulated coordinated attacks against the blue force Strike Groups. The Strike Groups would defend against the red air forces with air wing aircraft and simulated surface-to-air missile attacks.

The potential impacts on controlled and uncontrolled airspace, special use airspace, en route airways and jet routes, and airports and airfields would be similar to that described in Section 4.1.1.1 for the No-action Alternative. The additional types of training operations described in the previous paragraphs are similar to and would occur in the same areas as some of the operations analyzed under the No-action alternative. No new airspace proposal or any modification to the existing controlled airspace would be required. The Multiple Strike Group Exercises and training operations identified above would continue to use the existing Open Ocean Area special use airspace including the PMRF and Oahu Warning Areas and ATCAA shown on Figure 3.1.1-1. By appropriately containing hazardous military operations within the over-water Warning Areas or coordinating the use of the ATCAA areas, non-participating traffic would be advised or separated accordingly, thus avoiding substantial adverse impacts to the low altitude airways and high-altitude jet routes in the region of influence.

The advance planning and coordination with the FAA regarding scheduling of special use airspace and coordination of Navy training operations relative to en route airways and jet routes would result in minimal impacts on airspace from a Multiple Strike Group exercise. The use of three aircraft carriers during the 10-day exercise would require an increase in coordination and
scheduling by the Navy and the FAA. The increased training operations would be readily accommodated within the existing airspace.

4.1.2 BIOLOGICAL RESOURCES—OPEN OCEAN

Generally, impacts to biological resources are evaluated as potential losses to populations of species of concern or to important habitat resources. Criteria for assessing potential impacts to marine biological resources are based on the following:

- Loss of habitat (destruction, degradation, denial, competition)
- Over-harvesting or excessive take (accidental or intentional death, injury)
- Harassment
- Increases in exposure or susceptibility to disease and predation
- Decrease in breeding success
- Collision with ordnance, debris, or vessels; release of contaminants from munitions constituents or range debris; sound; or human contact could potentially cause impacts. Impacts are considered substantial if they have the potential to result in reduction of population size of Federally listed threatened or endangered species, degradation of biologically important unique habitat, or reduction in capacity of a habitat to support species.

4.1.2.1 CORAL (BIOLOGICAL RESOURCES—OPEN OCEAN)

As shown on Figure 3.1.2.1-1, deep sea coral within the Open Ocean Area is located in deep water and is limited in areal extent. The potential for impacts to these deep water corals from Navy training and RDT&E activities would be very limited. The Navy activities would not result in any direct impacts to the coral or degradation of water/sediment quality in the vicinity of the corals. The probability of intercept debris or debris from GUNEX, BOMBEX, MISSILEX, or SINKEX reaching the bottom of the ocean floor where the coral is located would be extremely small. In addition, the debris is spread out over a wide area so that even if in the unlikely event the debris lands on the coral, the pieces would be spread out and most would be small. There is no deep water coral located in the area where SINKEX is typically conducted. Because the potential for impacts to deep sea coral is so remote, it will not be discussed further.

4.1.2.2 FISH (BIOLOGICAL RESOURCES—OPEN OCEAN)

Essential Fish Habitat (EFH) is analyzed in a separate document, and will not be discussed under each alternative below. Due to the mitigation measures implemented to protect sensitive habitats, and the localized and temporary impacts of the Proposed Action and alternatives, it is concluded that the potential impact of the Proposed Action and alternatives on EFH for the five major Fisheries Management Plans and their associated management units would be minimal.

4.1.2.2.1 No-action Alternative (Fish—Biological Resources—Open Ocean)

The No-action Alternative includes a total of 3,134 hours of AN/AQS 53C mid-frequency active tactical sonar and the associated Directional Command Activated Sonobuoy System (DICASS).
sonobuoy, MK-48 torpedo, and dipping sonar. Underwater detonations are possible during SINKEX, A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS.

3 HRC Training Operations

Sonar

The HRC training operations involving sonar include Anti-Submarine Warfare (ASW) Tracking Exercise (TRACKEX) and ASW Torpedo Exercise (TORPEX) as described in Table 2.2.2.3-1 and Appendix D.

This section presents an evaluation of the potential acoustic effects on fish resulting from the implementation of the Proposed Action. There have been few directed studies on the impact of sonar on fish (Jørgensen et al., 2005; Kvadsheim and Sevaldsen, 2005). Some marine fishes may be able to detect mid-frequency sounds, but the most sensitive hearing range of most marine fishes is generally below the mid-frequency bandwidth. As discussed in the Affected Environment section, studies indicate that most marine fish are hearing generalists and have their best hearing sensitivity at or below 300 hertz (Hz) (Popper, 2003). It has been demonstrated that a few marine specialist species can detect sounds to 4,000 Hz and some to even above 120 kilohertz (kHz); however, a gap in the sensitivity exists from 3,200 Hz to 12,500 Hz for at least one of these species, the American shad (Dunning et al., 1992; Mann et al., 1998; Mann et al., 2001; Nestler et al., 2002; Popper and Carlson, 1998; Popper et al., 2004; Ross et al., 1996). Marine species that can hear in the mid-frequency range do not hear best at the frequencies of the operational sonars. Fish can only hear a sound at the edge of their hearing frequency sensitivity range if the sound is very loud. Thus, it is expected that most marine hearing specialists will be able to detect the lowest frequencies of the loudest pings of operational sonars and some, such as some clupeids, will be able to detect the entire range only if in close proximity to the loudest pings (i.e., 184 feet [ft] of a frequency modulated (FM) signal at 225 decibels (dB) re 1 micropascal (μPa), (see Kvadsheim and Sevaldsen, 2005).

Studies have shown that hearing generalists normally experience only minor or no hearing loss when exposed to continuous sound, but that hearing specialists may be affected by sound exposure. Exposure to loud sound can result in significant threshold shifts in hearing specialists. Studies thus far have shown these threshold shifts are temporary, and it is not evident that they lead to any long-term behavioral disruptions in fish that are biologically significant (Scholik and Yan, 2001; Smith et al., 2004a; Smith et al., 2004b). The only experiments to have shown mortality in fish due to mid-frequency active sonar have been investigations into the effects on juvenile herring exposed to intense mid-frequency active sonar. This is not to say, however, that fish, no matter what their hearing sensitivity, are not prone to injury as a result of exposure to mid-frequency active sonar. Individual juvenile fish with a swim bladder resonance in the frequency range of the operational sonars, and especially hearing specialists such as some clupeid species, may experience injury or mortality. The resonance frequency will depend on fish species, size and depth (McCartney and Stubbs, 1971; Løvik and Hovem, 1979). The swim bladder is a vital part of a system that amplifies the vibrations which reach the fish’s hearing organs, and at resonance the swim bladders may absorb much of the acoustic energy in the impinging sound wave (Sevaldsen and Kvadsheim, 2004). The resulting oscillations may cause mortality or harm the swim bladder itself or the auditory organs (Jørgensen et al., 2005). Kvadsheim and Sevaldsen (2005) found the zone within which injury may be caused in Atlantic herring at high levels of CW-signal mid-frequency active sonar (225 dB re 1 μPa), would be to a radius of 584 ft and to a depth of 748 ft (if the sonar is placed 27 fathoms deep). Lowering the source level by 25 dB reduced the ranges by over 328 ft. For an
FM signal, injury was predicted to occur over a radius of 184 ft and to a depth of 58 fathoms.
Lowering of the source level of the FM signal by 25 dB reduced the ranges by over 164 ft. Kvadsheim and Sevaldsen (2005) determined the effects to the Atlantic herring population are likely to be insignificant considering the natural mortality rate of juvenile fish and the limited exposure of the fish to the sound source (Jørgensen et al., 2005). The physiological effect of sonars on adult fish is expected to be less than for juvenile fish because adult fish are in a more robust stage of development, the swim bladder frequencies will be outside the range of the frequency of mid-frequency active sonar, and adult fish have more ability to move from an unpleasant stimulus (Kvadsheim and Sevaldsen, 2005). Ultrasound-detecting clupeids (American shad, blueback herring, alewife) with distributions overlapping the proposed HRC training operation locations may have similar reactions to mid-frequency active sonar as found by Jørgensen et al. (2005) and Kvadsheim and Sevaldsen (2005) because of their similarities in hearing sensitivity. Just as Kvadsheim and Sevaldsen (2005) determined that mid-frequency active sonar would not have a significant effect on Atlantic herring populations, a significant impact is not expected to juvenile fish species populations in the HRC areas even though some sonar levels have been shown to be powerful enough to cause injury to particular size classes of juvenile herring from the water’s surface to the seafloor. Sound sources will be moving, so exposure is limited, and continuous wave (CW) signals, the type considered to cause most impact, will rarely be used.

Studies have indicated that acoustic communication and orientation of fish may be restricted by sound regimes in their environment (Wysocki and Ladich, 2005). Although some species may be able to produce sound at higher frequencies (>1 kHz), vocal marine fish largely communicate below the range of mid-frequency levels used in the Proposed Action. Further, most marine fish species are not expected to able to detect sounds in the mid-frequency range of the operational sonars used in the Proposed Action. The few fish species that have been shown to be able to detect mid-frequencies do not have their best sensitivities in the range of the operational sonars. Thus, these fish can only hear mid-frequency sounds when they are very loud (i.e., when sonars are operating at their highest energy levels and fish are within a few meters). Considering the moving sound sources, the mid-frequency active sound sources used in the Proposed Action do not have the potential to significantly mask key environmental sounds.

While fish may respond behaviorally to mid-frequency sources, this behavioral modification is only expected to be brief and not biologically significant. Additionally, review of the available literature appears to indicate that low and high frequency acoustic sources are more likely to result in behavioral modifications in fish than are mid-frequency acoustic sources. Research by Gearin et al. (2000) and Culik et al. (2001) indicated the mid-frequency sound from acoustic devices designed to deter marine mammals from gillnet fisheries were either inaudible to fish, or the fish were not disturbed by the sound.

Sharks generally do not detect sounds above 1 kHz, and their best sensitivity is to signals below 300 Hz (Popper and Fay, 1977). Sensitivity in lemon and horn sharks is best at about 40 Hz (Nelson, 1967; Kelly and Nelson, 1975). Popper and Fay noted that distinctions between vibration and sound detection are probably not meaningful in a consideration of the shark auditory system.

In many teelost fish, the swim bladder can aid in hearing by transferring sound to the inner ear by resonance matching of the two structure (Yan et al., 2004). Loud low frequency (below 300 Hz and above 180 dB re 1 μPa) sounds can affect both the swim bladder and damage the inner
ear structures and the swim bladder. There is a mismatch between the low frequency hearing  
of fish coupled with the resonance frequency of their swim bladders and with the higher  
frequency mid-frequency active sonar; therefore, there is little effect from the Navy’s sonar on  
fish hearing.

Hastings et al. (1996) studied the effects of sound (up to 300 Hz and 180 re 1 μPa) stimulation  
on the ear and lateral line of a nonspecialist fish (e.g., oscar, Astronotus ocellatus). They found  
that there was some damage to the sensory hair cells of two of the otolith organs, the lagena  
and utricle, when the fish were exposed to continuous sound at 300 Hz and 180 dB for 1 hour.  
There was no apparent damage with higher frequencies, sounds with shorter duty cycles, or  
shorter stimulation time. Moreover, the only apparent damage was found 4 days after  
stimulation. The interpretation of these results was that exposure to a high intensity sound has  
the potential to damage the ears of fish. However, many caveats accompanied this  
interpretation, including the fact that the sound had to be continuous and last at least 1 hour;  
and the tissue had to be examined several days after the end of stimulation. Hastings et al.  
(1996) further pointed out that this study was the most highly controlled and quantified of any of  
the few studies on the effects of intense sounds on fish.

The potential effects on fish from sonar used during ASW Exercises will be negligible as most  
fish hear below the range of mid-frequency active sonar; therefore, they may detect the sonar  
but may not respond to it, and it will not affect their hearing.

Underwater Detonations

Underwater detonations are possible during SINKEX, A-S MISSILEX, S-S MISSILEX,  
BOMBEX, S-S GUNEX, and NSFS. The weapons used in most missile and Live Fire Exercises  
pose little risk to fish unless they were to be near the surface at the point of impact. Machine  
guns (50 caliber), 5-inch guns, 76-mm guns, and close-in weapons systems (anti-missile  
systems) exclusively fire non-explosive ammunition. The same applies to larger weapons firing  
inert ordnance for training operations. The rounds pose an extremely low risk of a direct hit and  
potential to directly affect a marine species. Target area clearance procedures will again reduce  
this risk. A SINKEX uses a variety of live fire weapons. These rounds pose a risk only at the  
point of impact.

Several factors determine a fish’s susceptibility to harm from underwater detonations. Most  
injuries in fish involve damage to air- or gas-containing organs (i.e., the swim bladder). Fish  
with swim bladders are vulnerable to effects of explosives, while fish without swim bladders are  
much more resistant (Yelverton, 1981; Young, 1991). Research has focused on the effects to  
the swim bladder from underwater detonations but not the ears of fish (Edds-Walton and  
Finneran, 2006).

For underwater demolition training, the effects on fish from a given amount of explosive depend  
on location, season, and many other factors. O’Keeffe (1984) provides charts that allow  
estimation of the potential effect on swim-bladder fish using a damage prediction method  
developed by Goertner (1982). O’Keeffe’s parameters include the size of the fish and its  
location relative to the explosive source, but are independent of environmental conditions (e.g.,  
depth of fish, explosive shot, frequency content). Table 4.1.2.2.1-1 lists the estimated maximum  
effects ranges using O’Keeffe’s (1984) method for an 8-pound (lb) explosion at source depths of  
1.7 fathoms (10 ft).
Table 4.1.2.1-1. Maximum Fish-Effects Ranges

<table>
<thead>
<tr>
<th>Fish Weight</th>
<th>10 Percent Mortality Range (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 ounce</td>
<td>518.3</td>
</tr>
<tr>
<td>1 pound</td>
<td>208.9</td>
</tr>
<tr>
<td>30 pounds</td>
<td>155.2</td>
</tr>
</tbody>
</table>

Source: O’Keefe, 1984

Potential impacts to fish from underwater demolition detonations would be negligible. A small number of fish are expected to be injured by detonation of explosive, and some fish located in proximity of the initial detonations can be expected to die. However, the overall impacts to water column habitat would be localized and transient. As operations begin, the natural reaction of fish in the vicinity would be to leave the area. When operations are completed, the fish stock would be expected to return to the area. The abundance and diversity of fish within the HRC will not measurably decrease as a result of implementation of the No-action Alternative.

HRC RDT&E Operations

Other sources such as unmanned aerial vehicles (UAVs), underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations will have minimal effects on fish.

Major Exercises

RIMPAC and USWEX

The operations and impacts from RIMPAC Exercises have been summarized in the RIMPAC 2006 Supplement to the 2002 RIMPAC Environmental Assessment (EA) (U.S. Department of the Navy, Commander Third Fleet, 2006). The No-action Alternative modeling included 532 hours of 53C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes per RIMPAC (conducted every other year). The operations and impacts to marine mammals from USWEX Exercises have been summarized in the USWEX Programmatic EA/Overseas EA (OEA) (U.S. Department of the Navy, 2007b). The No-action Alternative modeling included 1,167 hours of 53C surface ship sonar and associated dipping sonar and sonobuoys per year.

The potential impacts to fish from RIMPAC and USWEX sonar and underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS will be similar to those described above for the HRC Training Operations.

4.1.2.2 Alternative 1 (Fish—Biological Resources—Open Ocean)

The increased operations under Alternative 1 result in an increase in the number of hours of ASW training. Alternative 1 includes a total of 4,027 hours of AN/AQS 53C mid-frequency active tactical sonar and the associated DICASS sonobuoy, MK-48 torpedo, and dipping sonar.
Underwater detonations are possible during SINKEX, A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS.

**Increased Tempo and Frequency of Training Operations**

The HRC training operations for Alternative 1 involving sonar include ASW TRACKEX and ASW TORPEX as described in Table 2.2.2.3-1 and Appendix D. The number of hours of sonar for Alternative 1 is the same as the No-action Alternative, which included 1,440 hours of 53C surface ship sonar and associated sonobuoys per year. Potential impacts to fish from sonar and underwater detonations under Alternative 1 would be similar to those described under the No-Action Alternative. Although the number of hours of sonar and the number of underwater detonations would increase, the impacts would still be minimal considering the few fish species that would be able to detect sound in the frequencies of the Proposed Action and the limited exposure of juvenile fish with swim bladder resonance in the frequencies of the sound sources.

**Enhanced RDT&E Operations**

There are no new RDT&E operations that would affect fish. Sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish.

**Future RDT&E Operations**

There are no future RDT&E operations that would affect fish. Sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish.

**HRC Enhancements**

There are no new HRC enhancement operations that would affect fish. Other sources such as underwater communications and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish.

**Major Exercises**

**RIMPAC and USWEX**

The operations and impacts to marine mammals from RIMPAC Exercises have been summarized in the RIMPAC 2006 Supplement to the 2002 RIMPAC EA (U.S. Department of the Navy, Third Fleet, 2006). Alternative 1 assumes two Strike Groups and 1,064 hours of 53C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes per RIMPAC (conducted every other year). The operations and impacts to marine mammals from USWEX Exercises have been summarized in the USWEX Programmatic EA/OEA (U.S. Department of the Navy, 2007b). Alternative 1 assumes 1,167 hours of 53C surface ship sonar and associated dipping sonar and sonobuoys per year. Although the number of hours of sonar and the number of underwater detonations would increase over the No-action Alternative, the impacts would still be minimal considering the few fish species that would be able to detect
4.0 Environmental Consequences, Open Ocean Area

4.1.2.2.3 Alternative 2 (Fish—Biological Resources—Open Ocean)

The increased operations under Alternative 2 result in an increase in the number of hours of ASW training. Alternative 2 includes a total of 5,179 hours of AN/AQS 53C mid-frequency active tactical sonar and the associated DICASS sonobuoy, MK-48 torpedo, and dipping sonar. Underwater detonations are possible during SINKEX, A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS.

Increased Tempo and Frequency of Training Operations

The HRC training operations for Alternative 1 involving sonar include ASW TRACKEX and ASW TORPEX as described in Table 2.2.2.3-1 and Appendix D. The number of hours of sonar for Alternative 2 included 1,590 hours of 53C surface ship sonar and associated sonobuoys per year. Potential impacts to fish from sonar and underwater detonations under Alternative 2 would be similar to those described under the No-Action Alternative. Although the number of hours of sonar and the number of underwater detonations would increase over the No-action Alternative, the impacts would still be minimal considering the few fish species that would be able to detect sound in the frequencies of the Proposed Action and the limited exposure of juvenile fish with swim bladder resonance in the frequencies of the sound sources.

Enhanced RDT&E Operations

There are no new RDT&E operations that would affect fish. Sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish.

Future RDT&E Operations

There are no future RDT&E operations that would affect fish. Sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish.

HRC Enhancements

There are no new HRC enhancement operations that would affect fish. Other sources such as underwater communications and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect fish.

Additional Major Exercises—Multiple Strike Group Training

Up to three Strike Groups would conduct training operations simultaneously in the HRC. The Strike Groups would not be home ported in Hawaii, but would stop in Hawaii en route to a final destination. The Strike Groups would be in Hawaii for up to 10 days per exercise. Training would be provided to submarine, ship, and aircraft crews in tactics, techniques, and procedures for ASW, Defensive Counter Air, Maritime Interdiction, and operational level Command and
Control (C2) of maritime forces. The Three Strike Group Exercise would include 944 hours of 53 C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes. Although the number of hours of sonar and the number of underwater detonations would increase over Alternative 1, the impacts would still be minimal considering the few fish species that would be able to detect sound in the frequencies of the Proposed Action and the limited exposure of juvenile fish with swim bladder resonance in the frequencies of the sound sources.

4.1.2.3 SEA TURTLES (BIOLOGICAL RESOURCES—OPEN OCEAN)

Sonar
Extrapolation from human and marine mammal data to turtles is inappropriate given the morphological differences between the auditory systems of mammals and turtles. However, the measured hearing threshold for green turtles (and by extrapolation, at least the olive ridley, loggerhead, and hawksbill) is only slightly lower than the maximum levels to which these three species could be exposed. It is not believed that a temporary threshold shift would occur at such a small margin over threshold in any species. Therefore, no threshold shifts in green, olive ridley, loggerhead, or hawksbill turtles are expected.

Given the lack of audiometric information, the potential for temporary threshold shifts among leatherback turtles must be classified as unknown but would likely follow those of other sea turtles.

Any potential role of long-range acoustical perception in sea turtles has not been studied and is unclear at this time; anecdotal information suggests that the acoustic signature of a turtle’s natal beach might serve as a cue for nesting returns. However, the concept of sound masking is difficult, if not impossible, to apply to sea turtles. As described in Chapter 3.0, sea turtle hearing is generally most sensitive between 100 to 800 Hz for hard shell turtles, frequencies that are at the lower end of the sound spectrum. Although low frequency hearing has not been studied in many sea turtle species, most of those that have been tested exhibit low audiometric and behavioral sensitivity to low frequency sound. It appears, therefore, that if there were the potential for the mid-frequency sonar to increase masking effects of any sea turtle species, it would be expected to be minimal as most sea turtle species are apparently low frequency specialists.

Given their relatively low hearing sensitivity even within the frequency ranges that sea turtles hear best, which is for the most part below the frequency range of mid-frequency active sonar, it is unlikely that sea turtles would be affected by this type of sonar. Even if sea turtles were able to sense the sonar output, it is unlikely that any physiological stress leading to endocrine and corticosteroid imbalances over the long term (allostatic loading) would result (McEwen and Lashley, 2002). An example of plasma hormone responses to stress was described by Jessop et al. (2002) for breeding adult male green turtles. Using capture/restraint as a stressor, they found a smaller corticosterone response and significant decreases in plasma androgen for breeding migrant males as compared to nonbreeding males. These responses were highly correlated with the relatively poorer body condition and body length of the migrant breeders as compared to the nonmigrant and premigrant males. While this study illustrates the complex relationship between stress/physiological state and plasma hormone responses, these kinds of effects are unlikely for sea turtles from mid-frequency active sonar within the HRC.
Although there may be many hours of active ASW sonar events, the actual “pings” of the sonar signal may only occur several times a minute, as it is necessary for the ASW operators to listen for the return echo of the sonar ping before another ping is transmitted. Based on the current available data, we have concluded that sonar would not affect sea turtles.

Potential Non Acoustic Impacts
The Navy has adopted standard operating procedures (SOPs) that reduce the potential for collisions between surface vessels and sea turtles (See Chapter 6.0). At all times when ships are underway, there are many people on watch scanning the area around the ship. If a marine mammal or sea turtle is sighted, appropriate action will be taken to avoid the animal. Collisions with sea turtles are not expected.

The potential entanglement impact of MK-48 torpedo control wires on sea turtles is very low because the control wire is very thin (approximately 0.02 in) and has a relatively low breaking strength. In addition, when the wire is released or broken, it is relatively straight and the physical characteristics of the wire prevent it from tangling.

4.1.2.3.1 No-action Alternative (Sea Turtles—Biological Resources—Open Ocean)
Underwater detonations are possible during SINKEX, A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS.

HRC Training Operations
Underwater Detonation
Criteria and thresholds for estimating the impacts on marine mammals and sea turtles from a single underwater detonation event were defined and publicly vetted through the NEPA process during the environmental assessments for the two Navy ship-shock trials: the SEAWOLF Final EIS (U.S. Department of the Navy 1998a) and the Churchill Final EIS (U.S. Department of the Navy, 2001a). During the analysis of the effects of explosions on marine mammals and sea turtles conducted by the Navy for the Churchill EIS, analysts compared the injury levels reported by the best of these experiments to the injury levels that would be predicted using the modified Goertner method and found them to be similar (U.S. Department of the Navy, 2001a, Goertner 1982). The criteria and thresholds for injury and harassment are summarized in Table 4.1.2.3.1-1.

The criterion for non-injurious harassment is temporary threshold shift (TTS), which is a temporary, recoverable, loss of hearing sensitivity (National Marine Fisheries Service, 2001; U.S. Department of the Navy, 2001a). The criterion for TTS is 182 dB re 1 squared micropascal-second ($\mu$Pa$^2$-s) maximum Energy Flux Density Level (EL) level in any 1/3-octave band at frequencies >100 Hz for marine mammals (and by extrapolation, sea turtles). There is a second criterion for estimating TTS threshold: 12 pounds per square inch (psi) peak pressure that was developed for 10,000-lb charges as part of the Churchill Final EIS (U.S. Department of the Navy, 2001a; Federal Register, 2005 and 2006c). It was introduced to provide a safety zone for TTS when the explosive or the animal approaches the sea surface (for which case the explosive energy is reduced but the peak pressure is not). Navy policy is to use a 23 psi criterion for explosive charges less than 2,000 lb and the 12 psi criterion for explosive charges larger than 2,000 lb. All explosives modeled for the HRC EIS/OEIS are less than 1,500 lb.
Table 4.1.2.3.1-1. Summary of Criteria and Acoustic Thresholds for Underwater Detonation Impacts to Sea Turtles and Marine Mammals

<table>
<thead>
<tr>
<th>Harassment Level</th>
<th>Criterion</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level A Harassment Mortality</td>
<td>Onset of severe lung injury</td>
<td>“Goertner” modified positive impulse indexed to 31 psi-ms</td>
</tr>
<tr>
<td>Injury</td>
<td>Tympanic membrane rupture</td>
<td>50% rate of rupture</td>
</tr>
<tr>
<td></td>
<td></td>
<td>205 dB re 1 μPa^-s-2 (Energy Flux Density)</td>
</tr>
<tr>
<td>Injury</td>
<td>Onset of slight lung injury</td>
<td>Goertner Modified Positive Impulse Indexed to 13 psi-ms</td>
</tr>
<tr>
<td>Level B Harassment Non-Injury</td>
<td>Temporary Threshold Shift (TTS)</td>
<td>182 dB re 1 μPa^-s-2 (Energy Flux Density) in any 1/3-octave band at frequencies above 100 Hz for all toothed whales (e.g., sperm whales, beaked whales); above 10 Hz for all baleen whales</td>
</tr>
<tr>
<td>Non-Injury (Dual Criteria)</td>
<td>Onset of Temporary Threshold Shift</td>
<td>23 psi peak pressure level (for small explosives)</td>
</tr>
</tbody>
</table>

Notes: psi-ms = pounds per square inch-milliseconds μPa^-s-2 = squared micropascal-second

Two criteria are used for injury: onset of slight lung injury and 50 percent eardrum rupture (tympanic membrane [TM] rupture). These criteria are considered indicative of the onset of injury. The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 26.9 lb), and is given in terms of the “Goertner modified positive impulse,” indexed to 13 psi-millisecond (ms) in the (U.S. Department of the Navy, 2001a). This threshold is conservative since the positive impulse needed to cause injury is proportional to animal mass, and therefore, larger animals require a higher impulse to cause the onset of injury. The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50 percent of animals exposed to the level are expected to suffer TM rupture); this is stated in terms of an EL value of 205 dB re 1 μPa^-s-2. The criterion reflects the fact that TM rupture is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (e.g., Ketten 1998) indicates a 30 percent incidence of permanent threshold shift [PTS] at the same threshold).

The criterion for mortality for marine mammals used in the CHURCHILL Final EIS is “onset of severe lung injury.” This is conservative in that it corresponds to a 1 percent chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure. The threshold is stated in terms of the Goertner (1982) modified positive impulse with value “indexed to 31 psi-ms.” Since the Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, the actual impulse value corresponding to the 31-psi-ms index is a complicated calculation. Again, to be conservative, CHURCHILL used the mass of a calf dolphin (at 26.9 lb), so that the threshold index is 30.5 psi-ms.

There is a lead time for set up and clearance of the impact area before any event using explosives takes place (may be 30 minutes to several hours). There will, therefore, be a long period of area monitoring before any detonation or live-fire event begins. Ordnance cannot be released until the target area is determined clear. Operations are immediately halted if sea...
turtles are observed within the target area. Operations are delayed until the animal clears the
target area. All of these factors serve to avoid the risk of harming sea turtles.

GUNEX, BOMBEX, MISSILEX, NSFS, and SINKEX
The weapons used in most missile and Live Fire Exercises pose little risk to sea turtles unless
they were to be near the surface at the point of impact. Machine guns (fire 0.50 caliber) and the
close-in weapons systems (anti-missile systems) exclusively fire non-explosive ammunition.
The same applies to larger weapons firing inert ordnance for training operations. The rounds
pose an extremely low risk because only a direct hit has the potential to affect a marine species.
Target area clearance procedures will reduce the potential for impacting a sea turtle such that
impacts to sea turtles from missile and Live Fire Exercises will be highly unlikely.

HRC RDT&E Operations
RDT&E operations will not affect sea turtles.

Major Exercises
Underwater detonations during RIMPAC and USWEX will be similar to those described under
HRC Training Operations. Due to the clearance requirements for underwater detonations and
Live Fire Exercises (LFX), sea turtles will not be within the area and therefore impacts are not
anticipated.

4.1.2.3.2 Alternative 1 (Sea Turtles—Biological Resources—Open
Ocean)
The increased operations under Alternative 1 result in an increase in the number of underwater
detonations during SINKEX, A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and
NFSF.

Increased Tempo and Frequency of Training Operations
Although the number of underwater detonations would increase, due to the clearance
requirements for underwater detonations and exercises involving explosives, sea turtles would
not be within the area and therefore impacts are not anticipated.

Enhanced RDT&E Operations
Enhanced RDT&E operations would not affect sea turtles.

Future RDT&E Operations
There are no future RDT&E operations that would affect sea turtles.

HRC Enhancements
There are no new HRC enhancement operations that would affect sea turtles.

Major Exercises
Underwater detonations during RIMPAC and USWEX would be similar to those described under
the No-action Alternative. Due to the clearance requirements for underwater detonations and
exercises involving explosives, sea turtles would not be within the area and therefore impacts are not anticipated.

### 4.1.2.3.3 Alternative 2 (Sea Turtles—Biological Resources—Open Ocean)

The increased operations under Alternative 2 result in an increase in the number of underwater detonations during SINKEX, A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS.

#### Increased Tempo and Frequency of Training Operations

Although the number of underwater detonations would increase, due to the clearance requirements for underwater detonations and exercises involving explosives, sea turtles would not be within the area and therefore impacts are not anticipated.

#### Enhanced and Future RDT&E Operations

There are no enhanced or future RDT&E operations that would affect sea turtles.

#### HRC Enhancements

There are no new HRC enhancement operations that would affect sea turtles.

#### Additional Major Exercises—Multiple Strike Group Training

Up to three Strike Groups would conduct training operations simultaneously in the HRC. Underwater detonations during the Multiple Strike Group training would be similar to those described under the No-action Alternative for RIMPAC and USWEX. Due to the clearance requirements for underwater detonations and exercises involving explosives, sea turtles would not be within the area and therefore impacts are not anticipated.

### 4.1.2.4 MARINE MAMMALS (BIOLOGICAL RESOURCES—OPEN OCEAN)

Potential impacts to marine mammals from Navy actions can occur from sources that are non-acoustic (i.e., ship strikes) and acoustic with sonar and underwater detonations being the primary acoustic concern. The Navy has and is continuing to conduct research on the effect of sound on marine mammals, the modeling of sound effects to marine mammals in areas of Navy operations, and methods of reducing impacts through monitoring of marine mammals and sound reduction.

#### Marine Mammal Habitat

The primary source of potential marine mammal habitat impact during operations within the HRC is underwater sound resulting from ASW, MISSILEX and testing, LFX (e.g., 5-inch guns) operations and aerial bombardment and pressure effects from underwater detonations during mine clearing exercises. However, the sound does not constitute a long-term physical alteration of the water column or bottom topography, as the occurrences are of limited duration and are intermittent in time given that surface vessels associated with the operations move continuously and relatively rapidly through any given area. Other sources that may impact marine mammal
4.0 Environmental Consequences, Open Ocean Area

habitat were considered and potentially include the introduction of fuel, debris, ordnance, and chemical residues into the water column. The effects of each of these components were considered in this EIS/OEIS. Critical Habitat within the HRC for the Hawaiian monk seal was designated for beaches, sand spits, and bays out to the 20-fathom line (120 ft) for the Northwestern Hawaiian Islands (National Marine Fisheries Service, 1988). With the exception of a portion of Penguin Banks, the Hawaiian Islands Humpback Whale National Marine Sanctuary is located within 12 nautical miles (nm) of the islands, and potential impacts are discussed in the sections of this document that deal with each island.

4.1.2.4.1 Potential Non-Acoustic Impacts

Ship Collisions

Collisions with commercial and Navy ships can cause major wounds and may occasionally cause fatalities to sea turtles and cetaceans. The most vulnerable marine mammals are those that spend extended periods of time at the surface in order to restore oxygen levels within their tissues after deep dives (e.g., sperm whale). In addition, some baleen whales, such as the northern right whale and fin whale, swim slowly and seem generally unresponsive to ship sound, making them more susceptible to ship strikes (Nowacek et al., 2004). North Pacific right whales are primarily found in the Arctic, and there are only a few recorded sightings near the Hawaiian Islands (U.S. Department of the Navy, 2005a). Fin whales are only rarely seen in Hawaiian Island waters (Barlow, 2006). Most baleen whales are rare in the Hawaiian Islands with the exception of the humpback whale that occurs seasonally and generally close to shore, within 25 nm of shore (Mobley, 2004; U.S. Department of the Navy, 2005a).

The Navy has adopted standard SOPs that reduce the potential for collisions with surfaced marine mammals and sea turtles (See Chapter 6.0). At all times when ships are underway, there are many people on watch scanning the area around the ship. If a marine mammal or sea turtle is sighted, appropriate action will be taken to avoid the animal. Collisions with cetaceans, pinnipeds, and sea turtles are not expected.

Torpedo Guidance Wire

The potential entanglement impact of MK-48 torpedo control wires on sea turtles and marine mammals is very low because of the following:

- The control wire is very thin (approximately 0.02 inch) and has a relatively low breaking strength. Even with the exception of a chance encounter with the control wire while it was sinking to the sea floor (at an estimated rate of 0.5 ft per second), a marine animal would not be vulnerable to entanglement given the low breaking strength.

- The torpedo control wire is held stationary in the water column by drag forces as it is pulled from the torpedo in a relatively straight line until its length becomes sufficient for it to form a catenary droop (U.S. Department of the Navy, 1996). When the wire is released or broken, it is relatively straight and the physical characteristics of the wire prevent it from tangling, unlike the monofilament fishing lines and polypropylene ropes identified in the entanglement literature (U.S. Department of the Navy, 1996). Although Heezen (1957, as cited in U.S. Department of the Navy, 1996) theorized that the entanglement of marine mammals with undersea telecommunication cables was a direct result of the mammal coming into contact with loops in the cable (e.g., swimming through loops that then tightened around the mammal), this should not be
the case for the thin torpedo guidance wires. The Navy therefore believes the
potential for any harm or harassment to these species is extremely low.

**Torpedo Strike Impact**

There is negligible risk that a marine mammal or sea turtle could be struck by a torpedo during ASW training events. This conclusion is based on: (1) a review of ASW torpedo design features, and (2) review of a large number of previous Navy exercise ASW torpedo events. The torpedoes are specifically designed to ignore false targets. As a result, their homing logic does not detect or recognize the relatively small air volume associated with the lungs of marine mammals. They do not detect or home to marine mammals.

Given the relatively small size of sea turtles, there is negligible risk that a turtle could be struck by a torpedo during ASW training events. The Navy believes the potential for any harm or harassment to sea turtles is extremely low.

**Torpedo Air Launch Accessories**

Because some torpedo air launch accessories remain in the marine environment, the potential for impacting sea turtles and marine mammals through ingestion or entanglement has been previously analyzed. Ingestion of pieces of the launch accessories is unlikely because most of those are large and metallic and will sink rapidly (U.S. Department of the Navy, 1996a). With the exception of a chance encounter as the air launch accessories sink to the bottom, marine animals would only be vulnerable to entanglement or ingestion impacts if their diving and feeding behaviors place them in contact with the sea floor.

In previous studies, the Naval Ocean Systems Center identified two potential impacts of the MK-50 torpedo air launch accessories (Naval Ocean Systems Center, 1990). As the air launch accessories for the MK-46 torpedo are similar in function, materials, and size to those of the MK-50 torpedo, the following potential impacts identified by the Naval Ocean Systems Center are applicable to both torpedoes (U.S. Department of the Navy, 1996a):

- Upon water entry and engine startup, the air stabilizer would be released from the torpedo and sink to the bottom. Bottom currents may cause the air stabilizer canopy to billow, potentially posing an entanglement threat to marine animals that feed on the bottom. However, the canopy is large and highly visible compared to materials such as gill nets and nylon fishing line in which marine animals may become entangled. Thus, entanglement of marine animals in the canopy or suspension lines would be unlikely.

- Non-floating air launch debris ranges in length from 11 to 44 inches. Because of the relatively large size of this debris, the potential risk for ingestion of this debris by marine animals other than bottom-feeding whales would be small. The probability of a whale coming in contact with and ingesting the debris likewise would be small.

**MK-48 Torpedo Flex Hoses**

The Navy analyzed the potential for the flex hoses to impact sea turtles and marine mammals. The analysis concluded that the potential entanglement impact on marine animals would be
insignificant for reasons similar to those stated for the potential entanglement impact of control wires, specifically (U.S. Department of the Navy, 1996b):

- Due to its weight, the flex hose would rapidly sink to the bottom upon release. With the exception of a chance encounter with the flex hose while it was sinking to the sea floor, a marine animal would be vulnerable to entanglement only if its diving and feeding patterns placed it in contact with the bottom.
- Due to its stiffness, the 250-ft-long flex hose would not form loops that could entangle marine animals.

**Sonobuoy and Other Parachutes**

Sonobuoys, lightweight torpedoes, and other devices deployed from aircraft use nylon parachutes of varying sizes. At water impact, the parachute assembly is jettisoned and sinks away from the exercise weapon or target. The parachute assembly would potentially be at the surface for a short time before sinking to the sea floor.

Many large sea turtles subsist mainly on jellyfish, and the incidence of plastic bags being found in dead turtles indicates that the turtles may mistake floating plastic bags for jellyfish (Cottingham, 1989). Sea turtles also ingest pieces of polystyrene foam, monofilament fishing line, and several other kinds of synthetic drift items. Some ingestion of plastics by marine mammals is known to occur. However, the parachutes used on the proposed HRC are large in comparison with these animals’ normal food items, and would be very difficult to ingest.

Sea turtles and marine mammals are also subject to entanglement in marine debris, particularly anything incorporating loops or rings, hooks and lines, or sharp objects. Entanglement and the eventual drowning of a sea turtle or marine mammal in a parachute assembly would be unlikely, since the parachute would have to land directly on an animal, or an animal would have to swim into it before it sinks. The potential for a sea turtle or marine mammal to encounter an expended parachute assembly is extremely low, given the generally low probability of a sea turtle or marine mammal being in the immediate location of deployment. If bottom currents are present, the canopy may billow and pose an entanglement threat to marine animals with bottom-feeding habits; however, the probability of a sea turtle or marine mammal encountering a parachute assembly on the sea floor and the potential for accidental entanglement in the canopy or suspension lines is considered to be unlikely.

Overall, the possibility of sea turtles or marine mammals ingesting nylon parachute fabric or being entangled in parachute assemblies is very remote.

**4.1.2.4.2 Potential Sonar and Explosive Impacts**

ASW is a primary warfare area for Navy patrol ships (surface and submarines), aircraft, and ASW helicopters. ASW aircrews must practice using sensors, including electro-optical devices, radar, magnetic anomaly detectors, sonar (including helicopter dipping sonar and both active and passive sonobuoys) in both the deep and shallow water environment. The training events being analyzed for Alternative 1 are not new and have taken place in the HRC over the past 60 years, and with no significant changes in the equipment being used in the last 30 years.

Although there may be many hours of active ASW sonar events, the actual “pings” of the sonar signal may only occur several times a minute, as it is necessary for the ASW operators to listen
for the return echo of the sonar ping. As a result of scientific advances in acoustic exposure
effects analysis modeling on marine mammals, the extent of acoustic exposure on marine
mammals can be estimated.

The approach for estimating potential acoustic effects from operations within the HRC ASW
training operations on cetacean species makes use of the methodology that was developed in
cooperation with National Oceanic and Atmospheric Administration (NOAA) for the Navy’s
Undersea Warfare Training Range (USWTR) Draft OEIS/EIS (2005), USWEX Programmatic
EA/OEA (U.S. Department of the Navy, 2007b), RIMPAC EA/OEA (U.S. Department of the
Navy, Commander Third Fleet, 2006), and Composite Training Unit Exercise (COMPTUEX) /
Joint Task Force Exercise (JTFEX) EA/OEA (2007). In addition, the approach for estimating
potential acoustic effects from HRC training activities on marine mammals makes use of the
comments received on these previous documents. The National Marine Fisheries Service
(NMFS) and other commenters recommended the use of an alternate methodology to evaluate
when sound exposures might result in behavioral effects without corresponding physiological
effects.

Training operations that result in potential impacts from explosives include NSFS Exercise and
GUNEX (5-inch and 76-mm guns); MISSILEX (Penguin, Maverick, and Harpoon missiles);
BOMBEX (MK-82, MK-83, MK-84), SINKEX (multiple ordnance), and Mine Neutralization (20-lb
explosive charge).

The methodology for analyzing potential impacts from sonar and explosives includes the
following topics which are presented below (details of the acoustic modeling are presented in
Appendix J):

- Analytical Framework for Assessing Marine Mammal Response to Active Sonar
- Regulatory Framework
- Integration of Regulatory and Biological Framework
- Stress Response
- Criteria and Threshold for Physiological Effects
- Other Physiological Effects Considered
- Previous Criteria and Thresholds for Behavioral Effects
- Sound Pressure Level (SPL) Dose Function Functions for Estimating Behavioral
  Effects
- Application of Effect Thresholds to Other Species
- Cetacean Stranding Events
- Marine Mammal Mitigation Measures Related to Acoustic Effects
- Sonar Marine Mammal Modeling
- Explosive Source Marine Mammal Modeling
4.1.2.4.3 Analytical Framework for Assessing Marine Mammal Response to Active Sonar

As summarized by the National Research Council, the possibility that human-generated sound could harm marine mammals or significantly interfere with their “normal” activities is an issue of increasing concern (National Research Council, 2005). This section evaluates the potential for the specific Navy acoustic sources used in the HRC to result in harassment of marine mammals.

Assessing whether a sound may disturb or injure a marine mammal involves understanding the characteristics of the acoustic sources, the marine mammals that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those marine mammals. Although it is known that sound is important for marine mammal communication, navigation, and foraging, there are many unknowns in assessing the effects and significance of the response of marine mammals to sound exposures (National Research Council, 2005). For this reason, the Navy enlisted the expertise of NMFS as the cooperating agency. Their input assisted the Navy in developing a conceptual analytical framework for evaluating what sound levels marine mammals might receive as a result of Navy training actions at HRC, whether marine mammals might respond to these exposures, and whether that response might have a mode of action on the biology of ecology of marine mammals such that the response should be considered a potential harassment. From this framework of evaluating the potential for harassment incidents to occur, an assessment of whether acoustic sources might impact populations, stocks, or species of marine mammals can be conducted.

The conceptual analytical framework (Figure 4.1.2.4.3-1) presents an overview of how the mid-frequency active sonar sources used during training are assessed to evaluate the potential for marine mammals to be exposed to an acoustic source, the potential for that exposure to result in a physiological effect or behavioral response by an animal, and the assessment of whether that response may result in a consequence that constitutes harassment in accordance with Marine Mammal Protection Act (MMPA) definitions. As shown on the figure, the Navy has developed acoustic models to predict when Navy training and RDT&E operations could result in injury or behavioral disturbance. Total energy models are used to predict exposures that could result in physiological effects resulting in injury or temporary physiological changes. Dose function models are used to predict exposures that could result in behavioral effects.

Each exposure could result in a wide range of potential direct physiological effects, which could then lead to a behavioral response. For the purposes of this analysis all PTS exposures are assumed to result in injury (MMPA Level A harassment), and all TTS exposures are assumed to result in significant behavioral effects (MMPA Level B harassment). The other physiological effects are also considered in the analysis, although it is unlikely that they rise to the level of injury. The potential direct effects of physiological responses which may lead to behavioral exposures are considered in light of the biology and ecology of each species in order to arrive at the mode of action or result of the potential direct effect. The intensity of the resulting mode of action can then be used to determine if the natural behavioral patterns are abandoned or significantly altered.

Finally, the physiological and behavioral responses are reviewed in light of the population effects in order to determine the potential for effects on stocks or species.
The general analytical framework for analyzing potential effects of acoustic exposures on Endangered Species Act (ESA) listed species was developed by NMFS as presented in the Biological Opinion for RIMPAC 2006 and for the USWEX Programmatic EA/OEA (National Marine Fisheries Service, 2006, 2007). The framework is similar to the framework presented in Figure 4.1.2.4.3-1 in that the exposures calculated by the energy level and dose function models are used to evaluate a number of proximate responses and the resulting modes of action. The fitness consequences are then determined for individuals and populations.

The first step in the conceptual model is to estimate the potential for marine mammals to be exposed to a Navy acoustic source. Three questions are answered in this “acoustic modeling” step:

1. **What action will occur?** This requires identification of all acoustic sources that would be used in the exercises and the specific outputs of those sources. This information is provided in Appendix J.

2. **Where and when will the action occur?** The place and season of the action are important to:
   - Determine which marine mammal species are likely to be present. Species occurrence and density data (Chapter 3.0) are used to determine the subset of marine mammals that may be present when an acoustic source is operational. The species occurrence information is provided in Chapter 3.0 and the density data is provided in Appendix J, Acoustic Modeling.
   - Predict the underwater acoustic environment that would be encountered. The acoustic environment here refers to environmental factors that influence the propagation of underwater sound. Acoustic parameters influenced by the place, season, and time are described in Appendix J, Acoustic Modeling.

3. **How many marine mammals are predicted to be exposed to sound from the acoustic sources?** Sound propagation models are used to predict the received exposure level from an acoustic source, and these are coupled with species distribution and density data to estimate the accumulated received energy and sound pressure level that could be considered as potential harassment. Appendix J describes the acoustic modeling and Sections 4.1.2.5, 4.1.2.6, and 4.1.2.7 present the number of exposures predicted by the modeling.

The next steps in the analytical framework evaluate whether the sound exposures predicted by the acoustic model might cause a physiological response in a marine mammal, and if that response might cause a change in behavior. Harassment includes the concepts of potential injury (Level A Harassment) and behavioral disturbance (Level B harassment). The response assessment portion of the analytical framework examines the following question:

4. **Which potential acoustic exposures might result in harassment of marine mammals?** The predicted acoustic exposures are first considered within the context of the species biology (e.g., can a marine mammal detect the sound, and is that mammal likely to respond to that sound?). Next, if a response is predicted, what type of physiological change will occur (e.g., auditory trauma or fatigue, tissue effects...
from bubble formation or resonance). If a physiological change has occurred will there be a stress response (i.e., increases in heart rate, hormonal activity, respiration rate and awareness) followed by change in behavior (e.g., flight response or avoidance, changes in diving, foraging, or vocalization patterns or social behavior). Next, how will changes in behavior affect proximate life functions (e.g., survival, breeding, migration, and feeding) and ultimate life functions (e.g., survival, maturation, reproductive effort, and reproductive success). Ultimately determine, if possible with available information, what population or species/stock effects may occur. If a response is predicted, will it potentially be considered "harassment" in accordance with MMPA harassment definitions? For example, if a response to the acoustic exposure has a mode of action that results in a consequence for an individual, such as interruption of feeding, that response or repeated occurrence of that response could be considered “abandonment or significant alteration of natural behavioral patterns,” and therefore the exposure(s) would cause Level B harassment.

Section 4.1.2.3.4 reviews the regulatory framework and premise for the Navy/NMFS marine mammal response analytical framework. Sections 4.1.2.4, 4.1.2.5, and 4.1.2.6 include the analysis by species/stock for the No-action Alternative, Alternative 1, and Alternative 2, presenting relevant information about the species biology and ecology to provide a context for assessing whether modeled exposures might result in incidental harassment. Each alternative includes a discussion of estimated effects on ESA listed species and a section on non-ESA listed species. The potential for harassment is considered within the context of the affected marine mammal population to assess the fitness consequence under the ESA. Particular focus on recruitment and survival are provided to analyze whether the effects of the action can be considered to have negligible impact on species or stocks under MMPA.

Literature Searches for Relevant Information For Analysis

Literature searches were conducted to collect relevant reference material using published and unpublished sources. These include peer published journal articles, book chapters, monitoring or mitigation reports, Federal Register notices, environmental documents and workshop or conference reports. Recently, due to the increased concern over acoustic effects on marine animals, more information on the effects of a variety of underwater sound sources on marine animals has become available.

Literature searches using the Library of Congress’ First Search and Dissertation Abstracts databases, SCOPUS, Web of Science, BioOne, Oceanic Abstracts, Cambridge Abstract’s Aquatic Sciences, University of California MYLVYL, Biosis, Zoological Record Plus and Fisheries Abstracts (ASFA) database services. Specific journals that often publish marine mammal related publications (Aquatic Mammals, Journal of Mammalogy, Canadian Journal of Zoology, Marine Mammal Science), ecology (Ambio, Bioscience, Journal of Animal Ecology, Journal of Applied Ecology, Journal of the Marine Biological Association of the UK, Marine Pollution Bulletin), and bioacoustics (Journal of the Acoustical Society of America) were regularly searched for new publications. References were also obtained by contacting in the appropriate researchers in the field (commercial and academic researchers) and resource agencies (e.g. NMFS, U.S. Fish and Wildlife Service [USFWS]). This allowed us to collect gray literature reports and submitted or in-press journal articles.
4.0 Environmental Consequences, Open Ocean Area

4.1.2.4.4 Regulatory Framework

The MMPA and ESA prohibit the unauthorized harassment of marine mammals and endangered species, and provide the regulatory processes for authorization for any such harassment that might occur incidental to an otherwise lawful activity.

The regulatory framework for estimating potential acoustic effects from HRC ASW training activities on cetacean species makes use of the methodology that was developed in cooperation with NOAA for the Navy’s Undersea Warfare Training Range (USWTR) Draft Overseas Environmental Impact Statement/Environmental Impact Statement (OEIS/EIS), (U.S. Department of the Navy, Commander, U.S. Atlantic Fleet, 2005). Via response comment letter to USWTR received from NMFS January 30, 2006, NMFS concurred with the use of EL for the determination of physiological effects to marine mammals. Therefore, this methodology is used to estimate the annual exposure of marine mammals that may be considered Level A harassment or Level B harassment as a result of temporary, recoverable physiological effects.

In addition, the approach for estimating potential acoustic effects from HRC training activities on marine mammals makes use of the comments received on the Navy’s USWTR Draft OEIS/EIS (U.S. Department of the Navy, Commander, U.S. Atlantic Fleet, 2005) and the 2006 Rim of the Pacific Supplemental Overseas Environmental Assessment (U.S. Department of the Navy, 2006). NMFS and other commenters recommended the use of an alternate methodology to evaluate when sound exposures might result in behavioral effects without corresponding physiological effects. As a result of these comments, this document uses a dose function approach to evaluate the potential for behavioral effects. A number of Navy actions and NOAA rulings have helped to qualify possible events deemed as “harassment” under the MMPA. As stated previously, “harassment” under the MMPA includes both potential injury (Level A), and disruptions of natural behavioral patterns to a point where they are abandoned or significantly altered (Level B). NMFS also includes mortality as a possible outcome to consider in addition to Level A and Level B harassment. The acoustic effects analysis and exposure calculations are based on the following premises:

- Harassment that may result from Navy operations described in the HRC EIS/OEIS is unintentional and incidental to those operations.
- This HRC EIS/OEIS uses an unambiguous definition of injury as defined in the USWTR Draft OEIS/EIS (U.S. Department of the Navy, Commander, U.S. Atlantic Fleet, 2005), 2006 Rim of the Pacific Supplemental Overseas Environmental Assessment (U.S. Department of the Navy, 2006), and in previous rulings (National Oceanic and Atmospheric Administration, 2001; 2002a): injury occurs when any biological tissue is destroyed or lost as a result of the action.
- Behavioral disruption might result in subsequent injury and injury may cause a subsequent behavioral disruption, so Level A and Level B (defined below) harassment categories can overlap and are not necessarily mutually exclusive. However, by prior ruling (National Oceanic and Atmospheric Administration, 2001; 2006b), this HRC EIS/OEIS analysis assumes that Level A and B do not overlap.
- An individual animal predicted to experience simultaneous multiple injuries, multiple disruptions, or both, is counted as a single take (see National Oceanic and Atmospheric Administration, 2001; 2006b). An animal whose behavior is disrupted by an injury has already been counted as a Level A harassment and will not also be...
counted as a Level B harassment. Based on the consideration of two different acoustic modeling methodologies to assess the potential for sound exposures that might result in behavioral disturbance, it is possible that the model would count a Level B TTS exposure and a Level B behavioral exposure for the same animal. Although this approach overestimates the potential for behavioral disturbance incidents, it is considered conservative because the actual incidents of disturbance are expected to be lower.

- The acoustic effects analysis is based on primary exposures of the action. Secondary, or indirect, effects, such as susceptibility to predation following injury and injury resulting from disrupted behavior, while possible, can only be reliably predicted in circumstances where the responses have been well documented. Consideration of secondary effects would result in Level A exposures being considered Level B exposures, and vice versa, since Level A exposure (assumed to be Level A harassment and injury) has the potential to disrupt behavior resulting in Level B harassment. In like manner, temporary physiological or behavioral disruption (Level B exposures) could be conjectured to have the potential for injury (Level A). Consideration of secondary effects would lead to circular definitions of exposures. For beaked whales, where a connection between behavioral disruption by mid-frequency active sonar and injury to beaked whales is considered a possibility (under specific operational and environmental parameters), secondary effects are considered in the discussion for each species.

4.1.2.4.5 Integration of Regulatory and Biological Frameworks
This section presents a biological framework within which potential effects can be categorized and then related to the existing regulatory framework for MMPA and ESA. The information presented in Sections 4.1.2.4.6 and 4.1.2.4.7 is used to develop specific numerical exposure thresholds and dose function curves. Exposure thresholds and dose function curves are combined with sound propagation models and species distribution data to estimate the potential exposures as presented for the No-Action Alternative in Section 4.1.2.5; Alternative 1 in Section 4.1.2.6; and Alternative 2 in Section 4.1.2.7.

Physiological and Behavioral Effects
Sound exposure may affect multiple biological traits of a marine animal. The biological framework proposed here is structured according to potential physiological and behavioral effects resulting from sound exposure. The range of effects may then be assessed according to MMPA and ESA regulations.

Physiology and behavior are chosen over other biological traits because:

- They are consistent with regulatory statements defining harassment by injury and harassment by disturbance.
- They are components of other biological traits that may be relevant.
- They are a more sensitive and immediate indicator of effect.

For example, ecology is not used as the basis of the framework because the ecology of an animal is dependent on the interaction of an animal with the environment. The animal’s interaction with the environment is driven both by its physiological function and its behavior, and
an ecological impact may not be observable over short periods of observation. However, ecological information is considered in the analysis of the effects of individual species.

A “physiological effect” is defined here as one in which the “normal” physiological function of the animal is altered in response to sound exposure. Physiological function is any of a collection of processes ranging from biochemical reactions to mechanical interaction and operation of organs and tissues within an animal. A physiological effect may range from the most significant of impacts (i.e., mortality and serious injury) to lesser effects that would define the lower end of the physiological impact range, such as the non-injurious distortion of auditory tissues.

A “behavioral effect” is one in which the “normal” behavior or patterns of behavior of an animal are overtly disrupted in response to an acoustic exposure. Examples of behaviors of concern can be derived from the harassment definitions in the MMPA and ESA implementing regulations and Public Law (PL) 108—136 (2004).

In this EIS/OEIS the term “normal” is used to qualify distinctions between physiological and behavioral effects. Its use follows the convention of normal daily variation in physiological and behavioral function without the influence of anthropogenic acoustic sources. As a result, this EIS/OEIS uses the following definitions:

- A physiological effect is a variation in an animal’s respiratory, endocrine, hormonal, circulatory, neurological, or reproductive activity and processes, beyond the animal’s normal range of variability, in response to human activity or to an exposure to a stimulus such as active sonar.

- A behavioral effect is a variation in the pattern of an animal’s breathing, feeding, resting, migratory, intraspecific behavior (such as reproduction, mating, territorial, rearing, and agonistic behavior), and interspecific behavior, beyond the animal’s normal pattern of variability in response to human activity or to an exposure to a stimulus such as active sonar.

The definitions of physiological effect and behavioral effect used here are specific to this EIS/OEIS and should not be confused with more global definitions applied to the field of biology or to existing Federal law. It is reasonable to expect some physiological effects to result in subsequent behavioral effects. For example, a marine mammal that suffers a severe injury may be expected to alter diving or foraging to the degree that its variation in these behaviors is outside that which is considered normal for the species. If a physiological effect is accompanied by a behavioral effect, the overall effect is characterized as a physiological effect; physiological effects take precedence over behavioral effects with regard to their ordering. This approach provides the most conservative ordering of effects with respect to severity, provides a rational approach to dealing with the overlap of the definitions, and avoids circular arguments.

The severity of physiological effects generally decreases with decreasing sound exposure and/or increasing distance from the exposure source. The same generalization does not consistently hold for behavioral effects because they do not depend solely on the received sound level. Behavioral responses also depend on an animal’s learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which the sound is presented. However, to provide a tractable approach to predicting acoustic effects that is relevant to the regulatory terms of behavioral disruption, it is assumed here that

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the severities of behavioral effects also decrease with decreasing sound exposure and/or increasing distance from the sound source.

MMPA Level A and Level B Harassment

Categorizing potential effects as either physiological or behavioral effects allows them to be related to the harassment definitions. For military readiness operations, Level A harassment includes any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild. Injury defined in previous rule (National Oceanic and Atmospheric Administration, 2001; 2002a), is the destruction or loss of biological tissue. The destruction or loss of biological tissue will result in an alteration of physiological function that exceeds the normal daily physiological variation of the intact tissue. For example, increased localized histamine production, edema, production of scar tissue, activation of clotting factors, white blood cell response, etc., may be expected following injury. Therefore, this EIS/OEIS assumes that all injury is qualified as a physiological effect and, to be consistent with prior actions and rulings (National Oceanic and Atmospheric Administration, 2001), all injuries (slight to severe) are considered Level A harassment.

PL 108-136 (2004) amended the MMPA definition of Level B harassment for military readiness operations, which applies to this action. For military readiness operations, Level B harassment is now defined as “any act that disturbs or is likely to disturb a marine mammal or marine mammal stock by causing disruption of natural behavioral patterns including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering to a point where such behaviors are abandoned or significantly altered.” Unlike Level A harassment, which is solely associated with physiological effects, both physiological and behavioral effects may cause Level B harassment.

The volumes of ocean in which Level A and Level B harassment is predicted to occur are described as harassment zones. All marine mammals predicted to be in a zone are considered exposed to effects that could result in the corresponding level of harassment. Figure 4.1.2.4.5-1 illustrates harassment zones extending from a hypothetical, directional sound source.

The Level A harassment zone extends from the source out to the distance and exposure at which the slightest amount of injury is predicted to occur. The acoustic exposure that produces the slightest degree of injury is therefore the threshold value defining the outermost limit of the Level A harassment zone. Use of the threshold associated with the onset of slight injury as the most distant point and least injurious exposure takes account of all more serious injuries by inclusion within the Level A harassment zone. The threshold used to define the outer limit of the Level A harassment zone is given in Section 4.1.2.4-7.
The Level B harassment zone begins just beyond the point of slightest injury and extends outward from that point to include all animals that may possibly experience Level B harassment. Physiological effects extend beyond the range of slightest injury to a point where slight temporary distortion of the most sensitive tissue occurs, but without destruction or loss of that tissue. The animals predicted to be in this zone are assumed to experience Level B harassment by virtue of temporary impairment of sensory function (altered physiological function) that can disrupt behavior. The criterion and threshold used to define the outer limit of physiological effects leading to Level B harassment are given in Section 4.1.2.3.6. As described earlier, some behavioral effects occur without an accompanying physiological effect. The dose function that is used to define the non-physiological behavioral effects that constitute potential Level B harassment is described in Section 4.1.2.4.9.

**ESA Harm and Harassment**

ESA regulations define harm as “an act which actually kills or injures” fish or wildlife (50 Code of Federal Regulations [CFR] § 222.102). ESA regulations define harassment as an “intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering” (50 CFR § 17.3). Under ESA there are also behavioral effects that exceed the normal daily variation in behavior, but which arise without an accompanying physiological effect.

**Auditory Tissues as Indicators of Physiological Effects**

The severity of physiological effects generally decreases with decreasing sound exposure and/or increasing distance from the exposure source. The same generalization does not consistently hold for behavioral effects because they do not depend solely on the received sound level. Behavioral responses also depend on an animal’s learned responses, innate response tendencies, motivational state, the pattern of the sound exposure, and the context in which the sound is presented. However, to provide a tractable approach to predicting acoustic...
effects that is relevant to the regulatory terms of behavioral disruption, it is assumed here that
the severities of behavioral effects also decrease with decreasing sound exposure and/or
increasing distance from the sound source.

The mammalian auditory system, including those of marine mammals, consists of the outer ear
(vestigial in cetaceans), middle ear, inner ear, and central nervous system (Ketten 1998). Sound waves are transmitted through the middle ear to fluids within the inner ear, except in
cetaceans. The inner ear contains delicate electromechanical hair cells that convert the fluid
motions into neural impulses that are sent to the brain. The hair cells within the inner ear are
the most vulnerable to over-stimulation by sound exposure (Yost, 1994).

Very high sound levels may rupture the eardrum or damage the small bones in the middle ear
(Yost, 1994). Lower level exposures of sufficient duration may cause permanent or temporary
hearing loss; such an effect is called a sound-induced threshold shift, or simply a threshold shift
(TS) (Miller, 1974). A TS may be either permanent, in which case it is called a PTS, or
temporary, in which case it is called a TTS. Still lower levels of sound may result in auditory
masking, which may interfere with an animal’s ability to hear other concurrent sounds.

Because the tissues of the ear appear to be the most susceptible to the physiological effects of
sound and TSs tend to occur at lower exposures than other more serious auditory effects, PTS
and TTS are used here as the biological indicators of physiological effects. TTS is the first
indication of physiological non-injurious change and is not physical injury. The remainder of this
section is, therefore, focused on TSs, including PTSSs and TTSs. Because masking (without a
resulting TS) is not associated with abnormal physiological function, it is not considered a
physiological effect in this analysis, but rather a potential behavioral effect.

_noise-induced threshold shifts_

The amount of TS depends on the amplitude, duration, frequency, and temporal pattern of the
sound exposure. Threshold shifts will generally increase with the amplitude and duration of
sound exposure. For continuous sounds, exposures of equal energy will lead to approximately
equal effects (Ward, 1997). For intermittent sounds, less TS will occur than from a continuous
exposure with the same energy (some recovery will occur between exposures) (Kryter et al.,
1966; Ward, 1997).

The magnitude of a TS normally decreases with the amount of time post-exposure (Miller,
1974). The amount of TS just after exposure is called the initial TS. If the TS eventually returns
to zero (the threshold returns to the pre-exposure value), the TS is a TTS. Since the amount of
TTS depends on the time post-exposure, it is common to use a subscript to indicate the time in
minutes after exposure (Quaranta et al., 1998). For example, TTS$_2$ means a TTS measured 2
minutes after exposure. If the TS does not return to zero but leaves some finite amount of TS,
then that remaining TS is a PTS. The distinction between PTS and TTS is based on whether
there is a complete recovery of a TS following a sound exposure. Figure 4.1.2.4.5-2 shows two
hypothetical TSs, one that completely recovers, a TTS, and one that does not completely
recover, leaving some PTS.
PTS, TTS, and Harassment Zones

PTS is non-recoverable and, by definition, must result from the destruction of tissues within the auditory system. PTS therefore qualifies as an injury and is classified as Level A harassment under the wording of the MMPA. In the Draft EIS/OEIS, the smallest amount of PTS (onset-PTS) is taken to be the indicator for the smallest degree of injury that can be measured. The acoustic exposure associated with onset-PTS is used to define the outer limit of the Level A harassment zone.

TTS is recoverable and, as in recent rulings (National Oceanic and Atmospheric Administration, 2001, 2002a), is considered to result from the temporary, non-injurious distortion of hearing-related tissues. Because it is considered non-injurious (there is no tissue damage), the acoustic exposure associated with onset-TTS is used to define the outer limit of the portion of the Level B harassment zone attributable to physiological effects. This follows from the concept that hearing loss potentially affects an animal’s ability to react normally to the sounds around it. Therefore, in the HRC, TTS is considered as a Level B harassment resulting from physiological effects on the auditory system.

Criteria and Thresholds for Physiological Effects

This section presents the effect criteria and thresholds for physiological effects of sound leading to injury and behavioral disturbance as a result of sensory impairment. Section 4.1.2.4.5 identified the tissues of the ear as being the most susceptible to physiological effects of underwater sound. PTS and TTS were determined to be the most appropriate biological indicators of physiological effects that equate to the onset of injury (Level A harassment) and behavioral disturbance (Level B harassment), respectively. This section is, therefore, focused on criteria and thresholds to predict PTS and TTS in marine mammals.

Marine mammal ears are functionally and structurally similar to terrestrial mammal ears; however, there are important differences (Ketten, 1998). The most appropriate information from which to develop PTS/TTS criteria for marine mammals would be experimental measurements of PTS and TTS from marine mammal species of interest. TTS data exist for several marine mammal species and may be used to develop meaningful TTS criteria and thresholds. Because of the ethical issues presented, PTS data do not exist for marine mammals and are unlikely to
be obtained. Therefore, PTS criteria must be extrapolated using TTS criteria and estimates of
the relationship between TTS and PTS.

This section begins with a review of the existing marine mammal TTS data. The review is
followed by a discussion of the relationship between TTS and PTS. The specific criteria and
thresholds for TTS and PTS used in this authorization request are then presented. This is
followed by discussions of EL, the relationship between EL and SPL, and the use of SPL and
EL in previous environmental compliance documents.

### Energy Flux Density Level and Sound Pressure Level

Energy Flux Density Level (EL) is measure of the sound energy flow per unit area expressed in dB. EL is stated in dB re 1 μPa²-s for underwater sound and dB re (20 μPa)²-s for airborne sound.

Sound Pressure Level (SPL) is a measure of the root-mean square, or “effective,” sound pressure in decibels. SPL is expressed in dB re 1 μPa for underwater sound and dB re 20 μPa for airborne sound.

**TTS in Marine Mammals**

A number of investigators have measured TTS in marine mammals. These studies measured
hearing thresholds in trained marine mammals before and after exposure to intense sounds.
Some of the more important data obtained from these studies are onset-TTS levels – exposure
levels sufficient to cause a just-measurable amount of TTS, often defined as 6 dB of TTS (for
example, Schlundt et al., 2000). The existing cetacean TTS data are summarized in the
following bullets.

- **Schlundt et al. (2000)** reported the results of TTS experiments conducted with
  bottlenose dolphins and white whales exposed to 1-second tones. This paper also
  includes a reanalysis of preliminary TTS data released in a technical report by
  Ridgway et al. (1997). At frequencies of 3, 10, and 20 kHz, SPLs necessary to
  induce measurable amounts (6 dB or more) of TTS were between 192 and 201 dB re
  1 μPa (EL = 192 to 201 dB re 1 μPa²-s). The mean exposure SPL and EL for onset-
  TTS were 195 dB re 1 μPa and 195 dB re 1 μPa²-s, respectively. The sound
  exposure stimuli (tones) and relatively large number of test subjects (five dolphins
  and two white whales) make the Schlundt et al. (2000) data the most directly relevant
  TTS information for the scenarios described in the HRC EIS/OEIS.

- **Finneran et al. (2001, 2003, 2005)** described TTS experiments conducted with
  bottlenose dolphins exposed to 3-kHz tones with durations of 1, 2, 4, and 8 seconds.
  Small amounts of TTS (3 to 6 dB) were observed in one dolphin after exposure to
  ELs between 190 and 204 dB re 1 μPa²-s. These results were consistent with the
  data of Schlundt et al. (2000) and showed that the Schlundt et al. (2000) data were
  not significantly affected by the masking sound used. These results also confirmed
  that, for tones with different durations, the amount of TTS is best correlated with the
  exposure EL rather than the exposure SPL.
Nachtigall et al. (2003a) measured TTS in a bottlenose dolphin exposed to octave-band sound centered at 7.5 kHz. Nachtigall et al. (2003a) reported TTSs of about 11 dB measured 10 to 15 minutes after exposure to 30 to 50 minutes of sound with SPL 179 dB re 1 μPa (EL about 213 dB re μPa^2-s). No TTS was observed after exposure to the same sound at 165 and 171 dB re 1 μPa. Nachtigall et al. (2003b) reported TTSs of around 4 to 8 dB 5 minutes after exposure to 30 to 50 minutes of sound with SPL 160 dB re 1 μPa (EL about 193 to 195 dB re 1 μPa^2-s). The difference in results was attributed to faster post-exposure threshold measurement—TTS may have recovered before being detected by Nachtigall et al. (2003a). These studies showed that, for long-duration exposures, lower sound pressures are required to induce TTS than are required for short-duration tones. These data also confirmed that, for the cetaceans studied, EL is the most appropriate predictor for onset-TTS.

Finneran et al. (2000, 2002) conducted TTS experiments with dolphins and white whales exposed to impulsive sounds similar to those produced by distant underwater explosions and seismic waterguns. These studies showed that, for very short-duration impulsive sounds, higher sound pressures were required to induce TTS than for longer-duration tones.

Kastak et al. (1999, 2005) conducted TTS experiments with three species of pinnipeds, California sea lion, northern elephant seal and a Pacific harbor seal, exposed to continuous underwater sounds at levels of 80 and 95 dB SPL at 2.5 and 3.5 kHz for up to 50 minutes. Mean TTS shifts of up to 12.2 dB occurred with the harbor seals showing the largest shift of 28.1 dB. Increasing the sound duration had a greater effect on TTS than increasing the sound level from 80 to 95 dB.

Figure 4.1.2.4.6-1 shows the existing TTS data for cetaceans (dolphins and white whales). Individual exposures are shown in terms of SPL versus exposure duration (upper panel) and EL versus exposure duration (lower panel). Exposures that produced TTS are shown as filled symbols. Exposures that did not produce TTS are represented by open symbols. The squares and triangles represent impulsive test results from Finneran et al., 2000 and 2002, respectively. The circles show the 3-, 10-, and 20-kHz data from Schlundt et al. (2000) and the results of Finneran et al. (2003). The inverted triangle represents data from Nachtigall et al. (2003b).

Figure 4.1.2.4.6-1 illustrates that the effects of the different sound exposures depend on the SPL and duration. As the duration decreases, higher SPLs are required to cause TTS. In contrast, the ELs required for TTS do not show the same type of variation with exposure duration.

The solid line in the upper panel of Figure 4.1.2.4.6-1 has a slope of -3 dB per doubling of time. This line passes through the point where the SPL is 195 dB re 1 μPa and the exposure duration is 1 second. Since EL = SPL + 10log10 (duration), doubling the duration increases the EL by 3 dB. Subtracting 3 dB from the SPL decreases the EL by 3 dB. The line with a slope of -3 dB per doubling of time, therefore, represents an equal energy line—all points on the line have the same EL, which is, in this case, 195 dB re 1 μPa^2-s. This line appears in the lower panel as a horizontal line at 195 dB re 1 μPa^2-s. The equal energy line at 195 dB re 1 μPa^2-s fits the tonal and sound data (the non-impulsive data) very well, despite differences in exposure duration, SPL, experimental methods, and subjects.
Figure 4.1.2.4.6-1. Existing TTS Data for Cetaceans

In summary, the existing cetacean TTS data show that, for the species studied and sounds (non-impulsive) of interest, the following is true:

- The growth and recovery of TTS are analogous to those in land mammals. This means that, as in land mammals, cetacean TSs depend on the amplitude, duration, frequency content, and temporal pattern of the sound exposure. Threshold shifts will generally increase with the amplitude and duration of sound exposure. For continuous sounds, exposures of equal energy will lead to approximately equal effects (Ward, 1997). For intermittent sounds, less TS will occur than from a continuous exposure with the same energy (some recovery will occur between exposures) (Kryter et al., 1966; Ward, 1997).

- SPL by itself is not a good predictor of onset-TTS, since the amount of TTS depends on both SPL and duration.

- Exposure EL is correlated with the amount of TTS and is a good predictor for onset-TTS for single, continuous exposures with different durations. This agrees with human TTS data presented by Ward et al. (1958, 1959).
• An energy flux density level of 195 dB re 1 μPa²-s is the most appropriate predictor for onset-TTS from a single, continuous exposure.

**Relationship between TTS and PTS**

Since marine mammal PTS data do not exist, onset-PTS levels for these animals must be estimated using TTS data and relationships between TTS and PTS. Much of the early human TTS work was directed towards relating TTS₂ after 8 hours of sound exposure to the amount of PTS that would exist after years of similar daily exposures (e.g., Kryter et al., 1966). Although it is now acknowledged that susceptibility to PTS cannot be reliably predicted from TTS measurements, TTS data do provide insight into the amount of TS that may be induced without a PTS. Experimental studies of the growth of TTS may also be used to relate changes in exposure level to changes in the amount of TTS induced. Onset-PTS exposure levels may therefore be predicted by:

- Estimating the largest amount of TTS that may be induced without PTS. Exposures causing a TS greater than this value are assumed to cause PTS.
- Estimating the additional exposure, above the onset-TTS exposure, necessary to reach the maximum allowable amount of TTS that, again, may be induced without PTS. This is equivalent to estimating the growth rate of TTS—how much additional TTS is produced by an increase in exposure level.

Experimentally induced TTSs in marine mammals have generally been limited to around 2 to 10 dB, well below TSs that result in some PTS. Experiments with terrestrial mammals have used much larger TSs and provide more guidance on how high a TS may rise before some PTS results. Early human TTS studies reported complete recovery of TTSs as high as 50 dB after exposure to broadband sound (Ward, 1960; Ward et al., 1958, 1959). Ward et al. (1959) also reported slower recovery times when TTS₂ approached and exceeded 50 dB, suggesting that 50 dB of TTS₂ may represent a “critical” TTS. Miller et al. (1963) found PTS in cats after exposures that were only slightly longer in duration than those causing 40 dB of TTS. Kryter et al. (1966) stated: “A TTS₂ that approaches or exceeds 40 dB can be taken as a signal that danger to hearing is imminent.” These data indicate that TSs up to 40 to 50 dB may be induced without PTS, and that 40 dB is a reasonable upper limit for TS to prevent PTS.

The small amounts of TTS produced in marine mammal studies also limit the applicability of these data to estimates of the growth rate of TTS. Fortunately, data do exist for the growth of TTS in terrestrial mammals. For moderate exposure durations (a few minutes to hours), TTS₂ varies with the logarithm of exposure time (Ward et al., 1958, 1959; Quaranta et al., 1998). For shorter exposure durations the growth of TTS with exposure time appears to be less rapid (Miller, 1974; Keeler, 1976). For very long-duration exposures, increasing the exposure time may fail to produce any additional TTS, a condition known as asymptotic threshold shift (Saunders et al., 1977; Mills et al., 1979).

Ward et al. (1958, 1959) provided detailed information on the growth of TTS in humans. Ward et al. presented the amount of TTS measured after exposure to specific SPLs and durations of broadband sound. Since the relationship between EL, SPL, and duration is known, these same data could be presented in terms of the amount of TTS produced by exposures with different ELs.
Figure 4.1.2.4.6-2 shows results from Ward et al. (1958, 1959) plotted as the amount of TTS$_2$ versus the exposure EL. The data in Figure 4.1.2.4.6-2(a) are from broadband (75 Hz to 10 kHz) sound exposures with durations of 12 to 102 minutes (Ward et al., 1958). The symbols represent mean TTS$_2$ for 13 individuals exposed to continuous sound. The solid line is a linear regression fit to all but the two data points at the lowest exposure EL. The experimental data are fit well by the regression line ($R^2 = 0.95$). These data are important for two reasons: (1) they confirm that the amount of TTS is correlated with the exposure EL; and (2) the slope of the line allows one to estimate the additional amount of TTS produced by an increase in exposure. For example, the slope of the line in Figure 4.1.2.4.6-2(a) is approximately 1.5 dB TTS$_2$ per dB of EL. This means that each additional dB of EL produces 1.5 dB of additional TTS$_2$.

![Figure 4.1.2.4.6-2. Growth of TTS versus the Exposure EL (from Ward et al., 1958, 1959)](image)

The data in Figure 4.1.2.4.5-2(b) are from octave-band sound exposures (2.4 to 4.8 kHz) with durations of 12 to 102 minutes (Ward et al., 1959). The symbols represent mean TTS for 13 individuals exposed to continuous sound. The linear regression was fit to all but the two data points at the lowest exposure EL. The results are similar to those shown in Figure 4.1.2.4.5-2(a). The slope of the regression line fit to the mean TTS data was 1.6 dB TTS$_2$/dB EL. A similar procedure was carried out for the remaining data from Ward et al. (1959), with comparable results. Regression lines fit to the TTS versus EL data had slopes ranging from 0.76 to 1.6 dB TTS$_2$/dB EL, depending on the frequencies of the sound exposure and hearing test.

An estimate of 1.6 dB TTS$_2$ per dB increase in exposure EL is the upper range of values from Ward et al. (1958, 1959) and gives the most conservative estimate—it predicts a larger amount of TTS from the same exposure compared to the lines with smaller slopes. The difference between onset-TTS (6 dB) and the upper limit of TTS before PTS (40 dB) is 34 dB. To move from onset-TTS to onset-PTS, therefore, requires an increase in EL of 34 dB divided by 1.6 dB/dB, or approximately 21 dB. An estimate of 20 dB between exposures sufficient to cause onset-TTS and those capable of causing onset-PTS is a reasonable approximation. To summarize:

- In the absence of marine mammal PTS data, onset-PTS exposure levels may be estimated from marine mammal TTS data and PTS/TTS relationships observed in terrestrial mammals. This involves:
  - Estimating the largest amount of TTS that may be induced without PTS.
  - Exposures causing a TS greater than this value are assumed to cause PTS.
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- Estimating the growth rate of TTS – how much additional TTS is produced by an increase in exposure level.

- A variety of terrestrial mammal data sources point toward 40 dB as a reasonable estimate of the largest amount of TS that may be induced without PTS. A conservative estimate is that continuous-type exposures producing TSs of 40 dB or more always result in some amount of PTS.

- Data from Ward et al. (1958, 1959) reveal a linear relationship between TTS and exposure EL. A value of 1.6 dB TTS per dB increase in EL is a conservative estimate of how much additional TTS is produced by an increase in exposure level for continuous-type sounds.

- There is a 34 dB TS difference between onset-TTS (6 dB) and onset-PTS (40 dB). The additional exposure above onset-TTS that is required to reach PTS is therefore 34 dB divided by 1.6 dB/dB, or approximately 21 dB.

- Exposures with ELs 20 dB above those producing TTS may be assumed to produce a PTS. This number is used as a conservative simplification of the 21 dB number derived above.

Threshold Levels for Harassment from Physiological Effects

For this specified action, sound exposure thresholds for TTS and PTS are as presented in the following text box:

| 195 dB re 1 μPa²-s received EL for TTS |
| 215 dB re 1 μPa²-s received EL for PTS |

- Marine mammals predicted to receive a sound exposure with EL of 215 dB re 1 μPa²-s or greater are assumed to experience PTS and are counted as Level A harassment. Marine mammals predicted to receive a sound exposure with EL greater than or equal to 195 dB re 1 μPa²-s but less than 215 dB re 1 μPa²-s are assumed to experience TTS and are counted as Level B harassment.

Derivation of Effect Threshold

The TTS threshold is primarily based on the cetacean TTS data from Schlundt et al. (2000). Since these tests used short-duration tones similar to sonar pings, they are the most directly relevant data. The mean exposure EL required to produce onset-TTS in these tests was 195 dB re 1 μPa²-s. This result is corroborated by the short-duration tone data of Finneran et al. (2000, 2003) and the long-duration sound data from Nachtigall et al. (2003a, b). Together, these data demonstrate that TTS in cetaceans is correlated with the received EL and that onset-TTS exposures are fit well by an equal-energy line passing through 195 dB re 1 μPa²-s.

The PTS threshold is based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20 dB value is based on estimates from terrestrial mammal data of PTS occurring at 40 dB or more of TS, and on TS growth occurring at a rate of 1.6 dB/dB increase in exposure EL. This is conservative because: (1) 40 dB of TS is actually an upper limit for TTS used to
approximate onset-PTS, and (2) the 1.6 dB/dB growth rate is the highest observed in the data from Ward et al. (1958, 1959).

Use of EL for Physiological Effect Thresholds

Effect thresholds are expressed in terms of total received EL. Energy flux density is a measure of the flow of sound energy through an area. Marine and terrestrial mammal data show that, for continuous-type sounds of interest, TTS and PTS are more closely related to the energy in the sound exposure than to the exposure SPL.

The EL for each individual ping is calculated from the following equation:

\[
EL = SPL + 10\log_{10}(\text{duration})
\]

The EL includes both the ping SPL and duration. Longer-duration pings and/or higher-SPL pings will have a higher EL.

If an animal is exposed to multiple pings, the energy flux density in each individual ping is summed to calculate the total EL. Since mammalian TS data show less effect from intermittent exposures compared to continuous exposures with the same energy (Ward, 1997), basing the effect thresholds on the total received EL is a conservative approach for treating multiple pings; in reality, some recovery will occur between pings and lessen the effect of a particular exposure.

Therefore, estimates are conservative because recovery is not taken into account—intermittent exposures are considered comparable to continuous exposures.

The total EL depends on the SPL, duration, and number of pings received. The TTS and PTS thresholds do not imply any specific SPL, duration, or number of pings. The SPL and duration of each received ping are used to calculate the total EL and determine whether the received EL meets or exceeds the effect thresholds. For example, the TTS threshold would be reached through any of the following exposures:

- A single ping with \( SPL = 195 \text{ dB re } 1 \mu \text{Pa} \) and duration = 1 second.
- A single ping with \( SPL = 192 \text{ dB re } 1 \mu \text{Pa} \) and duration = 2 seconds.
- Two pings with \( SPL = 192 \text{ dB re } 1 \mu \text{Pa} \) and duration = 1 second.
- Two pings with \( SPL = 189 \text{ dB re } 1 \mu \text{Pa} \) and duration = 2 seconds.

Previous Use of EL for Physiological Effects

Energy measures have been used as a part of dual criteria for cetacean auditory effects in shock trials, which only involve impulsive-type sounds (U.S. Department of the Navy, 1998a, 2001a). These actions used 192 dB re 1 μPa2-s as a reference point to derive a TTS threshold in terms of EL. A second TTS threshold, based on peak pressure, was also used. If either threshold was exceeded, effect was assumed.
The 192 dB re 1 μPa²-s reference point differs from the threshold of 195 dB re 1 μPa²-s used in this HRC EIS/OEIS. The 192 dB re 1 μPa²-s value was based on the minimum observed by Ridgway et al. (1997) and Schlundt et al. (2000) during TTS measurements with bottlenose dolphins exposed to 1-second tones. At the time, no impulsive test data for marine mammals were available and the 1-second tonal data were considered to be the best available. The minimum value of the observed range of 192 to 201 dB re 1 μPa²-s was used to protect against misinterpretation of the sparse data set available. The 192 dB re 1 μPa²-s value was reduced to 182 dB re 1 μPa²-s to accommodate the potential effects of pressure peaks in impulsive waveforms.

The additional data now available for onset-TTS in small cetaceans confirm the original range of values and increase confidence in it (Finneran et al., 2001, 2003; Nachtigall et al., 2003a, 2003b). The HRC EIS/OEIS, therefore, uses the more complete data available and the mean value of the entire Schlundt et al. (2000) data set (195 dB re 1 μPa²-s), instead of the minimum of 192 dB re 1 μPa²-s. From the standpoint of statistical sampling and prediction theory, the mean is the most appropriate predictor—the “best unbiased estimator”—of the EL at which onset-TTS should occur; predicting the number of exposures in future actions relies (in part) on using the EL at which onset-TTS will most likely occur. When that EL is applied over many pings in each of many sonar exercises, that value will provide the most accurate prediction of the actual number of exposures by onset-TTS over all of those exercises. Use of the minimum value would overestimate the number of exposures because many animals counted would not have experienced onset-TTS. Further, there is no logical limiting minimum value of the distribution that would be obtained from continued successive testing. Continued testing and use of the minimum would produce more and more erroneous estimates.

**Summary of Physiological Effects Criteria**

PTS and TTS are used as the criteria for physiological effects resulting in injury (Level A harassment) and disturbance (Level B harassment), respectively. Sound exposure thresholds for TTS and PTS are 195 dB re 1 μPa²-s received EL for TTS and 215 dB re 1 μPa²-s received EL for PTS. The TTS threshold is primarily based on cetacean TTS data from Schlundt et al. (2000). Since these tests used short-duration tones similar to sonar pings, they are the most directly relevant data. The PTS threshold is based on a 20 dB increase in exposure EL over that required for onset-TTS. The 20 dB value is based on extrapolations from terrestrial mammal data indicating that PTS occurs at 40 dB or more of TS, and that TS growth occurring at a rate of approximately 1.6 dB/dB increase in exposure EL. The application of the model results to estimate marine mammal exposures for each species is discussed in Sections 4.1.2.5, 4.1.2.6, and 4.1.2.7.

**4.1.2.4.7 Other Physiological Effects Considered**

**Stress**

A possible stressor for marine mammals exposed to sound, including mid-frequency active sonar, is the effect on health and physiological stress (Fair and Becker, 2000). A stimulus may cause a number of behavioral and physiological responses such as an elevated heart rate, increases in endocrine and neurological function, and decreased immune function, particularly if the animal perceives the stimulus as life threatening (Seyle, 1950; Moberg, 2000; Sapolsky et al., 2005). The primary response to the stressor is to move away to avoid continued exposure. Next the animal's physiological response to a stressor is to engage the autonomic nervous system with the classic "fight or flight" response. This includes changes in the cardiovascular...
system (increased heart rate), the gastrointestinal system (decreased digestion), the exocrine
glands (increased hormone output), and the adrenal glands (increased norepinephrine). These
physiological and hormonal responses are short lived and may not have significant long-term
effects on an animal’s health or fitness. Generally these short-term responses are not
detrimental to the animal except when the health of the animal is already compromised by
disease, starvation, or parasites; or the animal is chronically exposed to a stressor.

Exposure to chronic or high intensity sound sources can cause physiological stress. Acoustic
exposures and physiological responses have been shown to cause stress responses (elevated
respiration and increased heart rates) in humans (Jansen, 1998). Jones (1998) reported on
reductions in human performance when faced with acute, repetitive exposures to acoustic
disturbance. Trimper et al. (1998) reported on the physiological stress responses of osprey to
low-level aircraft noise. Krausman et al. (2004) reported on the auditory (TTS) and physiology
stress responses of endangered Sonoran pronghorn to military overflights. Smith et al. (2004a,
2004b) recorded sound-induced physiological stress responses in a hearing-specialist fish that
was associated with TTS and PTS. Welch and Welch (1970), reported physiological and
behavioral stress responses that accompanied damage to the inner ears of fish and several
mammals.

Most of these responses to sound sources or other stimuli have been studied extensively in
terrestrial animals but are much more difficult to determine in marine mammals. Increases in
heart rate are a common reaction to acoustic disturbance in marine mammals (Miksis et al.,
2001) as are small increases in the hormones norepinephrine, epinephrine, and dopamine
(Romano et al., 2002; 2004). Increases in cortical steroids are more difficult to determine
because blood collection procedures will also cause stress (Romano et al., 2002; 2004). A
recent study, Chase Encirclement Stress Studies (CHESS), was conducted by NMFS on
chronic stress effects in small odontocetes affected by the Eastern Tropical Pacific tuna fishery
(Forney et al., 2002). Analysis was conducted on blood constituents, immune function,
reproductive parameters, heart rate, and body temperature of small odontocetes that had been
pursued and encircled by tuna fishing boats. Some effects were noted, including lower
pregnancy rates, increases in norepinephrine, dopamine, ACTH and cortisol levels, heart
lesions and an increase in fin and surface temperature when chased for over 75 minutes but
with no change in core body temperature (Forney et al., 2002). These stress effects in small
cetaceans that were actively pursued (sometimes for over 75 minutes) were relatively small and
difficult to discern. It is unlikely that marine mammals exposed to mid-frequency active sonar
would be exposed as long as the cetaceans in the CHESS study and would not be pursued by
the Navy ships; therefore, stress effects would be minimal from the short-term exposure to
sonar.

Acoustically Mediated Bubble Growth and Decompression Sickness

One suggested cause of injury to marine mammals is by rectified diffusion (Crum and Mao,
1996), which is the process of increasing the size of a bubble by exposing it to a sound field.
This process is facilitated if the environment in which the ensonified bubbles exist is
saturated with a gas, such as nitrogen, which makes up approximately 78 percent of air
(remainder of air is about 21 percent oxygen with some carbon dioxide). Repetitive diving by
marine mammals can cause the blood and some tissues to accumulate gas to a greater degree
than is supported by the surrounding environmental pressure (Ridgway and Howard, 1979).
Deeper and longer dives of some marine mammals (for example, beaked whales) are
theoretically predicted to induce greater supersaturation (Houser et al., 2001). Conversely,
studies have shown that marine mammal lung structure (both pinnipeds and cetaceans) facilitates collapse of the lungs at depths deeper than approximately 27 fathoms (Kooyman, et al., 1970). Collapse of the lungs would force air into the non-air exchanging areas of the lungs (into the bronchioles away from the alveoli), thus significantly decreasing nitrogen diffusion into the body. Deep diving pinnipeds such as the northern elephant seal (*Mirounga angustirostris*) and Weddell seal (*Leptonychotes weddellii*) typically exhale before long deep dives, further reducing air volume in the lungs (Kooyman, et al., 1970). If rectified diffusion were possible in marine mammals exposed to high-level sound, conditions of tissue supersaturation could theoretically speed the rate and increase the size of bubble growth. Subsequent effects due to tissue trauma and emboli would presumably mirror those observed in humans suffering from decompression sickness.

It is unlikely that the short duration of sonar pings would be long enough to drive bubble growth to any substantial size, if such a phenomenon occurs. However, an alternative but related hypothesis has also been suggested: stable bubbles could be destabilized by high-level sound exposures such that bubble growth then occurs through static diffusion of gas out of the tissues. In such a scenario the marine mammal would need to be in a gas-supersaturated state for a long enough period of time and exposed to a continuous sound source for bubbles to become of a problematic size.

Another hypothesis suggests that rapid ascent to the surface following exposure to a startling sound might produce tissue gas saturation sufficient for the evolution of nitrogen bubbles (Jepson et al., 2003). In this scenario, the rate of ascent would need to be sufficiently rapid to compromise behavioral or physiological protections against nitrogen bubble formation. Cox et al. (2006), with experts in the field of marine mammal behavior, diving, physiology, respiration physiology, pathology, anatomy, and bio-acoustics considered this to be a plausible hypothesis but requires further investigation. Conversely, Fahlman et al. (2006) suggested that diving bradycardia (reduction in heart rate and circulation to the tissues), lung collapse, and slow ascent rates would reduce nitrogen uptake and thus reduce the risk of decompression sickness by 50 percent in models of marine mammals. Recent information on the diving profiles of Cuvier’s (*Ziphius cavirostris*) and Blaineville’s (*Mesoplodon densirostris*) beaked whales in Hawaii (Baird et al., 2006) and in the Ligurian Sea in Italy (Tyack et al., 2006) showed that while these species do dive deeply (regularly exceed depths of 437 fathoms) and for long periods (48 to 68 minutes), they have significantly slower ascent rates than descent rates. This fits well with the Fahlman et al. (2006) model of deep and long duration divers that would have slower ascent rates to reduce nitrogen saturation and reduce the risk of decompression sickness. Therefore, if nitrogen saturation remains low, then a rapid ascent in response to sonar should not cause decompression sickness. Currently it is not known if beaked whales do rapidly ascend in response to sonar or other disturbances. It may be that deep diving animals would be better protected diving to depth to avoid predators, such as killer whales, rather than ascending to the surface where they may be more susceptible to predators.

Although theoretical predictions suggest the possibility for acoustically mediated bubble growth, there is considerable disagreement among scientists as to its likelihood (Piantadosi and Thalmann, 2004; Evans and Miller, 2003). To date, ELs predicted to cause in vivo bubble formation within diving cetaceans have not been evaluated (National Oceanic and Atmospheric Administration, 2002b). Further, although it has been argued that traumas from recent beaked whale strandings are consistent with gas emboli and bubble-induced tissue separations (Jepson et al., 2003), there is no conclusive evidence of this and complicating factors associated with
introduction of gas into the venous system during necropsy. Because evidence supporting it is
debatable, no marine mammals addressed in this EIS/OEIS are given special treatment due to
the possibility for acoustically mediated bubble growth. Beaked whales are assessed differently
from other species to account for factors that may have contributed to prior beaked whale
strandings as set out in Section 4.1.2.4.9.10.

Resonance

Another suggested cause of injury in marine mammals is air cavity resonance due to sonar
exposure. Resonance is a phenomenon that exists when an object is vibrated at a frequency
near its natural frequency of vibration—the particular frequency at which the object vibrates
most readily. The size and geometry of an air cavity determine the frequency at which the
cavity will resonate. Displacement of the cavity boundaries during resonance has been
suggested as a cause of injury. Large displacements have the potential to tear tissues that
surround the air space (for example, lung tissue).

Understanding resonant frequencies and the susceptibility of marine mammal air cavities to
resonance is important in determining whether certain sonars have the potential to affect
different cavities in different species. In 2002, NMFS convened a panel of government and
private scientists to address this issue (National Oceanic and Atmospheric Administration,
2002b). They modeled and evaluated the likelihood that Navy mid-frequency active sonar
caused resonance effects in beaked whales that eventually led to their stranding (U.S.
Department of Commerce and U.S. Department of the Navy, 2001). The frequencies at which
resonance was predicted to occur were below the frequencies utilized by the sonar systems
employed. Furthermore, air cavity vibrations due to the resonance effect were not considered to
be of sufficient amplitude to cause tissue damage. This EIS/OEIS assumes that similar
phenomenon would not be problematic in other cetacean species.

Likelihood of Masking

Natural and artificial sounds can disrupt behavior by masking, or interfering with an animal’s
ability to hear other sounds. Masking occurs when the receipt of a sound is interfered with by a
second sound at similar frequencies and at similar or higher levels. If the second sound were
artificial, it could be potentially harassing if it disrupted hearing-related behavior such as
communications or echolocation. It is important to distinguish TTS and PTS, which persist after
the sound exposure, from masking, which occurs during the sound exposure.

Historically, principal masking concerns have been with prevailing background sound levels
from natural and manmade sources (for example, Richardson et al., 1995). Dominant examples
of the latter are the accumulated sound from merchant ships and sound of seismic surveys.
Both cover a wide frequency band and are long in duration.

HRC ASW operations occur in areas that are away from harbors but may include heavily
traveled shipping lanes, although that is a small portion of the overall range complex. The
loudest underwater sounds in the proposed operations area are those produced by sonars and
other acoustic sources that are in the mid-frequency or higher range. The sonar signals are
likely within the audible range of most cetaceans, but are very limited in the temporal, frequency,
and spatial domains. In particular, the pulse lengths are short, the duty cycle low (number of
pings per minute are low), the total number of hours of operation per year small, and the tactical
sonars transmit within a narrow band of frequencies (typically less than one-third octave).
Finally, high levels of sound are confined to a volume around the source and are constrained by propagation attenuation rates at mid- and high frequencies, and relative short pulse lengths.

For the reasons outlined above, the chance of sonar operations causing masking effects is considered negligible.

4.1.2.4.8 Previous Criteria and Thresholds for Behavioral Effects

This section presents the effect criterion and threshold for behavioral effects of sound leading to behavioral disturbance without accompanying physiological effects. Since TTS is used as the biological indicator for a physiological effect leading to behavioral disturbance, the behavioral effects discussed in this section may be thought of as behavioral disturbance occurring at exposure levels below those causing TTS.

A large body of research on terrestrial animal and human response to airborne sound exists, but results from those studies are not readily extendible to the development of effect criteria and thresholds for marine mammals. For example, “annoyance” is one of several criteria used to define impact to humans from exposure to industrial sound sources. Comparable criteria cannot be developed for marine mammals because there is no acceptable method for determining whether a non-verbal animal is annoyed. Further, differences in hearing thresholds, dynamic range of the ear, and the typical exposure patterns of interest (e.g., human data tend to focus on 8-hour-long exposures) make extrapolation of human sound exposure standards inappropriate.

Behavioral observations of marine mammals exposed to anthropogenic sound sources exist (Review by Richardson et al., 1995); however, there are few observations and no controlled measurements of behavioral disruption of cetaceans caused by sound sources with frequencies, waveforms, durations, and repetition rates comparable to those employed by the tactical sonars to be used in the HRC. At the present time there is no consensus on how to account for behavioral effects on marine mammals exposed to continuous-type sounds (National Research Council, 2003).

This application uses behavioral observations of trained cetaceans exposed to intense underwater sound under controlled circumstances to develop a criterion and threshold for behavioral effects of sound. These data are described in detail in Schlundt et al. (2000) and Finneran and Schlundt (2004). These data, because they are based on controlled, tonal sound exposures within the tactical sonar frequency range, are the most applicable.

History of Assessing Potential Harassment from Behavioral Effects

The science of understanding the effects of sound on marine mammals is dynamic, and the Navy is committed to the use of the best available science for evaluating potential effects from training and testing activities. Prior Navy Letter of Authorization (LOA) and Incidental Harassment Authorization (IHA) requests for USWTR and RIMPAC mid-frequency active sonar training relied on behavioral observations of trained cetaceans exposed to intense underwater sound under controlled circumstances to develop a criterion and threshold for behavioral effects of sound based on energy flux density. These data are described in detail in Schlundt et al. (2000) and Finneran and Schlundt (2004). These data represented the best available data at the time those activities were proposed because they are based on controlled, tonal sound
exposures within the tactical sonar frequency range and because the species studied are
closely related to the majority of animals expected to be located within the Proposed Action
area. The USWTR Draft OEIS/EIS provided analysis to the 190 dB re 1 μPa²-s, which the Navy
believed to most accurately reflect scientifically-derived behavioral reactions from sound
sources that are most similar to mid-frequency sonars. A full discussion of the scientific data
and use of those data to derive the 190 dB re 1 μPa²-s threshold is presented in the original
USWTR Draft OEIS/EIS.

As described above, behavioral observations of trained cetaceans exposed to intense
underwater sound under controlled circumstances are an important data set in evaluating and
developing a criterion and threshold for behavioral effects of sound. These behavioral response
data are an important foundation for the scientific basis of the Navy’s prior threshold of onset
behavioral effects because of the (1) finer control over acoustic conditions; (2) greater quality
and confidence in recorded sound exposures; and (3) the exposure stimuli closely match those
of interest for the mid-frequency active sonar used as proposed in the HRC. Since no
comparable controlled exposure data for wild animals exist, or are likely to be obtained in the
near-term, the relationship between the behavioral results reported by Finneran and Schlundt
(2004) and wild animals is not known. Although experienced, trained subjects may tolerate
higher sound levels than inexperienced animals, it is also possible that prior experiences and
resultant expectations may have made some trained subjects less tolerant of sound exposures.

In response to USWTR comments, potential differences between trained subjects and wild
animals were considered by the Navy in conjunction with NMFS in the Navy’s application for
harassment authorization for RIMPAC 2006. At that time, NMFS recommended that the Navy
include analysis of this threshold based on NMFS’ evaluation of behavioral observations of
marine mammals under controlled conditions, plus NMFS’ interpretation of two additional
studies on reactions to vessel sound (Nowacek et al., 2004) and analysis of the Shoup sonar
event (National Marine Fisheries Service, 2005). For that exercise, a conservative threshold for
effect was derived compared to the regulatory definition of harassment, and Navy agreed to the
use of the 173 dB re 1 μPa²-s threshold for the RIMPAC IHA request.

Rationale for using energy flux density for evaluation of behavioral effects included:

- **EL effect exposures account for both the exposure SPL and duration into
  account.** Both SPL and duration of exposure affect behavioral responses to sound,
  so a behavioral effect threshold based on EL accounts for exposure duration.

- **EL takes into account the effects of multiple pings.** Effect thresholds based on SPL
  predict the same effect regardless of the number of received sounds. Previous actions
  using SPL-based criteria included implicit methods to account for multiple pings, such
  as the single-ping equivalent used in Surveillance Towed Array Sensor System Low-
  Frequency Active (SURTASS-LFA) (U.S. Department of the Navy, 2001b).

- **EL allows a rational ordering of behavioral effects with physiological effects.**
  The effect thresholds for physiological effects are stated in terms of EL because
  experimental data described above showed that the observed effects (TTS and PTS)
  are correlated best with the sound energy, not the SPL. Using EL for behavioral
  effects allows the behavioral and physiological effects to be placed on a single
  exposure scale, with behavioral effects occurring at lower exposures than
  physiological effects.
Subsequent to issuance of the RIMPAC IHA, additional public comments were received and considered. Based on this input, Navy continued to coordinate with NMFS to determine whether an alternate approach to energy flux density could be used to evaluate when a marine mammal may behaviorally be affected by mid-frequency sonar sound exposure. Coordination between the Navy and NMFS produced the adoption of dose function for evaluation of behavioral effects. The acoustic dose-function approach for evaluating behavioral effects is described in the following section and fully considers the controlled, tonal sound exposure data in addition to comments received from the regulatory, scientific and public regarding concerns with the use of EL for evaluating the effects of sound on wild animals.

4.1.2.4.9 Estimating the Probable Behavioral Responses of Marine Mammals to Active Sonar

To assess the potential effects on marine mammals of active sonar that is used during training activities, the U.S. Navy began with a series of mathematical models that estimate the number of times individuals of the different species of marine mammal might be exposed to mid-frequency active (MFA) sonar at different received levels. These exposure analyses assumed that the potential consequences of exposure to MFA sonar on individual animals would be a function of the intensity (measured in both sound pressure level in decibels and frequency), duration, and frequency of the animal’s exposure to the mid-frequency transmissions. These exposure analyses assume that MFA sonar poses no risk to marine mammals if they are not exposed to sound pressure levels from the mid-frequency active sonar above some critical value. Though, active sonar could have various indirect, adverse effects on marine mammals by disrupting marine food chains, a species’ predators, or a species’ competitors; however, the Navy and NMFS did not identify situations where this concern might apply to marine mammals under the National Marine Fisheries Service’s jurisdiction.

The second step of the assessment procedure requires the U.S. Navy and NMFS to identify how marine mammals are likely to respond when and if they are exposed to active sonar. Marine mammals can experience a variety of responses to sound including death, sensory impairment (permanent and temporary threshold shifts and acoustic masking), physiological responses (particular stress responses), behavioral responses, and social responses that might result in reducing the fitness of individual marine mammals.

Several “mass stranding” events – strandings that involve two or more individuals of the same species (excluding a single cow-calf pair) - that have occurred over the past two decades have been associated with naval operations, seismic surveys, and other anthropogenic activities that introduce sound into the marine environment. Although many of these mass stranding events have been correlated with sonar exposures, sonar exposure has been identified as a contributing cause of five specific mass stranding events: Greece in 1996; the Bahamas in March 2000; Madeira, Spain in 2000; and the Canary Islands in 2002 and 2004 (Advisory Committee Report 2006).

In these circumstances, exposure to acoustic energy has been considered an indirect cause of the death of marine mammals (Cox et al. 2006). Based on studies of lesions in beaked whales that have stranded in the Canary Islands and Bahamas associated with exposure to naval exercises that involved sonar, investigators have identified two physiological mechanisms that might explain why marine mammals stranded: tissue damage resulting from resonance effects (Ketten 2005) and tissue damage resulting from “gas and fat embolic syndrome” (Fernandez et al. 2005, Jepson et al. 2003, 2005).
Acoustic exposures can also result in noise induced hearing loss that is a function of the interactions of several factors, including individual hearing sensitivity and exposure amplitude, exposure duration, frequency, and other variables that have not been studied very well (e.g., kurtosis, temporal pattern, directionality). Loss of hearing sensitivity is referred to as a “threshold shift”; the extent and duration of threshold shifts depend on a combination of several acoustic features and is specific to particular species. A shift in hearing sensitivity may be temporary (temporary threshold shift or TTS) or it may be permanent (permanent threshold shift or PTS) depending on how the frequency, amplitude and duration of the exposure combine to produce damage and if that change is reversible.

Based on the evidence available, marine animals are likely to exhibit any of a suite of behavioral responses or combinations of behavioral responses upon exposure to sonar transmissions: they will try to avoid exposure or continue exposure, they will experience behavioral disturbance (including distress or disruption of social or foraging activity), they will habituate to the sound, they will become sensitized to the sound, or they will not respond. In experimental trials with trained marine mammals, behavioral changes typically involved what appeared to be deliberate attempts to avoid a sound exposure or to avoid the location of the exposure site during subsequent tests (Schlundt et al. 2000, Finneran et al. 2002). Dolphins exposed to 1-second intense tones exhibited short-term changes in behavior above received sound levels of 178 to 193 dB re 1 μPa rms and belugas did so at received levels of 180 to 196 dB and above. Test animals sometimes vocalized after exposure to impulsive sound from a seismic watergun (Finneran et al. 2002). In some instances, animals exhibited aggressive behavior toward the test apparatus (Ridgway et al. 1997, Schlundt et al. 2000).

Existing studies of behavioral effects of man-made sounds in marine environments remain inconclusive, partly because many of those studies have lacked adequate controls, apply only to certain kinds of exposures (which are often different from the exposures being analyzed), and have had limited ability to detect behavioral changes that may be significant to the biology of the animals that were being observed. These studies are further complicated by the wide variety of behavioral responses marine mammals exhibit and the fact that those responses can vary significantly by species, individuals, and the context of an exposure. In some circumstances, some individuals will continue normal behavioral activities in the presence of high levels of man-made noise; in other circumstances, the same individual or other individuals may avoid an acoustic source at much lower received levels (Richardson et al. 1995, Wartzok et al. 2004). These differences within and between individuals appear to result from a complex interaction of experience, motivation, and learning that are difficult to quantify and predict.

In the past, the Navy and NMFS have only used “acoustic thresholds” to identify the number of marine mammals that might experience hearing losses or behavioral harassment upon being exposed to active sonar (see Figure 4.1.2.4.9-1 right panel). These acoustic “thresholds” have been represented by either sound exposure level (related to sound energy, abbreviated as SEL), sound pressure level (abbreviated as SPL), or other metrics such as peak pressure level and acoustic impulse (not considered for sonar in this document). The general approach has been to apply these threshold functions such that a marine mammal is counted as behaviorally harassed or experiencing hearing loss (depending on which threshold) by received sound levels above the threshold and not counted as behaviorally harassed or experiencing hearing loss otherwise. For example, previous Navy EISs, environmental assessments, and permit applications, and NMFS MMPA permits used 195 dB re 1 μPa² as the energy threshold level for temporary hearing degradation for cetaceans. If the transmitted sonar energy received by a
whale was above 195 dB re 1 μPa\(^2\)s, then the animal was considered to have experienced a temporary loss in the sensitivity of its hearing. If the received energy level was below 195 dB re 1 μPa\(^2\)s, then the animal was not treated as having experienced a temporary loss in the sensitivity of its hearing.

The right panel in Figure 4.1.2.4.9-1 illustrates a typical step-function or threshold that might also relate a sonar exposure to the probability of a response. As this figure illustrates, acoustic thresholds the Navy and NMFS used in the past assumed that every marine mammal above a particular received level (for example, to the right of the red vertical line in the figure) would exhibit identical responses to a sonar exposure. This assumed that the responses of marine mammals would not be affected by differences in acoustic conditions, differences between species and populations, differences in gender, age, reproductive status, social behavior, or the prior experience of the individuals.

Both the Navy and NMFS are aware that the studies of marine mammals in the wild and in experimental settings do not support these assumptions — different species of marine mammals and different individuals of the same species respond differently to sonar exposure. Further, there are geographic differences in the response of marine mammals to sonar that suggest that different populations may respond differently to sonar exposure, and studies of animal physiology suggest that gender, age, reproductive status, and social behavior, among other variables, probably affects how marine mammals respond to sonar exposures. However, neither agency had the data necessary to implement alternatives to discrete acoustic thresholds.

Over the past several years, the U.S. Navy and the NMFS have worked on developing acoustic “dose-functions” to replace the acoustic thresholds used in the past to estimate the probability of marine mammals being behaviorally harassed by received levels of mid-frequency active sonar (the Navy and NMFS will continue to use acoustic thresholds to estimate the probability of temporary or permanent threshold shifts and for behavioral responses to explosives using SEL as the appropriate metric). Unlike acoustic thresholds, acoustic dose-functions (which are also called “exposure-response functions,” “dose-response functions,” or “stress-response functions” in other risk assessment contexts) assume that the probability of a response depends first on the “dose” (in this case, the received level of sound) and that the probability of a response increases as the “dose” increases. It is important to note that the probabilities associated with acoustic dose functions do not represent an individual’s probability of responding, they identify the proportion of an exposed population that is likely to respond to an exposure.
The left panel in Figure 4.1.2.4.9-1 illustrates a typical acoustic dose-function that might relate an exposure, as sound pressure level in decibels referenced to 1 microPascal (1 μPa), to the probability of a response. As the exposure or “dose” increases in this figure, the probability of a response increases as well but the relationship between an exposure and a response is “linear” only in the center of the curve (that is, unit increases in exposure would produce unit increases in the probability of a response only in the center of a dose-function curve). In the “tails” of an acoustic dose-function curve, unit increases in exposure produce smaller increases in the probability of a response. Using the illustration as an example, increasing an exposure from 190 dB to 200 dB would have greater effect on the probability of a response than increasing an exposure from 160 dB to 170 dB or from 210 dB to 220 dB (the upper and lower “tails” of the dose-function, respectively). Based on observations of various animals, including humans, the relationship represented by an acoustic dose-function is a more robust predictor of the probable behavioral responses of marine mammals to sonar and other acoustic sources.

The particular acoustic dose-functions the Navy and NMFS developed for this EIS estimate the probability of behavioral responses that NMFS would classify as harassment for the purposes of the Marine Mammal Protection Act given exposure to specific received levels of mid-frequency active sonar. In the example illustrated in Figure 4.1.2.4.9-2, about 50% of the marine mammals exposed to mid-frequency active sonar at a received level of 180 dB would be expected to exhibit behavioral responses that NMFS would classify as harassment for the purposes of the MMPA.

Because the Navy and NMFS will use acoustic dose-functions to estimate the proportion of marine mammals that would be expected to exhibit behavioral responses that would be classified as “harassment” for the purposes of the MMPA, the Navy and NMFS now use two methods to estimate the number of marine mammals that might be “taken,” as that term is defined by the MMPA, during training exercises. The agencies will use acoustic dose-functions to estimate the number of marine mammals that might be “taken” by behavioral harassment as a result of being exposed to mid-frequency active sonar. The agencies will continue to use...
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acoustic thresholds ("step-functions") to estimate the number of marine mammals that might be "taken" through sensory impairment as a result of being exposed to mid-frequency active sonar and to estimate the number of marine mammals that might be "taken" during exercises that use explosives (for example, sinking exercises). Using both of these methods to predict the number of marine mammals that might be "taken" by mid-frequency active sonar during training exercises will over-estimate the number of marine mammals by between approximately 5 and 10 percent.

Although the Navy has not used acoustic dose-functions in previous assessments of the potential effects of mid-frequency active sonar on marine mammals, dose-functions are not new concepts for risk assessments. They are common elements of the process of developing criteria for air, water, radiation, and ambient noise and for assessing the effects of sources of air, water, and noise pollution. The Environmental Protection Agency uses dose-functions to develop water quality criteria and to regulate pesticide applications (EPA 1998); the Nuclear Regulatory Commission uses dose-functions to estimate the consequences of radiation exposures (see NRC 1997 and 10 CFR 20.1201); the Centers for Disease Control and Prevention and the Food and Drug Administration use dose-functions as part of their assessment methods (for example, see Centers for Disease Control and Prevention, 2003, FDA and others 2001); and the Occupational Safety and Health Administration uses dose-functions to assess the potential effects of noise and chemicals in occupational environments on the health of people working in those environments (for examples, see Federal Register 61:56746-56856, 1996; Federal Register 71:10099-10385, 2006).

Figure 4.1.2.4.9-2 Illustration of a dose-function developed to estimate a marine mammal's probability of being "harassed" which we define as its probability of exhibiting a behavioral response that NMFS would classify as "harassment" for the purposes of the Marine Mammal Protection Act (see text). SPL is "Sound Pressure Level" in decibels referenced to 1 microPascal (1 μPa rms)
The U.S. Navy and NMFS have also used variants of acoustic dose-functions to estimate the probable responses of marine mammals to acoustic exposures for other training and research programs and were used in Navy EISs on the Surveillance Towed Array Sonar System – Low Frequency Active (SURTASS-LFA; DON, 2001); and the North Pacific Acoustic Laboratory experiments conducted off the Island of Kaua‘i (ONR, 2001).

4.1.2.4.9.1 The Data Used to Develop Acoustic Dose-Functions

The acoustic dose-functions can be generated using data from experiments conducted in the field and controlled settings or data extracted from observations not associated with an experiment (that is, opportunistic observations). To qualify as a sample that would be appropriate for use in an acoustic dose-function, an observation would have to satisfy the following minimal set of information: (a) the species of marine mammals observed, (b) the number of individuals of a species observed; (c) a measurement or estimate of the sound field (in terms of frequency and received level) to which the individuals were exposed; (d) the circumstances and context of the exposure, which includes the date, location, site, time of day, duration, oceanographic and bathymetric conditions under which the exposure occurred; and (e) a report (or other record) of the behavioral response of individual animals given an exposure; this might include a variety of responses when individuals are observed as members of a group.

Over time, as the amount of data available to generate acoustic dose-functions increases, the Navy and NMFS expect to develop a suite of dose-functions that reflect differences in species, populations, sound sources, how a sound source is operated, and bathymetric conditions among other variables. If and when that kind of data becomes available, acoustic dose-functions will be generated from data that represent equivalent sound sources (for sonar systems, this would include equivalent operations), equivalent environmental conditions, and equivalent species or populations. Because the data that is currently available is limited, the data used to generate the current set of acoustic dose-functions had to originate from sound sources in frequency ranges that were equivalent to those of the mid-frequency active sonar that would be used in during the training exercises proposed in this document.

The data that were used to generate acoustic dose-functions for the training exercises proposed in this document originated with two sources: a series of experiments conducted by researchers at the Space and Naval Warfare Systems Center San Diego in California (SSC San Diego), the University of California Santa Cruz (for example, Kastak et al., 1999; Schlundt et al., 2000; Finneran et al., 2000a; Finneran et al., 2002) and opportunistic observations collected while a Navy vessel was operating mid-frequency active sonar in Haro Strait, in the Pacific Northwest.

The series of experiments that provided the primary source of the data used to generate acoustic dose-functions for mid-frequency active sonar resulted from observations of the behavioral responses of trained marine mammals during investigations into the effects of acoustic exposures on the hearing sensitivity of trained marine mammals. These behavioral responses included attempts to avoid sites of previous noise exposures (e.g., Schlundt et al., 2000), attempts to avoid an exposure in progress (e.g., Kastak et al., 1999); aggressive behavior or refusal to further participate in tests (Schlundt et al., 2000).

Schlundt et al. (2000; see also Finneran et al. 2001, 2003, 2005) provided a detailed summary of the behavioral responses of trained marine mammals during TTS tests conducted at SSC San Diego with 1-second tones. Schlundt et al. (2000) reported eight individual TTS experiments.
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Fatiguing stimuli durations were 1 second; exposure frequencies were 0.4, 3, 10, 20, and 75 kHz. The experiments were conducted in San Diego Bay. Because of the variable ambient noise in the bay, low-level broadband masking noise was used to keep hearing thresholds consistent despite fluctuations in the ambient noise. Schlundt et al. (2000) reported that “behavioral alterations,” or deviations from the behaviors the animals being tested had been trained to exhibit, occurred as the animals were exposed to increasing fatiguing stimulus levels.

Finneran et al. (2001, 2003, 2005) conducted TTS experiments using tones at 3 kHz. The test method was similar to that of Schlundt et al. except the tests were conducted in a pool with a very low ambient noise level (below 50 dB re 1 µPa^2/Hz), and no masking noise was used. Two separate experiments were conducted using 1-second tones. In the first, fatiguing sound levels were increased from 160 to 201 dB SPL. In the second experiment, fatiguing sound levels between 180 and 200 dB re 1 µPa were randomly presented.

Finneran and Schlundt (2004) examined behavioral observations recorded by the trainers or test coordinators during the Schlundt et al. (2000) and Finneran et al. (2001, 2003, 2005) experiments featuring 1-second tones. These included observations from 193 exposure sessions (fatiguing stimulus level > 141 dB re 1 µPa) conducted by Schlundt et al. (2000) and 21 exposure sessions conducted by Finneran et al. (2001, 2003, 2005). The observations were made during exposures to sound sources at 0.4 kHz, 3 KHz, 10 kHz, 20 kHz, and 75 kHz. The acoustic dose-functions for mid-frequency active sonar were generated using data collected during experimental trials that exposed marine mammals to sound sources in the 3 - 10 kHz range.

4.1.2.4.9.2 USS SHOUP Analyses

In May 2003, killer whales (Orcinus orca) were observed exhibiting behavioral responses while the U.S.S. SHOUP was engaged in sonar operations in the Haro Strait in the vicinity of Puget Sound, Washington. Those observations have been documented in three reports developed by Navy and NMFS (Fromm, 2004a, 2004b; DON 2003). Although these observations were made in an uncontrolled environment, the sound field that may have been associated with the sonar operations had to be estimated, and the behavioral observations were reported for groups of whales, not individual whales, the observations associated with the U.S.S. SHOUP provide the only data set available of the behavioral responses of wild, non-captive animal upon exposure to SQS-53 sonar.

The U.S.S. SHOUP sonar data observations and analyses are complex, and some of the relevant information (especially the SQS 53 sonar source level versus transmit angle) is classified. Nevertheless, analyses of the U.S.S. SHOUP observations were made public in 2004 (Fromm 2004) and the observations qualify as a sample that can be used to generate acoustic dose-functions.

4.1.2.4.9.3 The Method Used to Calculate Acoustic Dose-Functions

To generate the acoustic dose-functions used to estimate behavioral exposures in this document, (see Tables 4.1.2.4.9.3-1 and 4.1.2.4.9.3-2), the Navy used “probit” analyses, which fit a normal distribution function to the transformed empirical data in Finneran et al. (2004)). To produce acoustic dose-functions for odontocetes, the Navy’s probit analyses fit normal
distribution function parameters to the 25, 50, and 75 percentiles of the data produced by SSC San Diego with an additional data point from the U.S. S.S. SHOUP incident. The acoustic dose-functions for mid-frequency active sonar presented in this document only used observations associated with sound sources in the 3 kHz range (which would be comparable to the range of the mid-frequency active sonar the U.S. Navy uses in its exercises).

Table 4.1.2.4.9.3-1. Sound Pressure Level Acoustic Dose-Functions for Behavioral Disturbance from Sonars and Projectors

<table>
<thead>
<tr>
<th>Animal</th>
<th>Center Frequency For Sonar or Projector</th>
<th>Dose-Function Mean (SPL)</th>
<th>Dose-Function Standard Deviation (SPL)</th>
<th>Cutoff (Sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small odontocetes (except beaked whales and harbor porpoises)</td>
<td>2 - 6 kHz</td>
<td>189 dB/μPa</td>
<td>12 dB/μPa</td>
<td>-3 (153 dB)</td>
</tr>
<tr>
<td>Beaked whales</td>
<td>2 – 6 kHz</td>
<td>189 dB/μPa</td>
<td>12 dB/μPa</td>
<td>-4 (141 dB)</td>
</tr>
<tr>
<td>Mysticetes</td>
<td>2 - 30 kHz</td>
<td>175 dB/μPa</td>
<td>10 dB/μPa</td>
<td>-3 (145 dB)</td>
</tr>
<tr>
<td>Pinnipeds</td>
<td>2 - 30 kHz</td>
<td>180 dB/μPa</td>
<td>10 dB/μPa</td>
<td>-3 (150 dB)</td>
</tr>
<tr>
<td>Small odontocetes (except beaked whales and harbor porpoises)</td>
<td>6 – 15 kHz</td>
<td>182 dB/μPa</td>
<td>10 dB/μPa</td>
<td>-3 (152 dB)</td>
</tr>
<tr>
<td>Beaked whales</td>
<td>6 – 15 kHz</td>
<td>182 dB/μPa</td>
<td>10 dB/μPa</td>
<td>-4 (142 dB)</td>
</tr>
</tbody>
</table>

Table 4.1.2.4.9.3-2. Sound Pressure Level Acoustic Dose-Functions for Behavioral Disturbance from non-MFA Sonars and Projectors

<table>
<thead>
<tr>
<th>Animal</th>
<th>Center Frequency For Sonar or Projector</th>
<th>Dose-Function Mean (SPL)</th>
<th>Dose-Function Standard Deviation (SPL)</th>
<th>Cutoff (Sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small odontocetes (except beaked whales and harbor porpoises)</td>
<td>15 – 30 kHz</td>
<td>189 dB/μPa</td>
<td>12 dB/μPa</td>
<td>-3 (153 dB)</td>
</tr>
<tr>
<td>Beaked whales</td>
<td>15 – 30 kHz</td>
<td>189 dB/μPa</td>
<td>12 dB/μPa</td>
<td>-4 (141 dB)</td>
</tr>
<tr>
<td>Small odontocetes (except beaked whales and harbor porpoises)</td>
<td>30 - 100 kHz</td>
<td>180 dB/μPa</td>
<td>12 dB/μPa</td>
<td>-3 (144 dB)</td>
</tr>
<tr>
<td>Beaked whales</td>
<td>30 - 100 kHz</td>
<td>180 dB/μPa</td>
<td>12 dB/μPa</td>
<td>-4 (136 dB)</td>
</tr>
<tr>
<td>Mysticetes</td>
<td>30 - 100 kHz</td>
<td>175 dB/μPa</td>
<td>10 dB/μPa</td>
<td>-3 (145 dB)</td>
</tr>
<tr>
<td>Pinnipeds</td>
<td>30 - 100 kHz</td>
<td>180 dB/μPa</td>
<td>10 dB/μPa</td>
<td>-3 (150 dB)</td>
</tr>
</tbody>
</table>

For cases other than the 2 - 6 kHz sonars and odontocetes, the same general approach was used as that for odontocetes exposed to MFA sound sources; namely, fit a normal distribution to the transformed data in Finneran et al. (2004) and modify the mean, standard deviation, and cutoff (low end) for each case. Parameters for odontocetes for non-MFA sonars and projectors are given in Table 4.1.2.4.9.3-2.
‘Cutoffs’ at – 3 and – 4 standard deviations were also based on rough estimates of range from a powerful sonar source (especially the SQS 53 shipboard sonar) at which an animal might be behaviorally harassed. For spherical spreading and a frequency range of 2 kHz to 6 kHz, the distance from the source for the cutoff threshold are of order 10 km for –3 standard deviations, and 30 km for –4 standard deviations. There are no controlled data to test these assumptions, but the approach accounts for behavioral responses out to 30 km for beaked whales. SPLs at the cutoff are shown in the tables, and range from 136 to 153 dB re 1 μPa. The acoustic dose-function thus accounts for very low level exposures that have the potential for behavioral harassment.

The values the Navy used to develop acoustic dose-functions for Mysticetes in this document relied on values used in previous assessments (such as the series of NEPA documents that Navy prepared for the Littoral Warfare and Defense program; Office of Naval Research, 1999a and 1999b) and supplemented with observations discussed in Richardson et al. 1995 (citing, inter alia, Malme et al., 1983 and 1984). TTS experiments on pinnipeds conducted by Kastak et al. (1996 – 1999) were included in the development of acoustic dose-functions for pinnipeds although, because the experiments were not designed as behavioral studies.

As explained above, the Navy’s original approach to developing acoustic dose function calculations was to fit normal distribution function parameters to the 25, 50, and 75 percentiles of the data produced by SSC San Diego (2004) with an additional data point from the U.S.S. SHOUP incident. Calculations generated using this original approach are reflected in tables 4.1.2.4.9.3-1 and 4.1.2.4.9.3-2. NMFS conducted a technical review of this approach and suggested an alternative, namely that the acoustic dose-function be calculated based on the direct empirical data from the SSC San Diego experiments and the U.S.S. SHOUP data described in the previous section of this document. While the Navy’s original approach to calculating acoustic dose function was used to estimate marine mammal exposures in this draft EIS, the Navy and NMFS are planning to utilize the NMFS approach to calculating acoustic dose-functions for the final EIS. Because the original Navy approach and the NMFS approach use the same data set, the two curves may be similar, but the methodology used to arrive at the curves will differ. The following section outlines NMFS’ recommended approach to calculating acoustic dose-functions.

4.1.2.4.9.3a NMFS Recommended Approach to Calculating Acoustic Dose-Functions

To prepare the behavioral observations produced by the experimental studies and from the U.S.S. SHOUP for analysis, the Navy and NMFS will code behavioral observations associated with a received level as “1” (for “yes, NMFS would classify this behavioral response as harassment”) or “0” (for “no, NMFS would not classify this behavioral response as harassment”). To develop acoustic dose-functions for mid-frequency active sonar, the Navy and NMFS will only use observations associated with sound sources in the 3 – 10 kHz range (which would be comparable to the range of the mid-frequency active sonar the U.S. Navy uses in its exercises).

Acoustic dose-functions will be developed from the resulting series of 1s and 0s using probit analysis (using the probit model) and logistic regression (using the logit model), which are designed to use binary data to estimate the probability of a response variable given a predictor variable (in this case, sound pressure level or SPL). Both of these statistical procedures produce s-shaped dose-functions, such as those illustrated in Figures 4.1.2.4.9-1 and 4.1.2.4.9-2, and both produce results that are similar to one another. Box 4.1.2.4.9.3-1 summarizes the
specific models used for both probit and logit analyses. Those interested in detailed technical explanations of probit and logit analyses should refer to texts such as Dobson (2002), Hoffman (2004), McCullagh and Nedler (1989), McCulloch and Searle (2001), and Nedler and Wedderburn (1972).

**Box 4.1.2.4.9.3-1. The probit and logit models**

Generalized linear models are generalizations of the classic linear regression model that assumes that a dependent variable is a linear function of a set of independent variables (and that the dependent variable is continuous). The classic linear regression model is limited because it only provides an accurate model when the data have a linear trend. Generalized linear models are a family of models developed for regressions when classic linear regression is not appropriate.

Generalized linear models rely on a linear relationship between the x's and a linear predictor, defined below as $\eta$:

$$\eta = \sum_{k=1}^{K} \beta_k X_k$$

Where $X$ is an independent variable, such as a behavioral response upon exposure to a received level of mid-frequency sonar, $\beta_k$ is the slope on the $X_k$ axis. Generalized linear models are designed to create linear relationships between a set of Xs and $\eta$ and then “linking” $\eta$ and $\mu$ (the dependent variable). Many functions can provide this “link,” but the underlying distribution of the data usually helps identify the most appropriate links. In this instance, the underlying data are binary (0 and 1), so the probit, or logit, models provide the most appropriate “link.”

The probit model is typically represented as

$$\eta = \Phi^{-1}(\mu)$$

where the symbol $\Phi$ (pronounced $\phi$) represents the standard normal distribution. In this model, the superscript -1 indicates the inverse of the standardized normal distribution, which provides the link between the Xs and $\eta$. Probit analysis transforms probabilities of an event into z-scores (number of standard deviations from the mean) of the cumulative standard normal distribution.

The logit model is typically represented as

$$\eta = \log\left(\frac{\mu}{1 - \mu}\right)$$

where the $\log_e$ represents the natural or Naperian logarithm. In application of this equation, the symbol $\mu$ represents the probability of a response that NMFS would classify as harassment for the purposes of the MMPA. The logit model estimates the probability of such a response by assuming the natural logarithm of the odds of “1” to the odds of “0” are linearly related to exposure level.

These analyses treat a “1” as equivalent to “there is a 100 percent probability that NMFS would classify this response as harassment for the purposes of the MMPA” and a “0” as equivalent to “there is a 0 percent probability that NMFS would classify this response as harassment for the purposes of the MMPA.” It is possible to envision a range of probabilities between these two extremes (for example, “there is a 10, 20, 30, 50, or 90 percent probability that an animal would
exhibit behavior responses that NMFS would classify as harassment for the purposes of the MMPA\(^*\)). The dose-functions the Navy and NMFS will develop convert these binary data into probabilities that form a continuous range between 100 percent and 0 percent.

As discussed in the introduction to this sub-section, the Navy and NMFS agreed to use sound pressure level (or SPL) rather than sound exposure level (or SEL) as the appropriate metric for behavioral disturbance (NOAA/NMFS 2007). This is a change from previous environmental analyses the Navy has conducted for training activities that use mid-frequency active sonar, which relied on SEL to assess the potential effects of mid-frequency sonar exposures on marine mammals. Sound exposure level may be a better metric for estimating the potential effects of sonar exposures on an animal’s hearing because it represents an accumulation of energy and the sensitivity of the mammalian ear degrades as energy accumulates. However, the behavioral responses of marine mammals to sonar exposures seem to reflect the amplitude of the sound animals receive more than the accumulation of energy. As a result, for most behavioral functions of hearing, SPL is a more appropriate measure of exposure.

Animals use hearing to detect signals in noise. They listen for echoes from their echolocation signals, for communication calls of conspecifics, for sounds of prey or predators. One of the ways in which anthropogenic sound can disrupt behavior is by impairing or “masking” an animal’s ability to detect an important signal. Another way that anthropogenic sound can disrupt behavior is by triggering reactions such as avoidance or causing the animal to break off from an activity such as feeding. For the purpose of producing acoustic dose-functions for behavioral harassment, using SPL rather than SEL makes more data available. Nearly all studies of behavioral effects of anthropogenic sound on marine mammals have reported SPL not SEL, and it would be difficult to estimate SEL based upon the information provided in these reports.

The U.S. Navy and NMFS are analyzing the behavioral observations made during the hearing sensitivity experiments and during the U.S.S. SHOUP incident in Haro Strait to determine whether NMFS would classify the behavioral responses as harassment for the purposes of the MMPA (responses coded as “1” or “0”). These data will be analyzed using the probit and logit procedures discussed in Box 4.1.2.4.9.3-1 to produce the acoustic dose functions and to estimate the probabilities of “harassment” given sonar exposures.

There are several important limitations to this procedure. First, the number of samples available for these analyses remains very small, which affects the level of confidence that can be assigned to acoustic dose-functions based on those samples. Second, the acoustic dose-functions are based on data from a small number of individuals representing three marine mammal species. The responses of those individuals may not be representative of the responses of populations of the same species and different populations may exhibit different responses to the same stimulus. Similarly, the responses of the three species for which data available may not be representative of the responses of other species, some of which may be more or less sensitive than bottlenose dolphins, beluga whales, or killer whales. Fourth, the limited data prevents these models from estimating effects on different behavioral activities such as feeding, reproduction, changes in diving behavior, etc. Finally, the data available do not allow us to assess the consequences of multiple or long-duration exposures.

It is important to note that the data the Navy and NMFS will use to produce the acoustic dose-functions for the FEIS are still being subjected to internal technical review and may be subjected to formal peer review. Those reviews may cause some of the specific data points to be removed from or added to the data set that has been used to produce the existing acoustic dose-function.
Any change in the dose-function is likely to change the number of marine mammals that have been estimated to be “taken” (in the form of harassment) for the purposes of the Marine Mammal Protection Act that are presented in this document. Based on reviews that have been conducted thus far, the acoustic dose-functions are not expected to change substantially, but even fractional changes in percentages would increase or decrease the number of marine mammals that are estimated to be “taken.” As a result, the “take” estimates for the different marine mammals presented might increase or decrease slightly between the draft EIS and the final EIS on this action.

4.1.2.4.9.4 Interpretation of Acoustic Dose-Function

The Navy developed acoustic dose-functions to estimate the probability of marine mammals being “harassed” (or of marine mammals exhibiting behavioral responses that NMFS would classify as harassment) given exposure to different received levels of mid and high frequency acoustic sources. There are, however, several important limitations to the analyses that affect how the dose-function for small odontocetes is interpreted. First, the number of samples available for these analyses was very small, which affects the level of confidence that can be assigned to dose-functions generated from those samples. Second, the dose-functions were generated from observations of a small number of individuals representing only three species of marine mammal; the responses of those individuals may not be representative of the responses of populations of the same species and different populations may exhibit different responses to the same stimulus. Similarly, the responses of the three species for which data are available may not be representative of the responses of other species, some of which may be more or less sensitive than bottlenose dolphins, beluga whales, or killer whales. Fourth, the data were not sufficient to estimate potential relationships between acoustic exposures and specific behavioral activities (such as feeding, reproduction, changes in diving behavior, etc.). Finally, the data available did not allow the Navy to assess the consequences of multiple or long-duration exposures. The data used for the analyses of other taxa may have additional limitations.

These limitations affect how the acoustic dose-functions are interpreted because probit regression models the Navy used to generate the dose-functions, like all generalized linear models, assume that the effects of independent variables other than received level have been controlled (Liao 1994). That is, probit models assume that variables that are not included in the models — such variables as bathymetry, acoustic waveguides, differences in individuals, populations, or species, or the prior experiences, reproductive state, hearing sensitivity, or age of the marine mammals, among many others — do not influence the behavioral responses of marine mammals that might be exposed to MFA sonar.

Application of Uncertainty Factors to the Dose-Functions

As discussed in the preceding paragraph, the model’s assumption that “all other things being equal” is not valid for the current set of acoustic dose-functions. Because that assumption is not valid and that invalid assumption has uncertain effect on the acoustic dose-functions, the Navy applied uncertainty factors to the dose-functions. These uncertainty factors modify the acoustic dose-functions to compensate for the biases inherent in the data that were used to generate the dose-functions (for additional background on uncertainty factors, see Dorne et al. 2005 and Krewski et al. 1984, Suter et al. 1993).
To comply with the requirements of the MMPA and ESA, NMFS may impose additional “uncertainty” factors on the Navy’s existing acoustic dose-functions to compensate for uncertainties about the probable responses of beaked whales, baleen whales, and pinnipeds to MFA sonar exposures.

**Beaked whales**

Acoustic dose-functions will be interpreted carefully for beaked whales — particularly Cuvier’s, Gervais’, and Blainville’s beaked whales, which have historically been involved in mass stranding events more than any other species of beaked whale — because these whales appear to be more sensitive to MFA sonar and may experience more serious consequences as a result of an exposure than other marine mammals. In training situations that include bathymetric circumstances that provide limited ability for beaked whales to avoid continued exposure, where the exercises occur proximate to a continental slope, where there is canyon-like bathymetry, where multiple sonar sources are operating in the area, and where there is a high probability of acoustic wave-guides (a significant surface duct), the Navy interpreted the results of acoustic dose-functions based on an assumption that they are likely to underestimate (a) the probability of behavioral responses that would be classified as harassment and (b) the severity of the behavioral responses of beaked whales to MFA sonar.

To account for these uncertainties, the Navy will adjust the estimates produced by the dose-functions for beaked whale in circumstances that might increase the probability of beaked whale stranding. These circumstances include: limited egress opportunities for the whales, proximity to the continental slope, presence of a significant surface duct, canyon-like bathymetry, and multiple sonar operations (of the SQS 53 and 56 types) in close proximity. One possible adjustment that the Navy and NMFS are considering for these special circumstances is assuming that 1% of the animals that are expected to be behaviorally harassed would be mortalities.

**Harbor Porpoises**

Data reviewed by Houser (2007) suggests that the threshold level at which both captive and wild animals responded to sound is very low (e.g., 120 dB SPL re 1 μPa), although the biological significance of the disturbances is uncertain. Nonetheless, the Navy’s estimates treated harbor porpoises as special cases based on these data.

**4.1.2.4.9.4a NMFS Interpretation of Acoustic Dose-Functions**

As discussed previously, the acoustic dose-functions make it possible to estimate the probability of marine mammals exhibiting behavioral responses that NMFS would classify as harassment given exposure to different received levels of mid-frequency active sonar. In practice, the Navy and NMFS will use these probabilities to estimate the proportion of marine mammals that would be expected to exhibit behavioral responses that would be classified as “harassment” for the purposes of the MMPA.

As more observations become available and more research is conducted, those data would be added to the dataset that is currently used to generate acoustic dose-functions and dose-functions would be re-estimated based on the entire dataset. Until then, acoustic dose-functions will be interpreted to compensate for the biases and uncertainties that are inherent in the data used to produce them.
Specifically, the Navy and NMFS will apply “uncertainty” factors to acoustic dose-functions to compensate for the fact that the data that was used to generate those dose-functions primarily reflect the behavioral responses of (a) bottlenose dolphins and, to a lesser degree, beluga whales and (b) those species were represented by captive animals that had been trained to participate in acoustic trials. It is uncertain whether and to what degree the behavioral responses would be representative of individuals of the same species that had not been trained to participate in acoustic trials, the same species in the wild, other small cetaceans in the wild, or other species of marine mammals (pinnipeds and baleen whales, in particular) that have different hearing sensitivities than small, toothed whales.

For example, acoustic dose-functions need to be interpreted carefully for beaked whales because they appear to be more sensitive to mid-frequency sonar and may experience more serious consequences as a result of an exposure than other marine mammals. In training situations that include bathymetric circumstances that provide limited ability for beaked whales to avoid continued exposure, where the exercises occur proximate to a continental slope, where there is canyon-like bathymetry, multiple sonar operations, and a high probability of acoustic wave-guides, the results of acoustic dose-functions need to be interpreted carefully. That is, they should be interpreted based on an assumption that they are likely to underestimate (a) the probability of behavioral responses that would be classified as harassment and (b) the severity of the behavioral responses of beaked whales to mid-frequency sonar.
The Navy and NMFS will address these differences by applying “uncertainty” factors to the set of acoustic dose-functions. These uncertainty factors will modify the acoustic dose-functions to compensate for the biases inherent in the data that were used to generate the dose-functions (for additional background on safety or uncertainty factors, see Dorne et al. 2005 and Krewski et al. 1984, Suter et al. 1993; see Figure 4.1.2.4.9.4-1 for an illustration of the effects of apply uncertainty factors to a dose-function). For beaked whales — particularly Cuvier’s, Gervais’, and Blainville’s beaked whales which have historically been involved in substantially larger numbers of mass stranding events than any other species of beaked whale — uncertainty factors would be designed to minimize the probability of assuming that beaked whales would not experience significant adverse consequences given exposure to mid-frequency sonar when such consequences are likely. For pinnipeds and baleen whales, uncertainty factors would adjust the acoustic dose-function for small, toothed cetaceans to reflect the lower sensitivity of pinnipeds and baleen whales to mid-frequency sound sources.
4.1.2.4.10 Application of Effect Thresholds to Other Species

Mysticetes

Information on auditory function in mysticetes is extremely lacking. Sensitivity to low-frequency sound by baleen whales has been inferred from observed vocalization frequencies, observed reactions to playback of sounds, and anatomical analyses of the auditory system. Baleen whales are estimated to hear from 15 Hz to 20 kHz, with good sensitivity from 20 Hz to 2 kHz (Ketten, 1998). Filter-bank models of the humpback whale’s ear have been developed from anatomical features of the humpback’s ear and optimization techniques (Houser et al., 2001). The results suggest that humpbacks are sensitive to frequencies between 40 Hz and 16 kHz, but best sensitivity is likely to occur between 100 Hz and 8 kHz. However, absolute sensitivity has not been modeled for any baleen whale species. Furthermore, there is no indication of what sorts of sound exposure produce threshold shifts in these animals.

The criteria and thresholds for PTS and TTS developed for odontocetes for this activity are also used for mysticetes. This generalization is based on the assumption that the empirical data at hand are representative of both groups until data collection on mysticete species shows otherwise. For the frequencies of interest for this action, there is no evidence that the total amount of energy required to induce onset-TTS and onset-PTS in mysticetes is different than that required for odontocetes.

Beaked Whales

Recent beaked whale strandings have prompted inquiry into the relationship between high-amplitude continuous-type sound and the cause of those strandings. For example, in the stranding in the Bahamas in 2000, the Navy mid-frequency sonar was identified as the only contributory cause that could have lead to the stranding. The Bahamas exercise entailed multiple ships using mid-frequency sonar during transit of a long constricted channel. The Navy participated in an extensive investigation of the stranding with the NMFS. The “Joint Interim Report, Bahamas Marine Mammal Stranding Event of 15-16 March 2000” concluded that the variables to be considered in managing future risk from tactical mid-range sonar were “sound propagation characteristics (in this case a surface duct), unusual underwater bathymetry, intensive use of multiple sonar units, a constricted channel with limited egress avenues, and the
4.0 Environmental Consequences, Open Ocean Area

The Navy analyzed the known range of operational, biological, and environmental factors involved in the Bahamas stranding and focused on the interplay of these factors to reduce risks to beaked whales from ASW training operations. Mitigation measures based on the Bahamas investigation are presented in Section 6.1.3. The confluence of these factors do not occur in the Hawaiian Islands. Beaked whales are present at PMRF and a there are a few individual beaked whales that appear to be resident in the area off of the island of Hawaii and the Alenuihaha Channel between the island of Hawaii and Maui where ASW sonar operations occur regularly (Baird et al. 2006; McSweeney et al. 2007). Although beaked whales are visually and acoustically detected in areas where sonar use routinely takes place, there has not been a stranding of beaked whales in the Hawaiian Islands associated with the 30-year use history of the present sonar systems.

This history would suggest that the simple exposure of beaked whales to sonar is not enough to cause beaked whales to strand. Brownell et al. (2004), have suggested that the high number of beaked whale strandings in Japan between 1980 and 2004 may be related to Navy sonar use in those waters given the presence of U.S. Naval Bases and exercises off Japan. The Center for Naval Analysis compiled the history of naval exercises taking place off Japan and found there to be no correlation in time for any of the stranding events presented in Brownell et al (2004). Like the situation in Hawaii, there are clearly beaked whales present in the waters off Japan (as evidenced by the strandings); however, there is no correlation in time to strandings and sonar use. Sonar did not cause the strandings identified by Brownell et al. (2004), and more importantly, this suggests sonar use in the presence of beaked whales over two decades has not resulted in strandings related to sonar use.

As suggested by the known presence of beaked whales in waters where sonar use has historically taken place, it is likely that beaked whales have been occasionally exposed to sonar during the 30-year history of sonar use in the Hawaiian Islands, and yet there is no indication of any adverse impact on beaked whales from exposure to sonar in Hawaiian waters. Therefore, the continued use of sonar in the HRC is not likely to result in effects to beaked whales.

Pinniped

The information on the hearing abilities of the Hawaiian monk seal is limited. The range of underwater hearing in monk seals is 12 to 70 kHz, with best hearing from 12 to 28 kHz and 60 to 70 kHz (Thomas et al., 1990). This audiogram was from only one animal, and the high upper frequency range, which is high for a phocid, may not be indicative of the species. There is no information on underwater sounds, and in-air sounds are low frequency sounds (below 1,000 Hz) such as “soft liquid bubble,” short duration guttural expiration, a roar and belching/coughing sound (Miller and Job, 1992). A pup produces a higher frequency call (1.4 kHz) that presumably is use to call its mother.

The audiogram of the Hawaiian monk seal suggests they hear above mid-frequency active sonar, although the in-air sounds they produce are below mid-frequency active sonar.
4.1.2.4.11 Cetacean Stranding Events

The Navy is very concerned about and thoroughly investigates each stranding (Norman, 2006) to better understand these interactions. Strandings can be a single animal, but several to hundreds may be involved. An event where animals are found out of their normal habitat is considered a stranding even though animals do not necessarily end up beaching (such as the July 2004 Hanalei Mass Stranding Event; see Southall et al, 2006). Several hypotheses have been given for the mass strandings, which include the impact of shallow beach slopes on odontocete sonar, disease or parasites, geomagnetic anomalies that affect navigation, following a food source in close to shore, avoiding predators, social interactions that cause other cetaceans to come to the aid of stranded animals, and from human actions. Generally inshore species do not strand in large numbers but generally just as a single animal. This may be due to their familiarity with the coastal area, whereas pelagic species that are unfamiliar with obstructions or sea bottom tend to strand more often in larger numbers (Woodings, 1995). The Navy has studied several stranding events in detail that may have occurred in association with Navy sonar activities. To better understand the causal factors in stranding events that may be associated with Navy sonar activities, the main factors, including bathymetry (i.e., steep drop offs), narrow channels (less than 35 nm), environmental conditions (e.g., surface ducting), and multiple sonar ships (see section on Stranding Events Associated with Navy Sonar) were compared between the different stranding events.

In a review of 70 reports of mass stranding events between 1960 and 2006, 48 (68 percent) involved beaked whales, 3 (4 percent) involved dolphins, and 14 (20 percent) involved whale species. Cuvier’s beaked whales were involved in the greatest number of these events (48 or 68 percent), followed by sperm whales (7 or 10 percent), and Blainville and Gervais’ beaked whales (4 each or 6 percent). Naval operations that might have involved tactical sonars are reported to have coincided with 9 (13 percent) or 10 (14 percent) of those stranding events. Between the mid-1980s and 2003 (the period reported by the IWC), we identified reports of 44 mass cetacean stranding events, of which at least 7 have been correlated with naval operations that were using mid-frequency sonar.

RIMPAC Exercises have occurred every second year since 1968, and ASW operations have occurred in each of the 19 exercises that have occurred thus far. If the mid-frequency sonar employed during those exercises killed or injured whales whenever the whales encountered the sonar, it seems likely that some mass strandings would have occurred at least once or twice over the 38-year period since 1968. With one exception, there is little evidence of a pattern in the record of strandings reported for the main Hawaiian Islands.

What is a Stranded Marine Mammal?

When a marine mammal swims or floats onto shore and becomes “beached” or stuck in shallow water, it is considered a “stranding” (MMPA Section 410,16 U.S.C. Section 1421g; National Marine Fisheries Service, 2007a). NMFS explains that “a cetacean is considered stranded when it is on the beach, dead or alive, or in need of medical attention while free-swimming in U.S. waters. A pinniped is considered to be stranded either when dead or when in distress on the beach and not displaying normal haul-out behavior (National Marine Fisheries Service, 2007b).”

There are three general categories that strandings can be grouped into: single, mass, and unusual mortality events. The most frequent type of stranding is a single stranding, which
involves one animal per event, or a mother/calf pair, and are most often the result of illness or injury (National Marine Fisheries Service, 2007f) or natural causes like old age.

Mass strandings involve two or more marine mammals of the same species coming ashore at the same time and place (other than a female and her calf), and can sometimes result in the death of a large number of animals. There are only a few species in North America that typically strand in groups of 15 or more: sperm whales, pilot whales, false killer whales, Atlantic white-sided dolphins, white-beaked dolphins, and rough-toothed dolphins. A few other species occasionally strand in smaller numbers: pygmy killer whales, common dolphins, Stenella spp. and Fraser’s dolphins (Geraci et al., 2005). Some species, such as pilot whales, false-killer whales, and melon-headed whales occasionally strand in groups of 50 to 150 or more (Geraci et al., 1999). All of these species are sociable and usually less accustomed to inshore waters than other coastal marine mammal species like the bottlenose dolphin or the harbor porpoise (Geraci et al., 2005). Sometimes these animals can be saved by releasing each member of the group out to sea all at the same time; however, studies have shown that stranded marine mammals that are returned to water have a tendency to re-strand themselves someplace else (National Marine Fisheries Service, 2007f; National Marine Fisheries Service, 2005b). In all cases of mass strandings, NOAA Fisheries (NMFS) coordinates stranding response and necropsy examination with partners around the country to try to determine the circumstance and cause for the stranding (National Marine Fisheries Service, 2006).

Unusual Mortality Events (UMEs) are strandings and/or mortalities that occur under unusual circumstances. These are usually unexpected, infrequent, and may involve a significant number of marine mammal mortalities. Unusual environmental conditions are probably responsible for most UMEs and marine mammal die-offs (Geraci et al., 1999). Because these events require an immediate response, special teams are assembled to determine the cause (National Marine Fisheries Service, 2007b). UMEs may occur for a variety of reasons ranging from diseases, to harmful algal blooms, to environmental conditions such as El Niño (National Marine Fisheries Service, 2007e).

Although an animal may be either dead or alive when it becomes stranded, a majority of stranded animals are dead. Many times the animal has died of natural causes and is then washed ashore from wind and tides. Usually, animals that are alive when stranded are in need of medical attention, or are free-swimming but cannot return to their natural habitat without assistance (National Marine Fisheries Service, 2007b). In some cases when an animal is found alive, it may be possible to transport it to a rehabilitation center to receive further care, and even possibly returned to the wild. Unfortunately, statistics on strandings show that most marine mammals that are alive when they strand will not survive. In most cases the cause of the stranding is not clear. Some identified causes include parasites, disease, interactions with fishing gear, and starvation, to name a few (National Marine Fisheries Service, 2007a).

Stranding Data
Stranding events, though unfortunate, can be useful to scientists and resource managers because they can provide information that is not accessible at sea or through any other means. Necropsies are useful in attempting to assess a reason for the stranding, and are performed on stranded animals when the situation allows. Stranded animals have provided us with the opportunity to gain insight into the lives of marine mammals such as their natural history, seasonal distribution, population health, reproductive biology, environmental contaminant levels, types of interactions with humans, and the prevalence of disease and parasites. The only
existing information on some cetacean species has been discovered from stranding events

Currently the government agency that is responsible for responding to strandings is the Marine
Mammal Health and Stranding Response Program (MMHSRP) within NMFS. The National
Marine Mammal Stranding Network, which is one part of the more comprehensive MMHSRP, is
made up of smaller organizations partnered with NMFS to investigate marine mammal
strandings. These stranding networks are established in all coastal states and consist of
professionals and volunteers from nonprofit organizations, aquaria, universities, and state and
local governments who are trained in stranding response. NMFS authorizes, coordinates, and
participates in response activities and personnel training (National Marine Fisheries Service,
2007b). NMFS oversees stranding response via a National Coordinator and a regional
coordinator in each of the NMFS regions. There are currently over 400 organizations that are
authorized by NMFS to respond to marine mammal strandings (National Marine Fisheries
Service, 2007c).

Stranding reporting and response efforts over time have been inconsistent and have been
increasing over the past three decades, making any trends hard to interpret (National Marine
Fisheries Service, 2007c). Over the past decade (1990–2000), approximately 40,000 stranded
marine mammals have been reported by the regional stranding networks, averaging 3,600
strandings reported per year (National Marine Fisheries Service, 2007e). The highest number
of strandings was reported between the years 1992–1993 and 1997–1998, with a peak in the
number of reported strandings in 1998 totaling 5,708 (National Marine Fisheries Service, 2007e;
National Marine Fisheries Service, 2007c). These have since been determined to have been El
Niño years, which for a variety of reasons can have a drastic effect on marine mammals (see
below).

Effort has been more consistent since 1994. Between 1994 and 1998 a total of 19,130
strandings were reported, with an average of 3,826 per year (National Marine Fisheries Service,
2007c). The composition of animals involved in strandings varies by region. For example, the
southwest always has more pinniped strandings, while the southeast always has the highest
number of cetacean strandings (National Marine Fisheries Service, 2007c). Table 4.1.2.4.11-1
describes numbers and composition of reported strandings during the 5-year period 1994–1998

<table>
<thead>
<tr>
<th>Region</th>
<th>Number of Cetaceans</th>
<th>Number of Pinnipeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast</td>
<td>3,683</td>
<td>44</td>
</tr>
<tr>
<td>Northeast</td>
<td>1,013</td>
<td>1,768</td>
</tr>
<tr>
<td>Southwest</td>
<td>624</td>
<td>10,147</td>
</tr>
<tr>
<td>Northwest</td>
<td>119</td>
<td>1098</td>
</tr>
<tr>
<td>Alaska</td>
<td>462</td>
<td>172</td>
</tr>
<tr>
<td><strong>Five-Year Totals</strong></td>
<td><strong>5,901</strong></td>
<td><strong>13,229</strong></td>
</tr>
</tbody>
</table>

Source: National Marine Fisheries Service, 2007c
Peak years for cetacean strandings were in 1994 and 1999, and can be attributed to two UMEs. In 1994, 220 bottlenose dolphins stranded off Texas, which represented almost double the annual average (National Marine Fisheries Service, 2007e). It has been determined that the probable cause for these strandings was a morbillivirus outbreak. Then in 1999, 223 harbor porpoises stranded from Maine to North Carolina, representing a four-fold increase over the annual average (National Marine Fisheries Service, 2007e). The most likely cause for these strandings is interspecific aggression due to sea surface temperatures and a shift in prey species in the Mid-Atlantic (National Marine Fisheries Service, 2007e).

4.1.2.4.11.1 Causes of Strandings

Marine mammal strandings have been occurring as long as humans have been recording scientific observations. The cause of the strandings was not clear in Aristotle’s day, and in most cases, the reason is not clear now. Current science suggests that there are multiple factors, both natural and man-made, that may be acting alone or in combination. Most stranded animals are already dead or in a weakened state. An animal may suffer from one ailment and then become susceptible to various other dilemmas because of its weakened condition, making it difficult to determine a primary cause. Therefore, anything that leads to mortality, weakness, confusion, or injury in an animal could be considered a potential factor in influencing stranding. The physical injuries that may occur during a stranding can hasten death, but the stranding itself is not usually the underlying cause (Geraci et al., 1999). While data collection and necropsies attempt to find a possible cause, it is difficult to pinpoint exactly one factor that can be blamed for any given stranding. In many stranding cases scientists never learn the exact cause of the stranding (National Oceanic and Atmospheric Administration, 2006).

Natural Causes

Marine mammals have been found stranded throughout human history, and therefore many strandings can be attributed to natural and environmental causes. Marine mammals die every single day from weakness resulting from trauma, predation, starvation, and disease (Geraci et al., 1999), or simply from old age (National Oceanic and Atmospheric Administration, 2006). Natural mortality in marine mammals is highest in the youngest and oldest age classes, which is typical of many large mammals (Geraci et al., 1999). Certain factors such as infections and environmental conditions can sometimes lead to the deaths of large numbers of marine mammals in a short period of time (Geraci et al., 1999). Because most stranded marine mammals come ashore either already dead or in a weakened state, it is believed that the original cause of death or weakness occurs at sea, and the animal is then brought to shore with the currents, tides, and wind.

Disease

Marine mammals frequently suffer from a variety of diseases resulting from viral, bacterial, parasite, or worm infections (National Oceanic and Atmospheric Administration, 2006).

Microparasites are small and can reproduce within their hosts, such as bacteria, viruses, and other microorganisms, including yeasts (Geraci et al., 1999). These types of organisms flourish in marine mammal habitats and usually pose little threat to a healthy animal (Geraci et al., 1999). For example, morbillivirus infection without mortality is endemic in certain marine mammal populations, such as in long-finned pilot whales of the western North Atlantic ocean (Geraci et al., 1999). This infection is presumed to be widespread but of little consequence because they have gained immunity through repeated exposure (Geraci et al., 1999). New
viruses are continuously being discovered, many with little or no known effects (Geraci et al., 1999).

The most notable role of viruses has been in their association with marine mammal die-offs. The first mass mortality attributed to a virus (Influenza A) happened between December 1979 and October 1980 along the New England coast (Geraci et al., 1999). Since 1980, viruses have been implicated in almost all marine mammal mass mortalities attributed to infectious diseases (Geraci et al., 1999). For example, a UME in 1993 and 1994 involving bottlenose dolphins was caused by morbillivirus—this UME started along the Florida Panhandle and spread westward with most of the mortalities occurring in Texas (National Marine Fisheries Service, 2005f).

Opportunistic species can invade and overwhelm those animals already weakened for other reasons such as malnutrition or infection (Geraci et al., 1999). It is hard to determine if a microparasite is the primary pathogen, or if it shows up later as a secondary infection in an already weakened animal (Geraci et al., 1999), thus making it difficult to determine the true cause of a stranding.

Macroparasites are usually large and require an intermediate host (Geraci et al., 1999). A wide range of different macroparasites can be found within marine mammals, and even heavy burdens of these organisms may have little effect on the animal unless it is also suffering from other illness, injury, or weakened by starvation (Geraci et al., 1999). *Nasitrema*, a trematode (parasitic flatworm) commonly found in the cranial sinuses of cetaceans, is fairly non-threatening to the animal (Geraci et al., 1999). But sometimes one of these organisms finds its way to the brain, critically damaging tissues as it moves (Geraci et al., 1999). This worm is one of the few that has been directly linked to strandings (Geraci et al., 1999).

**Naturally Occurring Toxins**

In Florida, “red tides” are created by a dinoflagellate (*Karenia brevis*) that blooms annually, and has been doing so since at least the mid 1800s (National Marine Fisheries Service, 2007m). *K. brevis* is distributed primarily throughout the Gulf of Mexico, and occasionally along the mid and southern Atlantic coasts (National Marine Fisheries Service, 2007m). This dinoflagellate produces a form of neurotoxin, known as brevetoxin, which affects public health and causes significant animal mortalities (National Marine Fisheries Service, 2007m).

Red tides resulting from *K. brevis* are responsible for annual mass mortalities of thousands of fish, and in some years they cause mass mortalities of marine mammals, birds, and sea turtles (National Marine Fisheries Service, 2007m). Over the years, the effects of red tide have been responsible for many marine mammal strandings.

Several species of diatoms (microscopic marine plants) have the ability to produce a toxin called domoic acid (National Marine Fisheries Service, 2007m). These diatoms are widespread and can be found on the east and west coasts of the U.S. as well as in the Gulf of Mexico (National Marine Fisheries Service, 2007m). Domoic acid has also been known to have serious effects on public health and a variety of marine species (National Marine Fisheries Service, 2007m). Since 1987, domoic acid has been identified as the cause of mass mortalities of seabirds and marine mammals off the coast of California, and whale deaths off Georges Bank (National Marine Fisheries Service, 2007m).
Between March 10 and April 13, 2004, 107 bottlenose dolphins were found dead and stranded on the Florida Panhandle, along with hundreds of dead fish and marine invertebrates (National Marine Fisheries Service, 2007n). This event was declared a UME. Analyses of the dolphins found brevetoxins at high levels within the dolphin stomach contents, and at variable levels within their tissues (National Marine Fisheries Service, 2007n). Low levels of domoic acid were also detected in some of the dolphins, and a diatom that produces domoic acid (Pseudo-nitzschia delicatissima) was present in low to moderate levels in water samples (National Marine Fisheries Service, 2007n). In the Gulf of Mexico, two other UMEs associated with red tide involving bottlenose dolphins occurred previously in 1996, and between 1999 and 2000 (National Marine Fisheries Service, 2005f).

**Predation**

Many species of marine mammal serve as prey to other animals and forms of marine life, including sharks and even other marine mammals. Predation from sharks is considered to be a contributing factor in the decline of the Hawaiian monk seal (Geraci et al., 1999). A stranded marine mammal will sometimes show signs of interactions with predators such as bites, teeth marks, and other injuries, which occasionally are bad enough to have been the primary cause of injury, death, and stranding.

**Traveling Inshore**

Inshore waters are certainly shallower than the waters of the open ocean, which may be a contributing factor in stranding events. Local coastal geography may be related to stranding events. Areas with gentle slopes and broad flats, extreme tidal changes, and strong or unusual currents may serve as “whale traps” (Geraci et al., 1999).

The presence of prey species close to the coast may result in bringing pelagic marine mammals, probably not familiar with the shoreline, closer to the coast than usual to feed (Chambers et al., 2005). Certain species of marine mammal follow their prey inshore, like Atlantic white-sided dolphins in the Bay of Fundy, or long-finned pilot whales seeking squid and herring close to Cape Cod, Massachusetts. Most of the time this is an uneventful activity, but occasionally a group hits land (Geraci et al., 2005). Between 1981 and 1991, at least 10 separate pilot whale mass stranding events occurred within a 20-mi radius of Cape Cod. The strandings totaled more than 475 animals between the months of September and December (Geraci et al., 2005).

Sometimes even coastal species are caught by an outgoing tide. Occasionally beluga whales that feed on salmon in Cook Inlet, Alaska, strand in large numbers due to unusually low tides. Most of the time, these animals seem to suffer little damage from the temporary grounding and are able to swim away with a higher tide and resume normal activities (Geraci et al., 2005).

**Echolocation Malfunction in Shallow Water**

Some researchers believe that some pelagic species of marine mammals may run aground because their echolocation is impaired in shallow waters (Geraci et al., 1999). When stranded cetaceans are determined to be free of disease or parasitic infection, it has been hypothesized that echolocation malfunction could be a possible cause of mass strandings on shallow beaches (Chambers et al., 2005). For a cetacean, echolocation signal reflections contain important information on the location of a shoreline (Chambers et al., 2005). A gently sloping beach may
present major difficulties to the navigational systems of some cetaceans, and in some instances may even be undetectable to echolocation. Navigational errors leading to incorrect or non-detection of a shoreline could result in confusion and disorientation, possibly causing a stranding (Chambers et al., 2005). In some cases, successful detection of a shoreline might happen too late, at a point where stranding becomes imminent (Chambers et al., 2005).

Chambers et al. (2005) explored this possibility as a cause of mass cetacean strandings in Geographe Bay in south-western Australia. Geographe Bay, a gently-sloping sandy bottomed beach, has been the location of several live mass strandings over the past 15 years, involving large groups (five or more) of apparently healthy, toothed cetaceans that utilize echolocation as a means of navigation (Chambers et al., 2005). They believe that a mechanism called "sonar termination" was a major factor in these strandings. Sonar termination occurs when an echolocation click is directed towards the coast, but then attenuates to a point to where the reflections are not detectable (Chambers et al., 2005).

Chambers et al. (2005) suggest that there are two factors that contribute to sonar termination: first, a gently sloping shore, and second, tiny micro-sized bubbles within the water column. Active echolocation detection of a shallow coast is hindered by a large amount of reflection loss due to gently sloping bathymetry (Chambers et al., 2005). They believe that the combined effect of reflection loss and microbubble attenuation can mask the presence of a shoreline or degrade an echolocation signal to a point where a navigational error may be made (Chambers et al., 2005).

It is widely accepted that small bubbles are continuously being created at the water’s surface by rain and surface waves, with tidal and wave motions thoroughly mixing these microbubbles in shallow water (Chambers et al., 2005). These microbubbles can stay within the water column for a few hours up to a few days, and their presence contributes directly to sonar termination by having an attenuative effect on echolocation (Chambers et al., 2005). They have a detrimental effect on the successful detection of a shallow shoreline by absorbing energy emitted from a marine mammal’s echolocation signals.

It is important to review weather data and underwater geography when researching possible causes of a stranding to determine if a cetacean’s active echolocation mechanisms could have been adversely affected. The importance of the presence of microbubbles in mass cetacean strandings should not be underestimated. A windy period could have created an unusual amount of microbubbles in the water, or the marine mammal’s echolocation may have had difficulty detecting a gently sloping coastline. Or, these factors could be acting together as they appear to be doing in Geographe Bay, where several mass cetacean strandings are believed to have been caused by the combination of a high density of microbubbles after stormy conditions, and reflection loss associated with the shallow bay (Chambers et al., 2005).

Weather Events and Climate Patterns

Even though marine mammals as a group have adapted to deal with varying and sometimes extreme environmental conditions, events such as severe storms or prolonged cold can have a big impact, and many individual animals may die as a direct result (Geraci et al., 1999).

Sometimes mass strandings coincide with unusual weather events and abnormal environmental conditions. For example, in 1999 in the British Virgin Islands, it is believed that severe hurricanes may have been responsible for the stranding of five pygmy killer whales (Geraci et
Weather events can also have an indirect effect on marine mammals by shifting or depleting food resources (Geraci et al., 1999). Some researchers have investigated the correlation of stranding frequency with changes in the oceanic currents or periods of climatic warming that may alter the distribution of prey, therefore altering the movement of predatory marine mammals. It is possible that these events may bring animals unfamiliar with the coastline closer to shore and into risky shallow territory, thus increasing the chance that some may run aground (Geraci et al., 2005).

Bradshaw et al. (2006) examined stranding events in the southeastern region of Australia including Tasmania, considered to be one of the world’s stranding “hotspots” (Bradshaw et al., 2006). Bradshaw et al. believe that the variability in the distribution and availability of food resources dictates the patterns in animal migration, survival, fecundity, and population size. They therefore believe that if movement of nutrient-rich waters is responsible for bringing marine mammals closer to land, the probability of stranding at those times will be higher (Bradshaw et al., 2006). Their analyses of stranding data for the area found cycles in the number of stranding events (occurring about every 12 to 14 years) and that these pulses in stranding activity were related to measurable changes in climate patterns (Bradshaw et al., 2006). They found that a good predictor for an increase in stranding frequency was to watch for increases in zonal meridional winds that result in colder and possibly more nutrient-rich water moving closer to southern Australian landmasses (Bradshaw et al., 2006). They put this hypothesis to test when their model predicted that the 2004 to 2005 austral summer would be a peak year for strandings in the area, which it was (Bradshaw et al., 2006). Bradshaw et al. conclude that while climatic and other models can provide broadscale mechanisms for predicting stranding frequency at a given location, the exact mechanisms for individual stranding events are likely to vary widely.

It is also possible that the sudden disappearance of prey due to an extreme weather event could have a sudden and dramatic effect throughout a marine mammal population (Geraci et al., 1999). Food resources dramatically decrease during El Niño years which have a strong impact on pinnipeds, especially affecting the very young—pups may be abandoned, while weanlings and juveniles starve (National Marine Fisheries Service, 2007e).

**Earth’s Magnetic Field**

The earth’s magnetic field provides a stable source of positional and directional information. It is now known that many animals detect the geomagnetic field and use it as a compass and a map to navigate, especially over long distances when it may not be possible to use other navigational abilities (Walker et al., 1992). This has been demonstrated in birds along their seasonal migration routes and in pigeon homing behavior. Fish and honeybees have also been conditioned to respond to various magnetic field stimuli (Walker et al., 1992).

Some scientists believe that marine mammals may also use this magnetic sensing, and there is some evidence that cetaceans use magnetic information to guide their movements. Alternating bands of magnetism run north to south parallel to the mid-ocean rift. If whales are able to detect these alterations in the magnetic field, it is possible that they may be able to use the magnetic patterns as north-south highways on their annual migrations (Wartzok et al., 1999). Underwater disturbances or anomalies in the magnetic field may then disrupt movements of marine mammals.
mammals by causing them to misinterpret the geomagnetic information, leading them astray by
providing incorrect direction and location.

In 2000, over 150 false killer whales stranded themselves on Mexico’s Yucatan peninsula
(Tracey, 2000). In relation to this stranding event, Dr. Randall Reeves, chairman of the IUCN
Species Survival Commission’s Cetacean Specialist Group, explained that the exact reason for
the strandings is unknown. He mentioned that one hypothesis to explain the strandings
involves magnetic irregularities in certain places that make it difficult for the whales to navigate,
and that magnetic disturbances in some areas have been linked to mass stranding occurrences
(Tracey, 2000).

Klinowska (1985) hypothesized that seemingly healthy whales that strand themselves alive
must have made a serious navigational mistake. She plotted live stranding positions on top of
magnetic field maps for the coast of Great Britain. Klinowska observed an association between
live stranding positions and levels within the magnetic field. She found that in all cases, live
strandings occurred at locations where magnetic minima, or lows in the magnetic fields,
intersect the coastline. The results suggest that cetaceans possess some type of magnetic
sensory system. There was no such correlation between magnetic data and strandings of dead
cetaceans, which had most likely been washed ashore by currents (Klinowska, 1985).

Others have expanded upon this research. Kirschvink and his colleagues (1986, 1990)
extended Klinowska’s study to the United States, testing the hypothesis that cetaceans use
anomalies in the geomagnetic field as cues for orientation and navigation. Stranding positions
were plotted on a map of magnetic data for the east coast of the United States, and they were
able to develop associations between stranding sites and locations where magnetic minima
intersected the coast. They found highly significant tendencies for cetaceans to beach
themselves near these coastal areas. Even small variations in total intensity were sufficient to
influence stranding location (Kirschvink et al., 1986; Kirschvink, 1990). Again, these results
suggest that cetaceans may have a magnetic sensory system comparable to that in other
migratory animals, and that marine magnetic topography and patterns may play an important
role in guiding long-distance movements (Kirschvink et al., 1986).

Walker et al. (1992) studied the locations where free-swimming fin whales had been observed
over the continental shelf off the northeastern United States. They found that migrating animals
associated themselves with lows in the geometric gradient or intensity. Their results suggested
that fin whales do in fact recognize and associate with features in the geomagnetic field
independent of other geophysical stimuli, and this association is correlated with seasonal
migration patterns. These results are consistent with earlier analyses of live whale strandings,
the occurrence of which happened most often on coastlines that intersected areas characterized
by low magnetic field gradients and intensities. It also supports the notion that fin whales, and
possibly other mysticete species, possess a magnetic sense that assists in migration (Walker et

To support these theories, there is anatomical evidence that some species of cetaceans have
crystals of magnetite in the soft tissue of their brains that may be to sense the earth’s magnetic
field (Geraci et al., 2005) (Wartzok et al., 1999).
Intentionally

There is debate as to why a marine mammal would intentionally strand. Some suggestions include to seek the safety of land, to rest, or to rub their skin (National Marine Fisheries Service, 2007f). Some have even suggested that it may be because they are distracted, for sensory stimulation, or a regression to instinctive behaviors (Bradshaw et al., 2006). Many cetaceans exhibit a strong kinship within social structures, which appears to be especially important in the group structure of some of the larger toothed whale species. Mass strandings have a tendency to involve those species with strong social bonds, which appear extraordinarily strong at times (Wells et al., 1999). Many individual animals within a mass stranding come ashore in seemingly good health (Geraci et al., 1999), with only a small proportion of animals within the group showing any indication of illness or injury. This suggests that social cohesion may contribute to bringing the entire group ashore—a force that is strong enough to make others in the pod likely to follow just a few (Geraci et al., 1999). Removal or loss of the injured members has led to the successful return of the rest of the group to sea (Wells et al., 1999). In September of 1975, 200 long-finned pilot whales stranded off Newfoundland; 125 died, and the rest returned to sea on the next tide (Geraci et al., 1999).

Anthropogenic Causes

Over the past few decades there has been an increase in marine mammal mortalities believed to be caused by a variety of human activities (Geraci et al., 1999), such as gunshots, collisions with vessels (National Oceanic and Atmospheric Administration, 2006), and other trauma and mutilations.

- Gunshot injuries are the most common man-made cause of strandings in sea lions and seals on the U.S. West Coast (National Marine Fisheries Service, 2007c).
- Every year a few northern right whales are killed within shipping lanes along the U.S. Atlantic coast, which may be enough to jeopardize stock recovery (Geraci et al., 1999).
- In 1998, two bottlenose dolphins and a calf were killed by vessel strikes in the Gulf of Mexico (National Marine Fisheries Service, 2005f).
- In 1999 there was one report of a stranded false killer whale on the Alabama coast that was classified as likely caused by fishery interactions or other human interaction due to limb mutilation (the fins and flukes of the animal had been amputated) (National Marine Fisheries Service, 2005c).
- 1,377 bottlenose dolphins were found stranded in the Gulf of Mexico from 1999 through 2003; 73 animals (11 percent) showed evidence of human interactions as the cause of death (e.g., gear entanglement, mutilations, gunshot wounds) (National Marine Fisheries Service, 2005f).

Data from strandings in which there was evidence of human interaction is available for the years 1999–2000. Table 4.1.2.4.11.2 provides the number of stranded marine mammals (cetaceans and pinnipeds) during this period that displayed evidence of human interactions (taken from National Marine Fisheries Service, 2007e). (Stranding data for the California region for the year 1999 is unavailable; therefore numbers are for stranded animals in 2000 only. Similarly, data is unavailable for the year 2000 in the Alaska region; numbers provided represent strandings for 1999 only.)
### Table 4.1.2.4.11-2. Summary of Marine Mammal Strandings By Cause for Each Region

<table>
<thead>
<tr>
<th>Interaction</th>
<th>Southeast</th>
<th>Northeast</th>
<th>Northwest</th>
<th>California</th>
<th>Alaska</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisheries</td>
<td>89</td>
<td>75</td>
<td>10</td>
<td>31</td>
<td>16</td>
</tr>
<tr>
<td>Vessel Strike</td>
<td>9</td>
<td>6</td>
<td>1</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Gun Shot</td>
<td>6</td>
<td>6</td>
<td>12</td>
<td>19</td>
<td>4</td>
</tr>
<tr>
<td>Blunt Trauma</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mutilation</td>
<td>4</td>
<td>17</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Plastic Ingestion</td>
<td>1</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Power Plant Entrapment</td>
<td>1</td>
<td>11</td>
<td>-</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Harassment</td>
<td>-</td>
<td>9</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Arrow Wound</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Harpoon Wound</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hit by Car</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Hit by Train</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Debris Entanglement</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>110</strong></td>
<td><strong>128</strong></td>
<td><strong>27</strong></td>
<td><strong>97</strong></td>
<td><strong>22</strong></td>
</tr>
</tbody>
</table>

Source: National Marine Fisheries Service, 2007e

### Fisheries Interactions/Marine Debris Entanglement

The incidental catch of marine mammals in commercial fisheries is a significant threat to many populations of marine mammals. Interactions between fisheries and marine mammals have been occurring for centuries, and are currently on the rise due to increases in the human population, fishery industrialization, and fishery expansion into new areas (Read et al., 2006). Interactions with fisheries and/or entanglement in discarded or lost gear continue to be a major factor in marine mammal deaths worldwide (Geraci et al., 1999). Marine mammals can not only get caught in gear that is actively being fished; there is a large amount of netting and other fishing gear that has been thrown away or lost and is floating in the oceans of the world. Baleen whales and pinnipeds have been found entangled in nets, ropes, monofilament line, and other fishing gear that has been discarded at sea (Geraci et al., 1999). To address these issues, there are a variety of Federal laws that regulate commercial and recreational fishing activities, and gear restrictions and usage.

Entangled marine mammals may die as a result of drowning, escape with pieces of gear still attached to their bodies, or manage to be set free either of their own accord or by fishermen. Many large whales carry off gear after becoming entangled (Read et al., 2006). Many times when a marine mammal swims off with gear attached, the end result can be fatal. For instance, the gear may be become too cumbersome for the animal, or it can be wrapped around a crucial body part and tighten over time. Stranded marine mammals frequently exhibit signs of previous fishery interaction, such as scarring or gear attached to their bodies, and the cause of death for many stranded marine mammals is often attributed to such interactions. Because marine mammals that die or that are injured in fisheries may not all wash ashore, and not all of those animals that do wash ashore exhibit clear signs of interactions, stranding data probably underestimates fishery-related mortality and serious injury (National Marine Fisheries Service, 2005a).
From 1993 through 2003, 1,105 harbor porpoises were reported stranded from Maine to North Carolina, many of which had cuts and body damage suggestive of net entanglement (National Marine Fisheries Service, 2005e). In 1999 it was possible to determine that the cause of death for 38 of the stranded porpoises was from fishery interactions, with one additional animal having been mutilated (right flipper and fluke cut off) (National Marine Fisheries Service, 2005e). In 2000, one stranded porpoise was found with monofilament line wrapped around its body (National Marine Fisheries Service, 2005e). And in 2003, nine stranded harbor porpoises were attributed to fishery interactions, with an additional three mutilated animals (National Marine Fisheries Service, 2005e).

Read et al. (2006) attempted to estimate the magnitude of marine mammal bycatch in U.S. and global fisheries. Data on marine mammal bycatch within the U.S. was obtained from fisheries observer programs, reports of entangled stranded animals, and fishery logbooks, and was then extrapolated to estimate global bycatch by using the ratio of U.S. fishing vessels to the total number of vessels within the world’s fleet (Read et al., 2006). Within U.S. fisheries, between 1990 and 1999 the mean annual bycatch of marine mammals was 6,215 animals, with a standard error of +/-448 (Read et al., 2006). Eighty-four percent of cetacean bycatch occurred in gill-net fisheries, with dolphins and porpoises constituting most of the cetacean bycatch (Read et al., 2006). Over the decade there was a 40 percent decline in marine mammal bycatch, which was significantly lower from 1995–1999 than it was from 1990–1994 (Read et al., 2006). Read et al. (2006) suggests that this is primarily due to effective conservation measures that were implemented during this time period.

Read et al. (2006) then extrapolated this data for the same time period and calculated an annual estimate of 653,365 marine mammals globally, with most of the world’s bycatch occurring in gill-net fisheries. With global marine mammal bycatch likely to be in the hundreds of thousands every year, bycatch in fisheries will be the single greatest threat to many marine mammal populations around the world (Read et al., 2006).

**Ingestion of Plastic Objects and Other Marine Debris**

For many marine mammals, debris in the marine environment is a great hazard and can be harmful to wildlife. Not only is debris a hazard because of possible entanglement, animals may mistake plastics and other debris for food (National Marine Fisheries Service, 2007g). There are certain species of cetaceans, along with Florida manatees, that are more likely to eat trash, especially plastics, which is usually fatal for the animal (Geraci et al., 1999).

Between 1990 through October 1998, 215 pygmy sperm whales stranded along the U.S. Atlantic coast from New York through the Florida Keys (National Marine Fisheries Service, 2005a). Remains of plastic bags and other debris were found in the stomachs of 13 of these animals (National Marine Fisheries Service, 2005a). Between Maine and Puerto Rico, 125 pygmy sperm whales were reported stranded from 1999–2003; in one pygmy sperm whale found stranded in 2002, red plastic debris was found in the stomach along with squid beaks (National Marine Fisheries Service, 2005a).

Toxic Pollution Exposure and Ingestion, Poisoning

High concentrations of potentially toxic substances within marine mammals along with an increase in new diseases have been documented in recent years. Scientists have begun to consider the possibility of a link between pollutants and marine mammal mortality events. NMFS takes part in a marine mammal biomonitoring program not only to help assess the health and contaminant loads of marine mammals, but also to assist in determining anthropogenic impacts on marine mammals, marine food chains and marine ecosystem health. Using strandings and bycatch animals the program provides tissue/serum archiving, samples for analyses, disease monitoring and reporting and additional response during disease investigations (National Marine Fisheries Service 2007d).

The man-made chemical PCB (polychlorinated biphenyl), and the pesticide DDT (dichlorodiphenyltrichloroethane), are both considered persistent organic pollutants that are currently banned in the United States for their harmful effects in wildlife and humans (National Marine Fisheries Service, 2007c). Despite having been banned for decades in the United States, the levels of these compounds are still high in marine mammal tissue samples taken along U.S. coasts (National Marine Fisheries Service, 2007c). Both compounds are long lasting, reside in marine mammal fat tissues (especially in blubber), and can be toxic, causing effects such as reproductive impairment and immunosuppression (National Marine Fisheries Service, 2007c).

Both long-finned and short-finned pilot whales have a tendency to mass strand throughout their range. Short-finned pilot whales have been reported as stranded as far north as Rhode Island, and long-finned pilot whales as far south as South Carolina (National Marine Fisheries Service, 2005b). (For U.S. east coast stranding records, both species are lumped together and there is rarely a distinction between the two because of uncertainty in species identification [National Marine Fisheries Service, 2005b]). Since 1980 within the Northeast region alone, between 2 and 120 pilot whales have stranded annually either individually or in groups (National Marine Fisheries Service, 2005b). Between 1999 and 2003 from Maine to Florida, 126 pilot whales were reported to be stranded, including a mass stranding of 11 animals in 2000 and another mass stranding of 57 animals in 2002, both along the Massachusetts coast (National Marine Fisheries Service, 2005b).

It is unclear how much of a role human activities play in these pilot whale strandings, and toxic poisoning may be a potential human-caused source of mortality for pilot whales (National Marine Fisheries Service, 2005b). Moderate levels of PCBs and chlorinated pesticides (such as DDT, DDE, and dieldrin) have been found in pilot whale blubber (National Marine Fisheries Service, 2005b). Bioaccumulation levels have been found to be more similar in whales from the same stranding event than from animals of the same age or sex (National Marine Fisheries Service, 2005b). Numerous studies have measured high levels of toxic metals (mercury, lead, cadmium), selenium, and PCBs in pilot whales in the Faroe Islands (National Marine Fisheries Service, 2005b). Population effects resulting from such high contamination levels are currently unknown (National Marine Fisheries Service, 2005b).

Habitat contamination and degradation may also play a role in marine mammal mortality and strandings. Some events caused by man have direct and obvious effects on marine mammals, such as oil spills (Geraci et al., 1999). But in most cases, effects of contamination will more than likely be indirect in nature, such as effects on prey species availability, or by increasing disease susceptibility (Geraci et al., 1999).
4.0 Environmental Consequences, Open Ocean Area

There is evidence that man-made sounds (such as explosions, drilling, construction, and certain types of sonar) (National Oceanic and Atmospheric Administration, 2006) that occur underwater may have an impact on marine mammals, and in some cases is believed to be a possible contributing factor in stranding events. Behavioral and physiological responses of marine mammals to various sound sources remain highly misunderstood (National Marine Fisheries Service, 2007k).

There is data to indicate that some active sonar systems are audible to a variety of marine mammal species over considerable distances (National Marine Fisheries Service, 2007k). The effect that sonar may have on marine mammals remains scientifically uncertain (National Marine Fisheries Service, 2007k), and the answers as to how sonar can contribute to a stranding remain unclear. Our comprehension of the type and magnitude of any behavioral or physiological responses from marine mammals to active sonar, and how these responses may contribute to strandings, is rudimentary at best (National Marine Fisheries Service, 2007k).

4.1.2.4.11.2 Stranding Events Associated with Navy Sonar

Greece Stranding Event, May 12–13, 1996

Description
On the morning of May 12, 1996, Cuvier’s beaked whales began to strand alive in different locations of Kyparissiakos Gulf, Greece, and continued through the afternoon of May 13 (Frantzis, 2004; International Council for the Exploration of the Sea, 2005). The Gulf is a long sandy beach in the west coast of the Peloponnese, along the Hellenic Trench (Frantzis, 2004). A total of 12 whales were reported stranded alive, spread across 23.7 mi of coastline and separated by a mean distance of 2.2 mi (Frantzis, 1998). The Greek Seas occupy the northern part of the eastern Mediterranean and are characterized by long and highly irregular coastlines with rich geomorphology (Frantzis, 2004). There are depressions and deep trenches that surround Greece, which are good habitats for deep diving cetaceans close to the coastline (Frantzis, 2004).

From May 11 through May 15, NATO research vessels were conducting sound-detecting system trials by transmitting to both low and medium frequencies (Cox et al., 2006). The period of time and the location where the tests had been carried out both encompassed the time and location of the marine mammal stranding coordinates (Frantzis, 2004).

Findings
Necropsies of eight of the animals were performed, but were limited to basic external examination and sampling of stomach contents, blood, and skin. No ears or organs were collected, and no histological samples were preserved because of problems related to permits, lack of trained specialists, and lack of facilities and means (International Council for the Exploration of the Sea, 2005).

- At least 12 of the 14 animals stranded alive in an atypical way (International Council for the Exploration of the Sea, 2005). The spread of strandings were also atypical in location and time, as mass-strandings usually occur at the same place and at the same time (Frantzis, 1998).
Open Ocean Area, 4.0 Environmental Consequences

- No apparent abnormalities or wounds were found (Frantzis, 2004).
- Examination of photos of the animals revealed that the eyes of at least four of the individuals were bleeding. Photos were taken soon after their death (Frantzis, 2004).
- Stomach contents contained the flesh of cephalopods, indicating that feeding had recently taken place (Frantzis, 1998).
- No unusual environmental events occurred before or during the stranding (Frantzis, 2004).

Conclusions
All available information regarding the conditions associated with this stranding were compiled, and many potential causes were examined including major pollution events, important tectonic activity, unusual physical or meteorological events, magnetic anomalies, epizootics, and conventional military activities (International Council for the Exploration of the Sea, 2005). However, none of these potential causes coincided in time with the mass stranding, or could explain its characteristics (International Council for the Exploration of the Sea, 2005). The robust condition of the animals, plus the recent stomach contents, is not consistent with pathogenic causes (Frantzis, 2004). In addition, environmental causes can be ruled out as there were no unusual environmental circumstances or events before or during this time period (Frantzis, 2004).

It was determined that because of the rarity of this mass stranding of Cuvier’s beaked whales in the Kyparissiakos Gulf (first one in history), the probability for the two events (the military exercises and the strandings) to coincide in time and location, while being independent of each other, was extremely low (Frantzis, 1998).

Because full necropsies had not been conducted, and no abnormalities were noted, the cause of the strandings cannot be precisely determined (Cox et al., 2006). The analysis of this stranding event provided support for, but no clear evidence for, the cause-and-effect relationship of sonar operations and beaked whale strandings (Cox et al., 2006).

Bahamas Marine Mammal Stranding Event, March 15-16, 2000
Description
On March 15-16, 2000, seventeen marine mammals comprised of four different species (Cuvier’s beaked whales, Blainville’s beaked whales, Minke whales, and one spotted dolphin) stranded along the Northeast and Northwest Providence Channels of the Bahamas Islands (National Marine Fisheries Service, 2001a; U.S. Department of the Navy and Department of Commerce, 2001). The strandings occurred within 24 hours of Navy ships using active mid-frequency sonar for an extended period while passing through the Northeast and Northwest Providence Channels (National Marine Fisheries Service, 2001a).

Because of the unusual nature and situation surrounding these strandings, a comprehensive investigation into every possible cause was quickly launched (U.S. Department of the Navy and Department of Commerce, 2001).
4.0 Environmental Consequences, Open Ocean Area

Strandings were first reported at the southern end of the channels, and proceeded northwest throughout March 15, 2000. It is probable that all of the strandings occurred on March 15, even though some of the animals were not found or reported until March 16. Seven of the animals died, while ten animals were returned to the water alive; however, it is unknown if these animals survived or died at sea at a later time. (U.S. Department of the Navy and Department of Commerce, 2001)

The animals that are known to have died include five Cuvier’s beaked whales, one Blainville’s beaked whale, and the single spotted dolphin (U.S. Department of the Navy and Department of Commerce, 2001). Six necropsies were performed, but only three out of the six (one Cuvier’s beaked whale, one Blainville’s beaked whale, and the spotted dolphin) were fresh enough to examine any lesions clearly. Results from the spotted dolphin necropsy revealed that the animal died with systemic debilitation disease, and is considered unrelated to the rest of the mass stranding (U.S. Department of the Navy and Department of Commerce, 2001).

Findings

Based on necropsies performed on the other five beaked whales, it was preliminarily determined that they had experienced some sort of acoustic or impulse trauma which led to their stranding and ultimate demise (U.S. Department of the Navy and Department of Commerce, 2001). Detailed microscopic tissue studies followed in order to determine the source of the acoustic trauma and the mechanism by which trauma was caused.

- All five necropsied beaked whales were in good body condition, showing no signs of infection, disease, ship strike, blunt trauma, or fishery related injuries, and three still had food remains in their stomachs. (U.S. Department of the Navy and Department of Commerce, 2001).
- Auditory structural damage was discovered in four of the whales, specifically bloody effusions or hemorrhaging around the ears (U.S. Department of the Navy and Department of Commerce, 2001).
- Bilateral intracochlear and unilateral temporal region subarachnoid hemorrhage with blood clots in the lateral ventricles were found in two of the whales (U.S. Department of the Navy and Department of Commerce, 2001).
- Three of the whales had small hemorrhages in their acoustic fats (located along the jaw and in the melon) (U.S. Department of the Navy and Department of Commerce, 2001).
- Passive acoustic monitor recordings within the area during the time of the stranding showed no signs of an explosion or other geological event such as an earthquake (U.S. Department of the Navy and Department of Commerce, 2001).
- The beaked whales showed signs of overheating, physiological shock, and cardiovascular collapse, all of which commonly result in death following a stranding (U.S. Department of the Navy and Department of Commerce, 2001).
Conclusions

The physiological trauma resulting from stranding is the mostly likely immediate cause of death, but the offshore acoustic event within a specific environment is what triggered this series of events (U.S. Department of the Navy and Department of Commerce, 2001).

The actual mechanism by which sonar could have caused tissue damage or caused the animals to strand remains unknown. The report concluded that the cause of the Bahamas stranding was the confluence of mid-frequency sonar with the variables which included sound propagation characteristics (in this case a surface duct), unusual underwater bathymetry, intensive use of multiple sonar units, a constricted channel with limited egress avenues, and the presence of beaked whales that appear to be sensitive to the frequencies produced by these sonars. (U.S. Department of the Navy and U.S. Department of Commerce, 2001).

May 10–14, 2000 Stranding Event, Madeira Island, Portugal

Description

From May 10–14, 2000, three Cuvier’s beaked whales were found stranded on two islands in the Madeira archipelago, Portugal (Cox et al., 2006)—two on Porto Santo Island, and one on the northeast coast of Madeira Island (Freitas, 2004). A fourth animal was reported floating in the Madeiran waters by fisherman, but did not come ashore (Woods Hole Oceanographic Institution, 2005).

Joint NATO amphibious training peacekeeping exercises involving participants from 17 countries took place in Portugal during May 2–15, 2000. The exercises were conducted across an area that stretched from the Island of Madeira to the Gulf of Gascony, and was named “Linked Seas 2000” (National Atlantic Treaty Organization, 2000). It involved Greek, British, Spanish, Portuguese, French, Romanian, and U.S. forces, and included 80 warships and several thousand men landing on the beaches (U.S. Army Corps of Engineers, 2001). The NATO exercises occurred concurrently with this atypical mass stranding of beaked whales (Freitas, 2004).

Findings

The bodies of the three stranded whales were examined post mortem (Woods Hole Oceanographic Institution, 2005). Two heads were taken to be examined, one intact and the other partially seared from a fire started by locals during an attempt to dispose of the corpse (Woods Hole Oceanographic Institution, 2005). Only one of the stranded whales was fresh enough (24 hours after stranding) to be necropsied (Cox et al., 2006).

- Results from the necropsy revealed evidence of hemorrhage and congestion in the right lung and both kidneys (Cox et al., 2006).
- There was also evidence of intercochlear and intracranial hemorrhage similar to that which was observed in the whales that stranded in the Bahamas event (Cox et al., 2006).
- There were no signs of blunt trauma, and no major fractures (Woods Hole Oceanographic Institution, 2005).
The cranial sinuses and airways were found to be quite clear with little or no fluid deposition, which may indicate good preservation of tissues (Woods Hole Oceanographic Institution, 2005).

**Conclusions**

Several observations on the Madeira stranded beaked whales, such as the pattern of injury to the auditory system, are the same as those observed in the Bahamas strandings. Blood in and around the eyes, kidney lesions, pleural hemorrhages, and congestion in the lungs are particularly consistent with the pathologies from the whales stranded in the Bahamas, and are consistent with stress and pressure related trauma. The similarities in pathology and stranding patterns between these two events suggest that a similar pressure event may have precipitated or contributed to the strandings at both sites. (Woods Hole Oceanographic Institution, 2005)

Even though no causal link can be made between the stranding event and naval exercises, certain conditions may have existed in the exercise area that, in their aggregate, may have contributed to the marine mammal strandings (Freitas, 2004).

- Operations were conducted in areas of at least 547 fathoms depth near a shoreline where there is a rapid change in bathymetry on the order of 547 to 3,281 fathoms occurring a cross a relatively short horizontal distance (Freitas, 2004).
- Multiple ships were operating around Madeira. It is not known if mid-frequency active sonar was used, and the specifics of the sound sources used the Linked Seas 2000 exercises, and their propagation characteristics, are unknown (Cox et al., 2006, Freitas, 2004).
- Exercises took place in an area surrounded by landmasses separated by less than 35 nm and at least 10 nm in length, or in an embayment. Operations involving multiple ships employing mid-frequency active near land may produce sound directed towards a channel or embayment that may cut off the lines of egress for marine mammals (Freitas, 2004).

**September 24, 2002 Canary Islands Stranding Event**

*Description*

The southeastern area within the Canary Islands is well known for aggregations of beaked whales due to its ocean depths of greater than 547 fathoms within a few hundred meters of the coastline (Fernandez et al., 2005). On September 24, 2002, 14 beaked whales were found stranded on Fuerteventura and Lanzarote Islands in the Canary Islands (International Council For Exploration of the Sea, 2005). Seven whales died, while the remaining seven live whales were returned to deeper waters (Fernandez et al., 2005). Four beaked whales were found stranded dead over the next 3 days either on the coast or floating offshore.

These strandings occurred within near proximity of an international naval exercise named Neo-Tapon 2002 that involved numerous surface warships and several submarines. Spanish naval sources indicated that tactical mid-range frequency sonar was utilized during the exercises, but no explosions occurred (Fernandez et al., 2005). Strandings began about 4 hours after the onset of mid-frequency sonar activity (International Council For Exploration of the Sea, 2005; Fernandez et al., 2005).
Findings

Eight Cuvier’s beaked whales, one Blainville’s beaked whale, and one Gervais’ beaked whale were necropsied, six of which were considered to be very fresh (Jepson et al., 2003).

- No pathogenic bacteria were isolated from the carcasses (Jepson et al., 2003)
- The animals displayed severe vascular congestion and hemorrhage especially around the tissues in the jaw, ears, brain, and kidneys, displaying marked disseminated microvascular hemorrhages associated with widespread fat emboli (Jepson et al., 2003; International Council For Exploration of the Sea, 2005).
- Several organs contained intravascular bubbles, although definitive evidence of gas embolism in vivo is difficult to determine after death (Jepson et al., 2003).
- The livers of the necropsied animals were the most consistently affected organ, which contained macroscopic gas-filled cavities and had variable degrees of fibrotic encapsulation. In some animals, cavitary lesions had extensively replaced the normal tissue (Jepson et al., 2003).
- Stomachs contained a large amount of fresh and undigested contents, which suggests a rapid onset of disease and death (Fernandez et al., 2005).
- Head and neck lymph nodes were enlarged and congested, and parasites were found in the kidneys of all animals (Fernandez et al., 2005).

Conclusions

There are similarities between this mass stranding and other strandings. The oceanographic features are characteristic of steep-slope regions, the species involved have been predominantly beaked whales, and they were temporally associated with naval maneuvers that employed low or mid-frequency range sonar signals (Fernandez et al., 2005). This leads to the observation that beaked whales that are found in association with certain oceanographic features may be behaviorally or physiologically susceptible to the effects of a variety of sound exposures, including certain types of anthropogenic sonar systems (Fernandez et al., 2005).

There are several different theories as to how gas bubble formation may occur in marine mammals, and how it might be related to strandings. One theory suggests that bubble formations such as the ones found in the animals involved in the Canary Islands stranding might result from behavioral changes to normal diving behavior, such as an accelerated ascent rate (Jepson et al., 2003; Fernandez et al., 2005).

Another theory suggests that gas bubble formation within the subcutaneous adipose tissue, and widespread vascular embolization of fat material, caused sudden spikes in the blood and tissue levels of PCBs or other related xenobiotics (Di Guardo et al., 2005). The liver is one of several sites where accumulation of PCBs occurs in cetaceans, and PCBs are known to act as immunosuppressors and as endocrine disruptors that are associated with morphologic changes in several of the hormone-producing glands (such as the adrenal and thyroid glands) (Di Guardo et al., 2005). A similar pathogenic mechanism may have been involved in three delphinids and one beaked whale found stranded in the United Kingdom between 1992 and 2003, which displayed gas-filled cystic cavities in their livers and other organs (Di Guardo et al., 2005).
However, at this point in time there is no definitive answer to the issue of how bubble formation (like those in the Canary Islands animals) may or may not be associated with marine mammal strandings, and how military sonar may or may not be involved. Aside from their bacteriologic status, there is no other data regarding the age or any pre-existing health of the whales that stranded in the Canary Islands, such as levels of pollutants in tissues (i.e., PCBs) (Di Guardo et al., 2005). A number of acute and chronic disease factors and mechanisms, either acting alone or in combination, may have also been involved in the deaths of the whales in the Canary Islands (Di Guardo et al., 2005).

May 5, 2003 USS SHOUP Washington State

On May 5, 2003 at 0855, SHOUP got underway from the pier at Naval Station Everett, Washington. SHOUP then transited from Everett through Admiralty Inlet to the west side of Whidbey Island, where at 1030 it began a training exercise. Use of SHOUP’s mid-frequency tactical active sonar began at 1040. At 1420, SHOUP entered the Haro Strait at a speed of 18 knots. SHOUP terminated active sonar use at 1438.

Between May 2 to June 2, 2003, approximately 16 strandings involving 15 harbor porpoise and one Dall’s porpoise were reported to the Northwest Marine Mammal Stranding Network. USS SHOUP was accused of having caused these strandings by use of its sonar. NMFS noted that the number of strandings in 2003 was one below the previously recorded high (National Marine Fisheries Service, 2003b). The annual stranding of harbor porpoise in Puget Sound is a known and expected seasonal phenomenon, with strandings occurring more frequently in May, and 70 percent of all annual strandings occurring between the months of March and June. Other cited causes of strandings include toxins (such as “red tide”) and contaminants (National Marine Fisheries Service, 2003; e.g., release of 40 tons of raw sewage in Admiralty Inlet on 3 May 2003 by a cruise liner; AP 2003).

For a historical perspective, since 1992 the San Juan Stranding Network has documented an average of 5.8 porpoise strandings per year. In 1997 there were 12 strandings in the San Juan Islands with over 30 strandings throughout the general Puget Sound area. On May 20, 2003, Dr. Richard Osborne, Research Director for The Whale Museum on San Juan Island wrote that he believed that he was observing a normal pattern of porpoise strandings (Osborne, 2003).

While this data and trends analysis from Dr. Osborne appears to conflict with the NMFS necropsy report abstract which noted a higher rate of strandings in 2003 than the six per year, they can be reconciled when accounting for several factors (National Marine Fisheries Service, 2003b). First, Dr. Osborne and NMFS point to the repeated and intense level of media attention focused on the strandings which increased reporting efforts (Osborne, 2003a; National Marine Fisheries Service, 2003b). NMFS noted in its report that the “sample size is too small and biased to infer a specific relationship with respect to sonar usage and subsequent strandings (National Marine Fisheries Service, 2003b). In addition, although NMFS has characterized 2003 as having “an abnormally high number” of strandings, it is actually less than the maximum previously recorded (15 strandings in 2001; National Marine Fisheries Service, 2003b). Finally, given the reported average of 6.0 (strandings annually) and the standard deviation of 6.1, a large variation in the number of annual strandings should be expected (National Marine Fisheries Service, 2003b).
Of the 16 strandings SHOUP was accused of potentially having caused, seven mammals died prior to SHOUP departing the pier at Everett on 5 May 2003. Of these seven, one, discovered on 5 May 2003, was in a state of moderate decomposition indicating it died well before 5 May 2003. Its cause of death was salmonella septicemia, and there was no evidence of acoustic trauma. Another porpoise, discovered at Port Angeles on 6 May 2003, was in a state of moderate decomposition indicating that this porpoise died prior to 5 May 2003. One stranded harbor porpoise discovered fresh at Dungeness on 6 May 2003 is the only animal that could potentially be linked in time to SHOUP’s 5 May 2003 active sonar use. Necropsy results for this porpoise found no evidence of acoustic trauma. Both the Port Angeles and Dungeness locations are known common harbor porpoise stranding sites. The remaining eight strandings were discovered 1 to 3 weeks after SHOUP’s 5 May 2003 Haro Strait transit and, therefore, cannot be causally linked in time. Two of the eight died from blunt trauma injury. A third suffered from parasitic infestation possibly contributing to its death (National Marine Fisheries Service, 2003: Appendix F). Of the remaining five, NMFS was unable to identify the causes of death.

As a result of the allegations regarding SHOUP, NMFS initiated a necropsy study involving 11 of the stranded animals discovered between 2 May and 2 June 2003. The purposes of these examinations were to provide scientific data on the causes of death and to investigate whether physical evidence could be found to link the stranding events to “naval sonar activity” (National Marine Fisheries Service, 2003). The necropsies took place at the National Marine Mammal Laboratory in Seattle.

Findings

- None of the 11 necropsied harbor porpoise showed signs of acoustic trauma (National Marine Fisheries Service, 2003b).
- One of the animals had fibrinous peritonitis, one had salmonellosis, and another had profound necrotizing pneumonia (Norman et al., 2004).
- Two of the five had perimortem blunt trauma injury with associated broken bones in their heads (National Marine Fisheries Service, 2003b)
- No cause of death could be determined for the remaining six animals, which is consistent with the expected percentage in most marine mammal necropsies from the region (National Marine Fisheries Service, 2003b).

Conclusions

Examination and test results from 11 of the 15 harbor porpoises did not reveal any definitive signs of acoustic trauma associated with the mid-range active sonar on May 5, 2003 (Norman et al., 2004).

It is noted that this stranding event is quite different from other events in which sonar may have played a role. In contrast to the event in the Bahamas, there were no strandings of live harbor porpoises and animals were recovered sporadically over a period of 1 month (Norman et al., 2004). In addition, lesions associated with possible trauma from active sonar have not been seen previously in harbor porpoises (Norman et al., 2004).
4.0 Environmental Consequences, Open Ocean Area

July 3, 2004, Hanalei Bay, Kauai Stranding Event

The majority of the following information on the stranding event was provided by Dr. Robert Braun, NMFS Pacific Islands Fisheries Science Center in Honolulu, Hawaii. At Hanalei Bay, Kauai on the morning of July 3, 2004, two individuals attending a canoe blessing ceremony noted that as the ceremony began (on time at 7:00 a.m.); melon-headed whales were seen entering the bay (Braun, 2005). They reported that the whales entered across the center of the bay in a “wave” as if they were chasing fish (Braun, 2005). The whales were moving fast, but not at maximum speed.

At 6:45 a.m. on July 3, 2004, approximately 25 nm from Hanalei Bay, active sonar was tested briefly prior to the start of an ASW event; this was about 15 minutes before the whales were observed in Hanalei Bay. At the nominal swim speed for melon-headed whales (5 to 6 knots), the whales had to be within 1.5 to 2 nm of Hanalei Bay before the sonar at PMRF was activated. The whales were not in their open ocean habitat but had to be close to shore at 6:45 a.m. when the sonar was activated, to have been observed inside Hanalei Bay from the beach by 7:00 a.m. (Hanalei Bay is very large area).

The whales stopped in the southwest portion of the bay grouping tightly with lots of spy hopping and tail slapping. As people went in the water among the whales, spy hopping increased and the pod separated into two groups with individual animals moving between the two clusters (Braun, 2005). This continued through most of the day, with the animals slowly moving south and then southeast within the bay (Braun, 2005). By about 3:00 p.m. police arrived and kept people from interacting with the animals. At 4:45 p.m. on July 3, 2004, the RIMPAC Battle Watch Captain received a call from an NMFS representative in Honolulu, Hawaii, reporting the sighting of as many as 200 melon-headed whales in Hanalei Bay. At 4:47 p.m., out of caution, the Battle Watch Captain directed all ships in the area to cease all active sonar transmissions.

An NMFS representative arrived at Hanalei Bay at 7:20 p.m. on July 3, 2004, and observed a tight single pod 75 yards from the southeast side of the bay (Braun, 2005). The pod was circling in a tight group and there was frequent tail slapping and minimal spy hopping. Occasionally one or two sub-adult sized animals broke from the tight pod and came nearer the shore to apparently chase fish and be in the shore break (Braun, 2005). The pod stayed in the bay through the night of July 3, 2004.

On July 4, 2004, a 700–800-foot rope was constructed by weaving together beach morning glory vines. This vine rope was tied between two canoes and with the assistance of 30 to 40 kayaks, by about 11:30 a.m. on July 4, 2004, the pod was coaxed out of the bay (Braun, 2005).

The following morning on July 5, 2004, a very young melon-headed whale was found stranded dead on the beach at Hanalei. NMFS undertook a necropsy to attempt to determine cause of death. Preliminary findings indicated the cause of death was starvation (Farris, 2004) and this was later confirmed upon completion of the NMFS stranding report (Southall et al., 2006).

Findings

- Observers reported the whales entered across the center of the bay in a “wave” as if they were chasing fish (Braun, 2005).
• A simultaneous “stranding” of 500 to 700 melon headed whales and Risso’s dolphins occurred at Sasanhaya Bay, Rota, in the Northern Marianas Islands on the same morning as the Hanalei stranding. A pod of melon-headed whales entered Hilo Bay in the 1870s in a manner similar to the occurrence at Hanalei Bay in July 2004.

• There was a full moon, which may affect the behavior of melon-headed prey species, and a squid run on the evening before the stranding.

• There was no evidence of unusual harmful algal blooms (National Marine Fisheries Service, 2007j).

• A newborn melon-headed whale was found stranded dead on the beach at Hanalei after the whales were coaxed from the bay. Necropsy found the cause of death was starvation.

Conclusions

The calculated received level at Hanalei Bay from the sonar at PMRF was approximately 147.5 dB re 1 μPa²s at 1 m. Although it is not impossible, it is unlikely that the sound level from the sonar caused the whales to enter the bay. The area between the islands of Oahu and Kauai, and the PMRF training range have been used in past RIMPAC Exercises and are used year-round for ASW training using mid frequency active sonar. Melon-headed whales inhabiting the waters around Kauai are likely not naive to the sound of sonar and there has never been another stranding event associated in time with ASW training at Kauai or in the Hawaiian Islands.

Marine mammal strandings in Hawaii are relatively rare. Two melon-headed whales stranded at Hauula Beach on Oahu in August, 2003 (Honolulu Advertiser, 2004). A report of a pod entering Hilo Bay in the 1870s indicates that on at least one other occasion, melon-headed whales entered a bay in a manner similar to the occurrence at Hanalei Bay in July 2004. The simultaneous “stranding” of 500 to 700 melon headed whales and Risso’s dolphins at Sasanhaya Bay, Rota, in the Northern Marianas Islands on the same morning as the 2004 Hanalei stranding (Jefferson et al., 2006), suggests melon-headed whales entering shallow embayments may be an infrequent but not extraordinary event.

There are many possible causes for whales appearing in Hanalei Bay (such as following prey as initial reports suggested) and many possible causes for stranding, including sick individual members of a pod. Clearly the starvation death of a newborn whale was not caused by RIMPAC naval operations. There will be no definitive answers to why the whales entered Hanalei Bay on the morning of July 3, 2004. NMFS produced a report on this stranding in April 2006 (Southall et al., 2006). That report concluded that sonar use was a, “plausible, if not likely, contributing factor in what may have been a confluence of events” (Southall et al., 2006). Since that time the primary author has attempted to clarify that the NMFS Hanalei Report, “did not conclude that active military sonar caused this event” (Southall, 2006). The authors of the NMFS report were unaware, at the time of publication, of the simultaneous Rota stranding and had partially based their “plausible, if not likely” finding on the “anomalous nature of the stranding” and “the absence of other compelling causative explanation” (Southall et al., 2006). In light of the simultaneous Rota stranding, the Hanalei stranding is no longer anomalous in nature. In addition, the presence of a full moon (affecting the distribution of prey species) on the date of the stranding as subsequently noted by Southall (2006) and the whales having entering Hanalei Bay as if they were chasing fish, it would seem that in retrospect there are other more
4.0 Environmental Consequences, Open Ocean Area

North Carolina Marine Mammal Mass Stranding Event, January 15-16, 2005

Description
On January 15 and 16, 2005, 36 marine mammals comprised of 3 separate species (33 short-finned pilot whales, 1 minke whale, and 2 dwarf sperm whales) stranded alive on the beaches of North Carolina (National Marine Fisheries Service, 2007h; Hohn et al., 2006) distributed over a 69-mi area between the northern part of the state down to Cape Hatteras (National Marine Fisheries Service, 2007i). Thirty-one different species of marine mammals have been known to strand along the North Carolina coast since 1992; all three of the species involved in this stranding occasionally strand in this area (National Marine Fisheries Service, 2007i). This stranding event was determined to be a UME because live strandings of three different species in one weekend in North Carolina are extremely rare; in fact, it is the only stranding of offshore species to occur within a 2- to 3-day period in the region on record (National Marine Fisheries Service, 2007h; Hohn et al., 2006).

The Navy indicated that they were conducting tactical mid-frequency sonar operations from individual surface vessels over short durations and on a small scale within the general area and time period investigated (National Marine Fisheries Service, 2007h); these kinds of transmissions are not unusual for the area or time of year (National Marine Fisheries Service, 2007i). Marine mammal observers located on the Navy vessels reported that they did not detect any marine mammals (National Marine Fisheries Service, 2007h).

Findings
On January 16 and 17, 2005, 2 dwarf sperm whales, 27 pilot whales, and the single minke whale were necropsied and sampled. Because of the uniqueness of the stranding, 9 locations of interest within 25 stranded cetacean heads were examined closely. The only common finding in all of the heads was a form of sinusitis (National Marine Fisheries Service, 2007h).

- The pilot whales and the dwarf sperm whale were not considered to be emaciated, even though none of them had recently-eaten food in their stomachs (National Marine Fisheries Service, 2007h).
- The minke whale was emaciated, and it is believed that this was a dependant calf that had become separated from its mother, and was not a part of the other strandings (National Marine Fisheries Service, 2007h).
- Most biochemistry abnormalities indicated deteriorating conditions from being on land for an extended amount of time, and are believed to be a result of the stranding itself (National Marine Fisheries Service, 2007h).
- Three pilot whales showed signs of pre-existing systemic inflammation (National Marine Fisheries Service, 2007h).
- Lesions involving all organ systems were seen, but consistent lesions were not observed across species (National Oceanic and Atmospheric Administration, 2006; Hohn et al., 2006).
Cardiovascular disease was present in one pilot whale and one dwarf sperm whale, while musculoskeletal disease was present in two pilot whales (National Marine Fisheries Service, 2007h).

Parasites were found and collected from 26 pilot whales and 2 dwarf sperm whales; parasite loads were considered to be within normal limits for free-ranging cetaceans (National Marine Fisheries Service, 2007h).

There were no harmful algal blooms present along the coastline during the months prior to the strandings (National Marine Fisheries Service, 2007h; Hohn et al., 2006).

Environmental conditions that are consistent with conditions under which other mass strandings have occurred were present (a gently sloping shore, strong winds, and changes in up-welling to down-welling conditions) (National Marine Fisheries Service, 2007h).

Conclusions

Several whales had pre-existing conditions that may have contributed to the stranding, but were not determined to be the cause of the stranding event (National Oceanic and Atmospheric Administration, 2006; National Marine Fisheries Service, 2007i). The actual cause of death for many of the whales was determined to be a result of the stranding itself (National Marine Fisheries Service, 2007i). NMFS concluded that this mass stranding event occurred simultaneously in time and space with active mid-frequency sonar naval activities, and has several features in common with other possible sonar-related stranding events (National Marine Fisheries Service, 2007h). For this reason, along with the rarity of the event, NMFS believes that it is possible that there exists a causal rather than a coincidental association between naval sonar activity and the stranding event (National Marine Fisheries Service, 2007h). But they also acknowledge that there are differences in operational and environmental characteristics between this event and other possible sonar-related stranding events (National Marine Fisheries Service, 2007h), such as constricted channels (National Marine Fisheries Service, 2007i).

Even though the stranding occurred while active military sonar was being utilized off the North Carolina coast, the investigation team was unable to determine what role, if any, military activities played in the stranding events (Hohn et al., 2006). If mid-frequency sonar played a part in the strandings, sound propagation models indicated that received acoustic levels would depend heavily on the position of the whales relative to the source; however, because the exact location of the cetaceans is unknown it is impossible to estimate the level of their exposure to active sonar transmissions (National Marine Fisheries Service, 2007h). Evidence to support a definitive association is lacking, and consistent lesions across species and individuals that could indicate a single cause of the stranding were not found (National Marine Fisheries Service, 2007h).

Based on the physical evidence, it cannot be definitively determined if there is a causal link between the strandings and anthropogenic sonar activity and/or environmental conditions, or a combination of both (National Marine Fisheries Service, 2007h).

January 26, 2006, Spain

Description

The Spanish Cetacean Society reported an atypical mass stranding of four beaked whales that occurred January 26, 2006, on the southeast coast of Spain, near Mojacar (Gulf of Vera) in the
Western Mediterranean Sea. According to the report, two of the whales were discovered the evening of January 26 and were found to be still alive. Two other whales were discovered during the day on January 27, but had already died. A following report stated that the first three animals were located near the town of Mojacar and were examined by a team from the University of Las Palmas de Gran Canarias, with the help of the stranding network of Ecologistas en Acción Almería-PROMAR and others from the Spanish Cetacean Society. The fourth animal was found dead on the afternoon of May 27, a few kilometers north of the first three animals.

From January 25-26, 2006, Standing North Atlantic Treaty Organization (NATO) Response Force Maritime Group Two (five of seven ships including one U.S. ship under NATO Operational Control) had conducted active sonar training against a Spanish submarine within 50 nm of the stranding site.

Findings
Veterinary pathologists necropsied the two male and two female beaked whales (Ziphius cavirostris, family Ziphiidae).

Conclusions
According to the pathologists, the most likely primary cause of this type of beaked whale mass stranding event is anthropogenic acoustic activities, most probably anti-submarine active mid-frequency sonar used during the military naval exercises. However, no positive acoustic link was established as a direct cause of the stranding.

Even though no causal link can be made between the stranding event and naval exercises, certain conditions may have existed in the exercise area that, in their aggregate, may have contributed to the marine mammal strandings (Freitas, 2004).

- Operations were conducted in areas of at least 547 fathoms depth near a shoreline where there is a rapid change in bathymetry on the order of 547 to 3,281 fathoms occurring a cross a relatively short horizontal distance (Freitas, 2004).
- Multiple ships (in this instance, five) were operating (in this case, mid-frequency active sonar) in the same area over extended periods of time (in this case, 20 hours) in close proximity.
- Exercises took place in an area surrounded by landmasses, or in an embayment. Operations involving multiple ships employing mid-frequency active sonar near land may produce sound directed towards a channel or embayment that may cut off the lines of egress for marine mammals (Freitas, 2004).

Causal Associations for Stranding Events
Several stranding events have been associated with Navy sonar activities, but relatively few of the total stranding events that have been recorded occurred spatially or temporally with Navy sonar activities. While sonar may be a contributing factor under certain rare conditions, the presence of sonar is not a necessary condition for stranding events to occur.
A review of past stranding events associated with sonar suggests that the potential factors that may contribute to a stranding event are steep bathymetry changes, narrow channels with limited egress avenues, multiple sonar ships, surface ducting, and the presence of beaked whales that in some geographic locations may be more susceptible to sonar exposures. The most important factors appear to be the presence of a narrow channel (e.g., Bahamas and Madeira Island, Portugal) that may prevent animals from avoiding sonar exposure and multiple sonar ships within that channel. There are no narrow channels (less than 35 nm wide and 10 nm in length) in the HRC and the ships would be spread out over a wider area, allowing animals to move away from sonar activities if they choose. In addition, beaked whales may not be more susceptible to sonar but may favor habitats that are more conducive to sonar effects.

The RIMPAC Exercises have been conducted every other year since 1968 in the HRC, and along with other ASW training events have only been implicated in one stranding event which may have been simply animals following prey into a bay (Braun, 2005; Southall et al., 2006). Given the large military presence and private and commercial vessel traffic in the Hawaiian waters it is likely that a mass stranding event would be detected. Therefore, it is unlikely that the conditions that may have contributed to past stranding events involving Navy sonar would be present in the HRC.

4.1.2.4.12 Marine Mammal Mitigation Measures Related To Acoustic and Explosive Exposures

Chapter 6.0 provides the complete sonar and explosives mitigation measures for the HRC. The following paragraphs provide summary information about these mitigation measures.

4.1.2.4.12.1 Acoustic Exposure Mitigation Measures

Effective training in the HRC dictates that ship, submarine, and aircraft participants utilize their sensors and train with their weapons to their optimum capabilities as required by the mission. The Navy recognizes that such use has the potential to cause behavioral disruption of some marine mammal species in the vicinity of an operation. As part of their SOPs, the Navy has developed mitigation measures that would be implemented to protect marine mammals and Federally listed species during ASW operations. These mitigation measures, which are part of the No-action Alternative, include the establishment of a safety zone and procedures to power down or shut off sonar if animals are detected within the safety zone. For detailed list of mitigation measures see Chapter 6.0. While conducting ASW operations, Navy ships always have two, although usually more, personnel on watch serving as lookouts. In addition to the qualified lookouts, the bridge team is present at a minimum also includes an Officer of the Deck and one Junior Officer of the Deck include observing the waters in the vicinity of the ship. At night, personnel engaged in ASW events may also use night vision goggles and infra-red detectors, as appropriate, which can aid in the detection of marine mammals. Passive acoustic detection of vocalizing marine mammals is used to alert bridge lookouts to the potential presence of marine mammals in the vicinity.

Navy lookouts undergo extensive training to qualify as a watchstander. This training includes on-the-job instruction under the supervision of an experienced watchstander, followed by completion of the Personal Qualification Standard program. The Navy includes marine species awareness as part of its training for its bridge lookout personnel on ships and submarines as required training for Navy lookouts. This training addresses the lookout’s role in environmental
Operating procedures are implemented to maximize the ability of personnel to recognize instances when marine mammals are close aboard and avoid adverse effects. These procedures include measures such as decreasing the source level and then shutting down active tactical sonar operations when marine mammals are encountered in the vicinity of a training event. Although these mitigation measures are SOPs, their use is also reinforced through promulgation of an Environmental Annex to the Operational Order for an operation. Sonar operators on ships, submarines, and aircraft use both passive and active sonar detection indicators of marine mammals as a measure of estimating when marine mammals are close. When marine mammals are detected nearby, all ships, submarines, and aircraft engaged in ASW will reduce mid-frequency active sonar power levels in accordance with specific guidelines developed for each type of training event.

If a stranding were to occur in the HRC where there was clear and credible available evidence implicating active sonar in the stranding event, the Navy will cease use of active sonar events in the vicinity of the stranding.

NMFS and the Navy will continue coordination on the “Communications and Response Protocol for Stranded Marine Mammal Events During Navy Operations in the Pacific Islands Region” that was prepared by NMFS Pacific Region Pacific Island Region Office to facilitate communication during RIMPAC 2006. The Navy will continue to coordinate with the Hawaii NMFS Stranding Coordinator for any unusual marine mammal behavior, including stranding, beached live or dead cetaceans, floating marine mammals, or out-of-habitat/milling live cetaceans that may occur during or shortly after Navy activities in the vicinity of the stranding.

**Long-Term Effects**

Navy Operations are conducted in the same general areas throughout the HRC, so marine mammal populations can be exposed to repeated operations over time. However, as described earlier, this HRC EIS/OEIS assumes that short-term non-injurious sound exposure levels predicted to cause TTS or temporary behavioral disruptions qualify as Level B harassment. Application of this criterion assumes an effect even though it is highly unlikely that all behavioral disruptions or instances of TTS will result in long-term significant impacts. There are resident populations of spinner dolphins and beaked whales in several areas throughout the HRC (Andrews et al., 2006; Baird et al., 2007) that have been exposed to Navy activities but continue to use those areas and increasing numbers of humpbacks in the Hawaiian Islands (Mobley 2004). Although this suggest that Navy activities do not have a long-term effect on marine mammals it does not unequivocally confirm this assumption. There will be long-term monitoring program of the marine mammal populations within the HRC.

**Likelihood of Prolonged Exposure**

The proposed ASW operations in the HRC would not result in prolonged exposure because the vessels are constantly moving, and the flow of the activity in the HRC when ASW training occurs reduces the potential for prolonged exposure. The implementation of the mitigation measures described in Chapter 6.0 would further reduce the likelihood of any prolonged exposure.
4.1.2.4.12.2 Explosive Source Mitigation Measures

As part of the official Navy clearance procedure before an underwater detonation or Live Fire Exercise, the target area must be inspected visually (from vessels and available aircraft) and determined to be clear. The required clearance zone at the target areas, and operations within controlled ranges, minimizes the risk to marine mammals. Open ocean clearance procedures are the same for live or inert ordnance. Whenever ships and aircraft use the ranges for missile and gunnery practice, the weapons are used under controlled circumstances involving clearance procedures to ensure cetaceans, pinnipeds, or sea turtles are not present in the target area. These involve, at a minimum, a detailed visual search of the target area by aircraft reconnaissance, range safety boats, and range controllers and passive acoustic monitoring.

Ordnance cannot be released until the target area is determined clear. Operations are immediately halted if cetaceans, pinnipeds, or sea turtles are observed within the target area. Operations are delayed until the animal clears the target area. All observers are in continuous communication in order to have the capability to immediately stop the operations. The operation can be modified as necessary to obtain a clear target area. If the area cannot be cleared, it is canceled. All of these factors serve to avoid the risk of harming cetaceans, pinnipeds, or sea turtles. Most underwater detonations take place in sandy areas that are generally not used by marine mammals. All of these factors serve to avoid the risk of harming cetaceans, pinnipeds, or sea turtles. Post event monitoring of underwater detonations have not observed any mortality.

The weapons used in most missile and Live Fire Exercises pose little risk to marine mammals unless they were to be near the surface at the point of impact. Machine guns (0.50 caliber), 5-inch guns, 76-mm guns, and close-in weapons systems (anti-missile systems) exclusively fire non-explosive ammunition. The same applies to larger weapons firing inert ordnance for training operations. The rounds pose an extremely low risk of a direct hit and potential to directly affect a marine species. Target area clearance procedures will reduce this risk. A SINKEX uses a variety of live fire weapons. These rounds pose a risk only at the point of impact. Target area clearance procedures will reduce this risk. Modeling results of the potential exposures of marine mammals to underwater sound from a SINKEX are summarized in Section 4.1.2.5.1 (Table 4.1.2.5.1-2).

The Navy has developed a mitigation plan to maximize the probability of sighting any ships or protected species in the vicinity of an operation. In order to minimize the likelihood of taking any threatened or endangered species that may be in the area, the following monitoring plan will be adhered to:

- All weapons firing will be conducted during the period 1 hour after official sunrise to 30 minutes before official sunset.
- Extensive range clearance operations will be conducted in the hours prior to commencement of the operation, ensuring that no shipping is located within the hazard range of the longest-range weapon being fired for that event.
- An exclusion zone with a radius of 1.0 nm will be established around each target. This exclusion zone is based on calculations using a 990 lb H6 net explosive weight high explosive source detonated 5 ft below the surface of the water, which yields a distance of 0.85 nm (cold season) and 0.89 nm (warm season) beyond which the
4.0 Environmental Consequences, Open Ocean Area

received level is below the 182 dB re: 1 μPa²-s threshold established for the WINSTON S. CHURCHILL (DDG 81) shock trials. An additional buffer of 0.5 nm will be added to account for errors, target drift, and animal movements. Additionally, a safety zone, which extends from the exclusion zone at 1.0 nm out an additional 0.5 nm, will be surveyed. Together, the zones extend out 2 nm from the target.

A series of surveillance over-flights would be conducted within the exclusion and the safety zones, prior to and during the operation, when feasible. Survey protocol will be as follows:

- All visual surveillance operations will be conducted by Navy personnel trained in visual surveillance. In addition to the over flights, the exclusion zone will be monitored by passive acoustic means, when assets are available.
- If a protected species observed within the exclusion zone is diving, firing will be delayed until the animal is re-sighted outside the exclusion zone, or 30 minutes has elapsed. After 30 minutes, if the animal has not been re-sighted it will be assumed to have left the exclusion zone. This is based on a typical dive time of 30 minutes for traveling listed species of concern. The Officer conducting the exercise will determine if the listed species is in danger of being adversely affected by commencement of the operation.

There is a long lead-time for set up and clearance of the impact area before any event using explosives takes place (may be one to several hours). There will, therefore, be a long period of area monitoring before any detonation or live-fire event begins. Ordinance cannot be released until the target area is determined clear. Operations are immediately halted if marine mammals are observed within the target area. Operations are delayed until the animal clears the target area.

4.1.2.4.13 Sonar Marine Mammal Modeling

4.1.2.4.13.1 Active Acoustic Devices

Tactical military sonars are designed to search for, detect, localize, classify, and track submarines. There are two types of sonars, passive and active:

- Passive sonars only listen to incoming sounds and, since they do not emit sound energy in the water, lack the potential to acoustically affect the environment.
- Active sonars generate and emit acoustic energy specifically for the purpose of obtaining information concerning a distant object from the received and processed reflected sound energy.

Modern sonar technology has developed a multitude of sonar sensor and processing systems. In concept, the simplest active sonars emit omni-directional pulses (“pings”) and time the arrival of the reflected echoes from the target object to determine range. More sophisticated active sonar emits an omni-directional ping and then rapidly scans a steered receiving beam to provide directional, as well as range, information. More advanced sonars transmit multiple preformed beams, listening to echoes from several directions simultaneously and providing efficient detection of both direction and range.
The tactical military sonars to be deployed in during testing and training in the HRC are designed to detect submarines in tactical operational scenarios. This task requires the use of the sonar mid-frequency range (1 kHz to 10 kHz) predominantly. The types of tactical acoustic sources that would be used in training events are discussed in the following paragraphs.

- **Surface Ship Sonars.** A variety of surface ships participate in testing and training events, including guided missile cruisers, destroyers, guided missile destroyers, and frigates. Some ships (e.g., aircraft carriers) do not have any onboard active sonar systems, other than fathometers. Others, like guided missile cruisers, are equipped with active as well as passive sonars for submarine detection and tracking. For purposes of the analysis, all surface ship sonars were modeled as equivalent to SQS-53 having the nominal source level of 235 dB re 1 μPa at 1 m. Since the SQS-53 hull-mounted sonar is the Navy’s most powerful surface ship hull-mounted sonar, modeling this source is a conservative assumption tending towards an overestimation of potential effects. Sonar ping transmission durations were modeled as lasting 1 second per ping and omni-directional, which is a conservative assumption that will overestimate potential effects. Actual ping durations will be less than 1 second. The SQS-53 hull-mounted sonar transmits at center frequencies of 2.6 kHz and 3.3 kHz. Effects analysis modeling used frequencies that are required in tactical deployments such as those during RIMPAC and USWEX. Details concerning the tactical use of specific frequencies and the repetition rate for the sonar pings is classified but was modeled based on the required tactical training setting.

- **Submarine Sonars.** Submarine sonars are used to detect and target enemy submarines and surface ships. Because submarine active sonar use is very rare and in those rare instances, very brief, it is extremely unlikely that use of active sonar by submarines would have any measurable effect on marine mammals. Therefore, this type of sonar was not modeled for the HRC.

- **Aircraft Sonar Systems.** Aircraft sonar systems that would operate in the HRC include sonobuoys and dipping sonar. Sonobuoys may be deployed by maritime patrol aircraft or helicopters; dipping sonars are used by carrier-based helicopters. A sonobuoy is an expendable device used by aircraft for the detection of underwater acoustic energy and for conducting vertical water column temperature measurements. Most sonobuoys are passive, but some can generate active acoustic signals, as well as listen passively. Dipping sonar is an active or passive sonar device lowered on cable by helicopters to detect or maintain contact with underwater targets. During ASW training, these systems active modes are only used briefly for localization of contacts and are not used in primary search capacity. Because active mode dipping sonar use is very brief, it is extremely unlikely its use would have any effect on marine mammals. However, the AN/AQS-22 dipping sonar was modeled based on estimated use during major exercises within the HRC.

- **Torpedoes.** Torpedoes are the primary ASW weapon used by surface ships, aircraft, and submarines. The guidance systems of these weapons can be autonomous or electronically controlled from the launching platform through an attached wire. The autonomous guidance systems are acoustically based. They operate either passively, exploiting the emitted sound energy by the target, or actively, ensonifying the target and using the received echoes for guidance. Potential impacts from the use of torpedoes on the PMRF range areas were analyzed in the PMRF EIS and, consistent with NOAA’s June 3, 2002, ESA Section
7 letter to the Navy for RIMPAC 2002 and the RIMPAC 2006 Biological Opinion, the Navy determined that the activities are not likely to adversely affect ESA listed species under the jurisdiction of the NMFS. The MK-48 torpedo was modeled for active sonar transmissions during specified training operations within the HRC.

- **Acoustic Device Countermeasures (ADC).** ADCs are, in effect, submarine simulators that make sound to act as decoys to avert localization and/or torpedo attacks. Previous classified analysis has shown that, based on the operational characteristics (source output level and/or frequency) of these acoustic sources, the potential to affect marine mammals was unlikely.

- **Training Targets.** ASW training targets are used to simulate target submarines. They are equipped with one or a combination of the following devices: (1) acoustic projectors emanating sounds to simulate submarine acoustic signatures; (2) echo repeaters to simulate the characteristics of the echo of a particular sonar signal reflected from a specific type of submarine; and (3) magnetic sources to trigger magnetic detectors. Based on the operational characteristics (source output level and/or frequency) of these acoustic sources, the potential to affect marine mammals is unlikely, and therefore they were not modeled for this analysis. Consistent with NOAA’s June 3, 2002, ESA Section 7 letter to the Navy for RIMPAC 2002 and the RIMPAC 2006 Biological Opinion, the Navy determined that the activities are not likely to adversely affect ESA listed species under the jurisdiction of NMFS.

- **Range Sources.** Range pingers are active acoustic devices that allow each of the in-water platforms on the range (e.g., ships, submarines, target simulators, and exercise torpedoes) to be tracked by the range transducer nodes. In addition to passively tracking the pinger signal from each range participant, the range transducer nodes also are capable of transmitting acoustic signals for a limited set of functions. These functions include submarine warning signals, acoustic commands to submarine target simulators (acoustic command link), and occasional voice or data communications (received by participating ships and submarines on range).

  Based on the operational characteristics (source output level and/or frequency) of these acoustic sources, the potential to affect marine mammals is unlikely, and therefore they were not modeled for this analysis. Consistent with NOAA’s June 3, 2002, ESA Section 7 letter to the Navy for RIMPAC 2002 and the RIMPAC 2006 Biological Opinion, the Navy determined that the activities are not likely to adversely affect ESA listed or MMPA protected species under the jurisdiction of NMFS.

### 4.1.2.4.13.2 Sonar Modeling Methodology

Modeling of the effects of mid frequency sonar and underwater detonations was conducted using methods described in brief below. A detailed description of the representative modeling areas, sound sources, model assumptions, acoustic and oceanographic parameters, underwater sound propagation and transmission models, and diving behavior of species modeled are presented in Appendix J.

The approach for estimating potential acoustic effects from HRC ASW training operations on cetacean species makes use of the methodology that was developed in cooperation with NOAA for the Navy’s USWTR Draft OEIS/EIS (2005), USWEX EA/OEA (U.S. Department of the Navy, 2005a), RIMPAC EA/OEA (U.S. Department of the Navy, Commander Third Fleet, 2006) and COMPTUEX/JTFEX EA/OEA (2007). The methodology is provided here to determine the number and species of marine mammals for which incidental take authorization is requested.
In order to estimate acoustic effects from the HRC ASW operations, acoustic sources to be used were examined with regard to their operational characteristics as described in the previous section. In addition, ship systems such as fathometers, with acoustic source levels below 205 dB re 1 μPa at 1 m were not included in the analysis given that at this source level (205 dB re 1 μPa at 1 m) or below, a ping would attenuate below the dose function cutoff threshold for the majority of the species, with a received level of approximately 145 dB within a distance of about 3,281 ft, which is also the Navy’s current sonar mitigation safety zone.

In addition, systems with an operating frequency greater than 100 kHz were not analyzed in the detailed modeling as these signals attenuate rapidly resulting in very short propagation distances. Acoustic countermeasures were previously examined and found not to be problematic. These acoustic sources, therefore, did not require further examination in this analysis.

Based on the information above, only AN/SQS 53C hull-mounted mid-frequency active tactical sonar, DICASS sonobuoy, MK-48 torpedo, and AN/AQS 21 (dipping sonar) were determined to have the potential to affect marine mammals protected under the MMPA and ESA during HRC ASW training events.

For modeling purposes, sonar parameters (source levels, ping length, the interval between pings, output frequencies, etc.) were based on records from training events, previous exercises, and preferred ASW tactical doctrine to reflect the sonar use expected to occur during events in the HRC. The actual sonar parameters such as output settings, distance between ASW surface, subsurface, and aerial units, their deployment patterns, and the coordinated ASW movement (speed and maneuvers) across the exercise area are classified, however, modeling used to calculate exposures to marine mammals employed actual and preferred parameters to which the participants are trained and have in the past, used during ASW events in the HRC.

For discussion purposes surface ship sonars can be considered as having the nominal source level of 235 dB re 1 μPa²-s at 1 m, transmitting a 1-second omnidirectional ping at center frequencies of 2.6 kHz and 3.3 kHz, with 30 seconds between pings.

Every active sonar operation includes the potential to expose marine animals in the neighboring waters. The number of animals exposed to the sonar in any such action is dictated by the propagation field and the manner in which the sonar is operated (i.e., source level, depth, frequency, pulse length, directivity, platform speed, repetition rate).

The modeling for surface ship active tactical sonar occurred in five broad steps, listed below. Results were calculated based on the typical ASW operations planned for the HRC. Acoustic propagation and mammal population data are analyzed for both the summer and winter timeframe. Marine mammal survey data for the offshore area beyond 25 nm (Barlow, 2006) and survey data for offshore areas within 25 nm (Mobley et al., 2000) provided marine mammal species density for modeling.

Step 1. Environmental Provinces. The Hawaii Operating Area (OPAREA) is divided into six marine modeling areas, and each has a unique combination of environmental conditions. These are addressed by defining eight fundamental environments in two seasons that span the variety of depths, bottom types, sound speed profiles, and
sediment thicknesses found in the Hawaii OPAREA. Each marine modeling area can be quantitatively described as a unique combination of these environments.

Step 2. Transmission Loss. Since sound propagates differently in these eight environments, separate transmission loss calculations must be made for each, in both seasons. The transmission loss is predicted using CASS-GRAB sound modeling software.

Step 3. Exposure Volumes. The transmission loss, combined with the source characteristics, gives the energy field of a single ping. The energy of over 10 hours of pinging is summed, carefully accounting for overlap of several pings, so an accurate average exposure of an hour of pinging is calculated for each depth increment. Repeating this calculation for each environment in each season gives the hourly ensonified volume, by depth, for each environment and season.

Step 4. Marine Mammal Densities. The marine mammal densities were given in two dimensions, but using sources such as the North Pacific Acoustic Laboratory EIS, the depth regimes of these marine mammals are used to project the two dimensional densities into three dimensions.

Step 5. Exposure Calculations. Each marine mammal’s three dimensional density is multiplied by the calculated impact volume—to that marine mammal depth regime. This is the number of exposures per hour for that particular marine mammal. In this way, each marine mammal's exposure count per hour is based on its density, depth habitat, and the ensonified volume by depth.

The movement of various units during an ASW event is largely unconstrained and dependent on the developing tactical situation presented to the commander of the forces. The planned sonar hours, by ASW operation type, are given in the discussion for each type of operation for each alternative. The product of the hours of sonar and the hourly exposure count from the model provides the total exposures.

4.1.2.4.14 Explosive Source Marine Mammal Modeling

Underwater detonation activities can occur at various depths depending on the activity (SINKEX and mine neutralization), but may also include activities which may have detonations at or just below the surface (SINKEX, GUNEX, or MISSILEX).

4.1.2.4.14.1 Explosive Source Exercises

The exercises that use explosives are described in the following paragraphs.

Sink Exercise (SINKEX)

In a SINKEX, a specially prepared, deactivated vessel is deliberately sunk using multiple weapons systems. The exercise provides training to ship and aircraft crews in delivering live ordnance on a real target. The target is a decommissioned and empty, cleaned, and environmentally-remediated ship hulk. It is towed to sea and set adrift at the SINKEX location. The duration of a SINKEX is unpredictable since it ends when the target sinks, sometimes immediately after the first weapon impact and sometimes only after multiple impacts by a variety
of weapons. Typically, the exercise lasts for 4 to 8 hours over 1 to 2 days. SINKEXs occur only occasionally during HRC exercises.

Some or all of the following weapons may be employed in a SINKEX:

- Three Harpoon surface-to-surface and air-to-surface missiles
- Two to eight air-to-surface Maverick missiles
- Two to four MK-82 General Purpose Bombs
- Two Hellfire air-to-surface missiles
- One SLAM-ER air-to-surface missile
- Two-hundred and fifty rounds for a 5-inch gun
- One MK-48 heavyweight submarine-launched torpedo

**Air-to-Surface Gunnery Exercise (A-S GUNEX)**

Air-to-Surface GUNEX operations are conducted by rotary-wing aircraft against stationary targets (Floating At-Sea Target [FAST] and smoke buoy). Rotary-wing aircraft involved in this operation would include a single SH-60 using either 7.62-mm or 0.50-caliber door-mounted machine guns. A typical GUNEX will last approximately 1 hour and involve the expenditure of approximately 400 rounds of 0.50-caliber or 7.62-mm ammunition. Due to the small size of these rounds, they are not considered to have an underwater detonation impact.

**Surface-to-Surface Gunnery Exercise (S-S GUNEX)**

Surface GUNEX take place in the open ocean to provide gunnery practice for Navy and Coast Guard ship crews. GUNEX training operations conducted in the Offshore OPAREA involve stationary targets such as a MK-42 FAST or a MK-58 marker (smoke) buoy. The gun systems employed against surface targets include the 5-inch, 76 millimeter (mm), 25-mm chain gun, 20-23 mm Close-in Weapon System, and 0.50 caliber machine gun. Typical ordnance expenditure for a single GUNEX is a minimum of 21 rounds of 5-inch or 76-mm ammunition, and approximately 150 rounds of 25-mm or .50-caliber ammunition. Both live and inert training rounds are used. After impacting the water, the rounds and fragments sink to the bottom of the ocean. A GUNEX lasts approximately 1 to 2 hours, depending on target services and weather conditions. The 5-inch and 76-mm rounds are considered in the underwater detonation modeling.

**Naval Surface Fire Support Exercise**

Navy surface combatants conduct fire support exercise operations at PMRF on a virtual range against “Fake Island,” located on Barking Sands Tactical Underwater Range (BARSTUR). Fake Island is unique in that it is a virtual landmass simulated in three dimensions. Ships conducting fire support exercise training against targets on the island are given the coordinates and elevation of targets. PMRF is capable of tracking fired rounds to an accuracy of 30 ft. The 5-inch and 76-mm rounds fired into ocean during this exercise are considered in the underwater detonation modeling.
Air-to-Surface Missile Exercise (A-S MISSILEX)

The Air-to-Surface Missile Exercise (A-S MISSILEX) consists of the attacking platform releasing a forward-fired, guided weapon at the designated towed target. The exercise involves locating the target, then designating the target, usually with a laser.

A-S MISSILEX training that does not involve the release of a live weapon can take place if the attacking platform is carrying a captive air training missile (CATM) simulating the weapon involved in the training. The CATM MISSILEX is identical to an LFX in every aspect except that a weapon is not released. The operation requires a laser-safe range as the target is designated just as in an LFX.

From 1 to 16 aircraft, carrying live, inert, or CATMs, or flying without ordnance (dry runs) are used during the exercise. At sea, seaborne powered targets (SEPTARs), Improved Surface Towed Targets (ISTTs), and excess ship hulks are used as targets. A-S MISSILEX assets include helicopters and/or 1 to 16 fixed wing aircraft with air-to-surface missiles and anti-radiation missiles (electromagnetic radiation source seeking missiles). When a high-speed anti-radiation missile (HARM) is used, the exercise is called a HARMEX. Targets include SEPTARs, ISTTs, and excess ship hulks.

Surface-to-Surface Missile Exercise (S-S MISSILEX)

Surface-to-surface missile exercise (S-S MISSILEX) involves the attack of surface targets at sea by use of cruise missiles or other missile systems, usually by a single ship conducting training in the detection, classification, tracking, and engagement of a surface target. Engagement is usually with Harpoon missiles or Standard missiles in the surface-to-surface mode. Targets could include virtual targets or the SEPTAR or ship deployed surface target. S-S MISSILEX training is routinely conducted on individual ships with embedded training devices.

S-S MISSILEX could include 4 to 20 surface-to-surface missiles, SEPTARs, a weapons recovery boat, and a helicopter for environmental and photo evaluation. All missiles are equipped with instrumentation packages or a warhead. Surface-to-air missiles can also be used in a surface-to-surface mode. S-S MISSILEX activities are conducted within PMRF Warning Area W-188. Each exercise typically lasts 5 hours. Future S-S MISSILEX could range from 4 to 35 hours.

Bombing Exercise (BOMBEX)

Fixed-wing aircraft conduct bombing exercise (BOMBEX [Sea]) operations against stationary targets (MK 42 FAST or MK 58 smoke buoy) at sea. An aircraft will clear the area, deploy a smoke buoy or other floating target, and then set up a racetrack pattern, dropping on the target with each pass. At PMRF, a range boat might be used to deploy the target for an aircraft to attack.

Mine Neutralization

Mine Neutralization operations involve the detection, identification, evaluation, rendering safe, and disposal of mines and unexploded ordnance that constitutes a threat to ships or personnel. Mine neutralization training can be conducted by a variety of air, surface and sub-surface assets.
Tactics for neutralization of ground or bottom mines involve the diver placing a specific amount of explosives, which when detonated underwater at a specific distance from a mine results in neutralization of the mine. Floating, or moored, mines involve the diver placing a specific amount of explosives directly on the mine. Floating mines encountered by Fleet ships in open-ocean areas will be detonated at the surface. In support of an expeditionary assault, divers and Navy marine mammal assets deploy in very shallow water depths (10 to 40 ft) to locate mines and obstructions. Divers are transported to the mines by boat or helicopter. Inert dummy mines are used in the exercises. The total net explosive weight used against each mine ranges from less than 1 to 20 lb.

Various types of surveying equipment may be used during RIMPAC. Examples include the Canadian Route Survey System that hydrographically maps the ocean floor using multi-beam side scan sonar and the Bottom Object Inspection Vehicle used for object identification. These units can help in supporting mine detection prior to Special Warfare Operations (SPECWAROPS) and amphibious exercises.

Mine neutralization operations take place offshore in the Pu`uloa Underwater Range (called Keahi Point in earlier documents); Naval Station Pearl Harbor; Lima Landing; Barbers Point Underwater Range off-shore of Coast Guard Air Station Barbers Point/Kalaeloa Airport (formerly Naval Air Station Barbers Point); PMRF, Kauai (Majors Bay area); PMRF and Oahu Training Areas; and in Open Ocean Areas.

All demolition activities are conducted in accordance with Commander Naval Surface Forces Pacific Instruction 3120.8F, Procedures for Disposal of Explosives at Sea/Firing of Depth Charges and Other Underwater Ordnance (U.S. Department of the Navy, 2003). Before any explosive is detonated, divers are transported a safe distance away from the explosive. Standard practices for tethered mines in Hawaiian waters require ground mine explosive charges to be suspended 10 ft below the surface of the water.

Extended Echo Ranging and Improved Extended Echo Ranging (EER/IEER) SSQ-110

The Extended Echo Ranging and Improved Extended Echo Ranging (EER/IEER) Systems are airborne ASW systems used in conducting “large area” searches for submarines. These systems are made up of airborne avionics ASW acoustic processing and sonobuoy types that are deployed in pairs. The IEER System’s active sonobuoy component, the AN/SSQ-110 Sonobuoy, would generate a sonar “ping” and the passive AN/SSQ-101 ADAR Sonobuoy would “listen” for the return echo of the sonar ping that has been bounced off the surface of a submarine. These sonobuoys are designed to provide underwater acoustic data necessary for naval aircrews to quickly and accurately detect submerged submarines. The sonobuoy pairs are dropped from a fixed-wing aircraft into the ocean in a predetermined pattern with a few buoys covering a very large area. The AN/SSQ-110 Sonobuoy Series is an expendable and commandable sonobuoy. Upon command from the aircraft, the bottom payload is released to sink to a designated operating depth. A second command is required from the aircraft to cause the second payload to release and detonate generating a “ping.” There is only one detonation in the pattern of buoys at a time.

Mitigation measures and modeling approaches are still being coordinated between the Navy and NMFS. Standard practice is that EER/IEER are not/will not be used during the winter months.
when humpback whales and other mysticetes are present. In addition, buoys are not dropped or activated if marine species are observed or marine mammals are acoustically detected.

For a separate but otherwise identical action, modeling of exposures from EER/IEER was undertaken for analysis of the JTFEX/COMPTUEX series of exercises in the waters of Southern California. Based on the results from modeling for Southern California where the densities of marine mammals are three orders of magnitude higher than in the HRC, there were only a few exposures resulting from the modeling. For the HRC where the density of marine mammals is much less, incorporating seasonal restrictions during the winter months when humpback and other mysticetes are present, along with the SOP mitigation measures (such as command detonating the buoys only when marine mammals are not observed in the area or heard acoustically), it is very unlikely there will be any exposures exceeding the current regulatory thresholds or of consequence to marine species. This conclusion will be confirmed through subsequent review and modeling or otherwise revised as necessary before completion of the Final HRC EIS/OEIS.

**4.1.2.4.14.2 Explosive Source Modeling Criteria**

As described in Section 4.1.2.3 for sea turtles there are several criterions for mortality, injury and TTS. The criterion for mortality for marine mammals used in the Churchill Final EIS (U.S. Department of the Navy, 2001c) is “onset of severe lung injury.” This is conservative in that it corresponds to a 1 percent chance of mortal injury, and yet any animal experiencing onset severe lung injury is counted as a lethal exposure.

- The threshold is stated in terms of the Goertner (1982) modified positive impulse with value “indexed to 31 psi-ms.” Since the Goertner approach depends on propagation, source/animal depths, and animal mass in a complex way, the actual impulse value corresponding to the 31-psi-ms index is a complicated calculation. Again, to be conservative, CHURCHILL used the mass of a calf dolphin (at 27 lb), so that the threshold index is 30.5 psi-ms.

Two criteria are used for injury: onset of slight lung hemorrhage and 50 percent eardrum rupture (TM rupture). These criteria are considered indicative of the onset of injury.

- The threshold for onset of slight lung injury is calculated for a small animal (a dolphin calf weighing 27 lb), and is given in terms of the “Goertner modified positive impulse,” indexed to 13 psi-ms in the (U.S. Department of the Navy, 2001a). This threshold is conservative since the positive impulse needed to cause injury is proportional to animal mass, and therefore, larger animals require a higher impulse to cause the onset of injury.

- The threshold for TM rupture corresponds to a 50 percent rate of rupture (i.e., 50 percent of animals exposed to the level are expected to suffer TM rupture); this is stated in terms of an EL value of 205 dB re 1 μPa²-s. The criterion reflects the fact that TM rupture is not necessarily a serious or life-threatening injury, but is a useful index of possible injury that is well correlated with measures of permanent hearing impairment (e.g., Ketten, 1998 indicates a 30 percent incidence of PTS at the same threshold).
Two criteria are considered for non-injurious harassment: TTS, which is a temporary, recoverable, loss of hearing sensitivity (National Marine Fisheries Service, 2001; U.S. Department of the Navy, 2001a).

- The first criterion for TTS is 182 dB re 1 μPa² s maximum EL level in any 1/3-octave band at frequencies >100 Hz for sea turtles.
- A second criterion for estimating TTS threshold: 12 pounds per square inch (psi) peak pressure was developed for 10,000-lb charges as part of the Churchill Final EIS (U.S. Department of the Navy, 2001a, [FR70/160, 19 Aug 05; FR 71/226, 24 Nov 06]). It was introduced to provide a safety zone for TTS when the explosive or the animal approaches the sea surface (for which case the explosive energy is reduced but the peak pressure is not). Navy policy is to use a 23 psi criterion for explosive charges less than 2,000 lb and the 12 psi criterion for explosive charges larger than 2,000 lb. All explosives modeled for the HRC EIS/OEIS are less than 1,500 lb.

4.1.2.5 MARINE MAMMALS NO-ACTION ALTERNATIVE
(BIOLOGICAL RESOURCES—OPEN OCEAN)

The discussions regarding potential impacts to fish (Section 4.1.2.2) and sea turtles (Section 4.1.2.3), as well as the discussion of non-acoustic impacts (Section 4.1.2.4.1) apply to the No-action Alternative.

4.1.2.5.1 No-action Alternative Summary of Exposures

The sonar modeling input includes a total of 3,134 hours of AN/AQS 53C mid-frequency active tactical sonar and the associated DICASS sonobuoy, MK-48 torpedo, and dipping sonar modeling inputs. These exposure numbers are generated by the model without consideration of mitigation measures that would reduce the potential for marine mammal exposures to sonar. Table 4.1.2.5.1-1 provides a summary of the total sonar exposures from all No-action Alternative ASW operations that will be conducted over the course of a year. The number of exposures from each type of exercise are presented separately in Sections 4.1.2.5.5, 4.1.2.5.6, and 4.1.2.5.7.

The explosive modeling input includes mine neutralization, MISSILEX, BOMBEX, SINKEX, GUNEX, and NSFS. The modeled explosive exposure harassment numbers by species are presented in Table 4.1.2.5.1-2. The table indicates the potential for non-injurious (Level B) harassment, as well as the onset of injury (Level A) harassment to cetaceans. The modeling indicates 51 annual exposures to pressure from underwater detonations that could result in TTS. The modeling indicates no exposures from pressure from underwater detonations that could cause injury. These exposure modeling results are estimates of marine mammal underwater detonation sound exposures without consideration of standard mitigation and monitoring procedures. The implementation of the mitigation and monitoring procedures presented in Chapter 6.0 will minimize the potential for marine mammal exposure and harassment through range clearance procedures.
Table 4.1.2.5.1-1. No-action Alternative Sonar Modeling Summary—Yearly Marine Mammal Exposures From all ASW (TRACKEX, TORPEX, RIMPAC, USWEX)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>173</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale&lt;sup&gt;1, 2&lt;/sup&gt;</td>
<td>53</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale&lt;sup&gt;1, 2&lt;/sup&gt;</td>
<td>53</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>28,359</td>
<td>401</td>
<td>1</td>
</tr>
<tr>
<td>Sperm whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>767</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>1,653</td>
<td>90</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>675</td>
<td>37</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>1,025</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>113</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>391</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>33</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>887</td>
<td>46</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>53</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>53</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>214</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>2,012</td>
<td>106</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>559</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>671</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>869</td>
<td>47</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>1,003</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>2,770</td>
<td>133</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>338</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>4,043</td>
<td>194</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>362</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>47,129</strong></td>
<td><strong>1,281</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

Notes:
1. Endangered Species
2. Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
3. Dose Function Curve
4. 195 dB – TTS 195-215 dB re 1 μPa<sup>2</sup>
5. 215 dB – PTS >215 dB re 1 μPa<sup>2</sup>
6. dB = decibel
7. TTS = temporary threshold shift
8. PTS = permanent threshold shift
### Table 4.1.2.5.1-2. No-action Alternative Explosives Modeling Summary—Yearly Marine Mammal Exposures From all Explosive Sources

<table>
<thead>
<tr>
<th>Marine Mammal Species</th>
<th>TTS Modeled at &lt; 182 dB re 1 µPa²–s or 23 psi</th>
<th>Total Exposures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale¹ ²</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale¹</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale¹</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal¹</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:**

1. Endangered Species
2. Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
3. dB = decibel
4. µPa²–s = squared micropascal-second
5. NMFS = National Marine Fisheries Service
6. PTS = permanent threshold shift
7. TM = tympanic membrane
8. TTS = temporary threshold shift
4.0 Environmental Consequences, Open Ocean Area

4.1.2.5.2 Estimated Effects on ESA Listed Species—No-action Alternative

The endangered species that may be affected as a result of implementation of the HRC No-action Alternative operations include the blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Hawaiian monk seal (*Monachus schauinslandi*), humpback whale (*Megaptera novaeangliae*), North Pacific right whale (*Eubalaena japonica*), sei whale (*Balaenoptera borealis*) and sperm whale (*Physeter macrocephalus*).

For the No-action Alternative, modeling results predict that if there were no mitigation measures in place, exposures that are temporary, non-injurious physiological effects (TTS) or behavioral effects will occur. The modeling predicts one exposure to energy in excess of 215 dB re 1 µPa²-s, which is the threshold indicative of onset PTS.

The following sections discuss the exposure of ESA listed species to sonar and to underwater detonations from all No-action ASW Exercises per year. The exposure numbers are given without consideration of mitigation measures. However, mitigation measures that are implemented during the ASW or Underwater Detonation Exercises will reduce the potential for marine mammal exposures. For each species the likelihood of detection is given based on systematic line transect surveys (Barlow, 2006) but the ability to detect marine mammals will depend on sea state conditions.

**Blue Whale (*Balaenoptera musculus*)**

There is no density information available for blue whales in Hawaiian waters given they have not been seen during any surveys. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any blue whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No blue whales will be exposed to impulsive sound or pressures from underwater detonations that will cause TTS or physical injury.

Given the large size (up to 98 ft) of individual blue whales (Leatherwood et al., 1982), pronounced vertical blow, and aggregation of approximately two to three animals in a group (probability of track line detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003), it is likely that lookouts will detect a group of blue whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, blue whales that migrate into the Hawaii OPAREA will be detected by visual observers. Implementation of mitigation measures and increased probability of detecting a large blue whale reduces the likelihood of exposure and potential effects.

In the unlikely event that blue whales are exposed to mid-frequency sonar, the anatomical information available on blue whales suggests that they are not likely to hear mid-frequency (1 kHz to 10 kHz) sounds (Ketten, 1997). There are no audiograms of baleen whales, but blue whales tend to react to anthropogenic sound below 1 kHz (e.g., seismic air guns), and most of their vocalizations are also in that range, suggesting that they are more sensitive to low frequency sounds (Richardson et al., 1995; Croll et al., 2002). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels.
Based on the model results, behavioral patterns, acoustic abilities of blue whales, results of past training operations, and the implementation of mitigation measures, the Navy finds that the HRC training events will not likely result in any death or injury to blue whales, effects on their behavior or physiology, or abandonment of areas that are regularly used by blue whales.

**Fin Whale (*Balaenoptera physalus*)**

There is no density information for fin whales in the Hawaiian Islands (Barlow, 2006). For purposes of acoustic effects analysis, it was assumed that the number and density of fin whales did not exceed that of false killer whales and the modeled number of exposures for both species will therefore be the same. Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 53 exposures of fin whale would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling also indicates there would be three exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates no exposures for fin whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No fin whales will be exposed to impulsive sound or pressures from underwater detonations that will cause TTS or physical injury (Table 4.1.2.5.1-2).

Given the large size (up to 78 ft) of individual fin whales (Leatherwood et al., 1982), pronounced vertical blow, and mean aggregation of three animals in a group (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003), it is likely that lookouts will detect a group of fin whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar. Therefore, fin whales in the vicinity of operations will be detected by visual observers. Implementation of mitigation measures and probability of detecting a large fin whale reduce the likelihood of exposure and potential effects.

In the unlikely event that fin whales are exposed to mid-frequency sonar, the anatomical information available on fin whales suggests that they are not likely to hear mid-frequency (1 kHz to 10 kHz) sounds (Richardson et al., 1995; Ketten, 1997). Fin whales primarily produce low frequency calls (below 1 kHz) with source levels up to 186 dB re 1μPa at 1 m, although it is possible they produce some sounds in the range of 1.5 to 28 kHz (review by Richardson et al., 1995; Croll et al., 2002). There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low frequency sounds (Richardson et al., 1995). Based on this information, if they do not hear these sounds, they are not likely to respond physiologically or behaviorally to those received levels.

In the St. Lawrence estuary area, fin whales avoided vessels with small changes in travel direction, speed and dive duration, and slow approaches by boats usually caused little response (MacFarlane, 1981). Fin whales continued to vocalize in the presence of boat sound (Eds and MacFarlane, 1987). Even though any undetected fin whales transiting the HRC may exhibit a reaction when initially exposed to active acoustic energy, field observations indicate the effects will not cause disruption of natural behavioral patterns to a point where such behavioral patterns will be abandoned or significantly altered.
Based on the model results, behavioral patterns, acoustic abilities of fin whales, results of past HRC training, and the implementation of mitigation measures, the Navy finds that the HRC training events will likely not result in any death or injury to fin whales. The proposed ASW Exercises may affect fin whales.

**Humpback Whale (Megaptera novaeangliae)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 28,359 exposures of humpback whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates there would be 401 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. Modeling indicates there would be one exposure for humpback whales to accumulated acoustic energy above 215 dB re 1 μPa^2-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be eight exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold, and no exposures that would exceed the slight injury threshold or the massive lung injury threshold (Table 4.1.2.5.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no humpback whales within the safety zone, and therefore potential exposure of humpback whales to sound levels that exceed TTS or injury levels is highly unlikely.

Given the large size (up to 53 ft) of individual humpback whales (Leatherwood et al., 1982), and pronounced vertical blow, it is very likely that lookouts would detect humpback whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, humpback whales that are present in the vicinity of ASW operations would be detected by visual observers reducing the likelihood of exposure, such that effects would be discountable. There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low frequency sounds (Richardson et al., 1995). A single study suggested that humpback whales responded to mid frequency sonar (3.1-3.6 kHz re 1 μPa^2-s) sound (Maybaum, 1989). The hand-held sonar system had a sound artifact below 1,000 Hz which caused a response to the control playback (a blank tape) and may have affected the response to sonar (i.e., the humpback whale responded to the low frequency artifact rather than the mid-frequency sonar sound).

While acoustic modeling results indicate mid-frequency active sonar may expose humpback whales to accumulated acoustic energy levels resulting in temporary behavioral effects, these exposures would have negligible impact on annual survival, recruitment, and birth rates. The aggregation of humpback whales in Hawaii has been increasing at up to 7 percent annually (Mobley, 2004) despite frequent encounters with tour boats. There have been no mother calf separations as a result of Navy activities. Most social vocalizations, including female vocalizations, are below 3 kHz (Silber, 1986); therefore, are below mid-frequency active sonar range. Male songs range from 20 Hz to 24 kHz, but most of the components range from 200 Hz to 3 kHz (Au et al., 2001). Mitigation measures presented in Chapter 6.0 would further reduce the potential acoustic exposure. The final determination of affect will be discussed through the ESA Section 7 process.
North Pacific Right Whale (*Eubalaena japonica*)

There is no density information available for North Pacific right whales in Hawaiian waters since they have not been seen during survey. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any right whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No right whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury.

Given their large size (up to 56 ft) of individual North Pacific right whales (Leatherwood et al., 1982), surface behavior (e.g., breaching), pronounced blow, and mean group size of approximately three animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003), it is likely that lookouts would detect a group of North Pacific right whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar. Therefore, large whales that are present in the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large North Pacific right whale reduce the likelihood of exposure and potential effects.

In the unlikely event that North Pacific right whales are exposed to mid-frequency sonar, the information available on North Pacific right suggests that they may hear the lower range of mid-frequency (1 kHz to 10 kHz) sounds (Richardson et al., 1995; Ketten, 1997). There are no audiograms for baleen whales, but they are estimated to hear from 15 Hz to 20 kHz with good sensitivity from 20 Hz to 2 kHz (Ketten, 1998).

Active sonars may temporarily mask some sounds in the range of North Pacific right whale hearing and may also cause a temporary behavioral response (i.e., diving or swimming away from the sound source). Even though any undetected North Pacific right whales transiting HRC may exhibit a reaction when initially exposed to active acoustic energy, these observations indicate the effects will not cause disruption of natural behavioral patterns to a point where such behavioral patterns will be abandoned or significantly altered.

Based on the model results, behavioral patterns, acoustic abilities of North Pacific right whales, results of past training, and the implementation of mitigation measures, the Navy finds that the HRC training events would likely not result in any death or injury to North Pacific right whales, will not affect their behavior, physiology or cause abandonment of areas that are regularly used by North Pacific right whales.

Sei Whale (*Balaenoptera borealis*)

For purposes of the acoustic effects analysis, the same assumptions made previously regarding fin whales are also made for sei whales. It was therefore assumed that the number and density of sei whales did not exceed that of false killer whales, and the modeled number of exposures for both species would therefore be the same.

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 53 exposures of sei whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).
Modeling also indicates there would be three exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates no exposures for sei whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No sei whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.5.1-2).

Given the large size (up to 53 ft) of individual sei whales (Leatherwood et al., 1982), pronounced vertical blow, and aggregation of approximately three animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003), it is likely that lookouts will detect a group of sei whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar. Therefore, sei whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large sei whale reduce the likelihood of exposure and potential effects.

There is little information on the acoustic abilities of sei whales or their response to human activities. The only recorded sounds of sei whales are frequency modulated sweeps in the range of 1.5 to 3.5 kHz (Thompson et al., 1979; Knowlton et al., 1991), but it is likely that they also vocalized at frequencies below 1 kHz as do fin whales. There are no audiograms of baleen whales, but they tend to react to anthropogenic sound below 1 kHz, suggesting that they are more sensitive to low frequency sounds (Richardson et al., 1995). Sei whales were more difficult to approach than were fin whales and moved away from boats but were less responsive when feeding (Gunther, 1949).

Based on the model results, behavioral patterns, acoustic abilities of sei whales, results of past training, and the implementation of mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to sei whales. The proposed ASW Exercises may affect sei whales but are not likely to cause long-term effects on their behavior or physiology or abandonment of areas that are regularly used by sei whales.

**Sperm Whales (Physeter macrocephalus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 767 exposures of sperm whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling indicates there would 23 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates no exposures for sperm whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be nine exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold (Table 4.1.2.5.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no sperm whales within the safety zone, and therefore potential exposure of sperm whales to sound levels that exceed TTS is highly unlikely.
Given the large size (up to 56 ft) of individual sperm whales (Leatherwood et al., 1982), pronounced blow (large and angled), mean group size of approximately seven animals (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less; Barlow, 2003; 2006), it is likely that lookouts would detect a group of sperm whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar. Therefore, sperm whales that migrate into the Hawaii OPAREA will be detected by visual observers. Implementation of mitigation measures and probability of detecting a large sperm whale reduce the likelihood of exposure and potential effects.

In the unlikely event that sperm whales are exposed to mid-frequency sonar, the information available on sperm whales exposed to received levels of active mid-frequency sonar suggests that the response to mid-frequency (1 kHz to 10 kHz) sounds is variable (Richardson et al., 1995). While Watkins et al. (1985) observed that sperm whales exposed to 3.25 kHz to 8.4 kHz pulses interrupted their activities and left the area, other studies indicate that, after an initial disturbance, the animals return to their previous activity. During playback experiments off the Canary Islands, André et al. (1997) reported that foraging whales exposed to a 10 kHz pulsed signal did not exhibit any general avoidance reactions. When resting at the surface in a compact group, sperm whales initially reacted strongly, then ignored the signal completely (André et al., 1997).

Based on the model results, behavioral patterns, acoustic abilities of sperm whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to sperm whales. The proposed ASW Exercises may affect sperm whales but are not likely to cause long-term effects on their behavior or physiology or abandonment of areas that are regularly used by sperm whales.

**Hawaiian Monk Seal** *(Monachus schauinslandi)*

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 362 exposures of Hawaiian monk seals would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling indicates there would be seven exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates there would be no exposures for monk seals to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be no exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold and no exposures that would exceed the injury threshold (Table 4.1.2.5.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no monk seals within the safety zone, and therefore potential exposure of monk seals to sound levels that exceed TTS is highly unlikely.

Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Hawaiian monk seals that move into the Hawaii OPAREA would be insignificant. Critical habitat was designated 1986 as the area extending out to the 10-fathom depth (60 ft) for the Northwestern Hawaiian Islands (National Marine Fisheries Service, 1986).
Critical habitat was extended out to the 20-fathom depth in 1988 (National Marine Fisheries Service, 1988).

Based on the model results, behavioral patterns, acoustic abilities of monk seals, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the training events would not likely result in any death or injury to Hawaiian monk seals. The proposed ASW Exercises may affect monk seals.

4.1.2.5.3 Estimated Exposures for Non-ESA Species—No-action Alternative

Bryde’s Whale (*Balaenoptera edeni*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 173 exposures of Bryde’s whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling indicates there would two exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Bryde’s whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Bryde’s whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given the large size (up to 46 ft) of individual Bryde’s whales, pronounced blow, and mean group size of approximately 1.5 animals and (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less; Barlow 2003; 2006), it is very likely that lookouts would detect a group of Bryde’s whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Bryde’s whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Bryde’s whale reduce the likelihood of exposure, such that effects would be discountable. Based on the model results, behavioral patterns, acoustic abilities of Bryde’s whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Bryde’s whales. There may be up to 276 exposures of Bryde’s whale to potential Level B harassment annually.

Minke Whale (*Balaenoptera acutorostrata*)

There is no density information available for minke whales in Hawaiian waters given they have rarely been seen during surveys. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any minke whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No minke whales would be exposed to impulsive noise or pressures from underwater detonations that would cause TTS or physical injury.

Given the large size (up to 27 ft) of individual minke whales, pronounced blow, breaching behavior and mean group size of approximately 1.4 animals (Barlow, 2003), it is very likely that lookouts would detect a group of minke whales at the surface although a systematic survey in
the Hawaiian Islands failed to visually detect minke whales but were able to detect using acoustic methods (Barlow, 2006). Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, minke whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a minke whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of minke whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to minke whales.

**Blainville’s Beaked Whale (Mesoplodon densirostris)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 391 exposures of Blainville’s beaked whale would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 15 exposures to accumulated acoustic energy between 195 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS, and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset PTS. Modeling for all alternatives indicates that no Blainville’s beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s. Modeling indicates there would be two exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given the size (up to 15.5 ft) of individual Blainville’s beaked whales, aggregation of 2.3 animals, it is likely that lookouts would detect a group of Blainville’s beaked whales at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Blainville’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large Blainville’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Blainville’s beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Blainville’s beaked whales. There may be up to 613 exposures of Blainville’s beaked whale to potential Level B harassment annually.

**Bottlenose Dolphin (Tursiops truncatus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 887 exposures of bottlenose dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 46 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no bottlenose dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No bottlenose dolphins would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).
Given the frequent surfacing, aggregation of approximately nine animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of bottlenose dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, bottlenose dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting bottlenose dolphins reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of bottlenose dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to bottlenose dolphins. There may be up to 1,348 exposures of bottlenose dolphins to potential Level B harassment annually.

**Cuvier’s Beaked Whale (Ziphius cavirostris)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,025 exposures of Cuvier’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 14 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Cuvier’s beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would 10 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury (Table 4.1.2.5.1-2).

Given the medium size (up to 23 ft) of individual Cuvier’s beaked whales, aggregation of approximately two animals (Barlow, 2006), it is likely that lookouts would detect a group of Cuvier’s beaked whales at the surface although beaked whales make long duration dives. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Cuvier’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Cuvier’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Cuvier’s beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Cuvier’s beaked whales. There may be up to 1,593 exposures of Cuvier’s beaked whales to potential Level B harassment annually.

**Dwarf Sperm Whale (Kogia sima)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,653 exposures of dwarf sperm whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).
Modeling indicates 90 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no dwarf sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates seven exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or onset of massive lung injury (Table 4.1.2.5.1-2).

Based on the model results, behavioral patterns, acoustic abilities of dwarf sperm whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to dwarf sperm whale. There may be up to 2,565 exposures of dwarf sperm whales to potential Level B harassment annually.

**False Killer Whale (*Pseudorca crassidens*)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 53 exposures of false killer whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 3 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no false killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No false killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given their size (up to 19.7 ft) and large mean group size of 10.3 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow 2003), it is very likely that lookouts would detect a group of false killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, false killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of false killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of false killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to false killer whales. There may be up to 82 exposures of false killer whales to potential Level B harassment annually.

**Fraser’s Dolphin (*Lagenodelphis hosei*)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,003 exposures of Fraser’s dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling indicates 55 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all
alternatives indicates that no Fraser’s dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be four exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or onset of massive lung injury (Table 4.1.2.5.1-2).

Given their large aggregations, mean group size of 286.3 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow 2006), it is very likely that lookouts would detect a group of Fraser’s dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Fraser’s dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of Fraser’s dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of Fraser’s dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Fraser’s dolphins. There may be up to 1,556 exposures of Fraser’s dolphins to potential Level B harassment annually.

**Killer Whale (Orcinus orca)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 53 exposures of killer whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates three exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given their size (up to 23 ft), conspicuous coloring, pronounced dorsal fin and large mean group size of 6.5 animals (probability of trackline detection = 0.90; Barlow, 2003), is very likely that lookouts would detect a group of killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to killer whales. There may be up to 82 exposures of killer whale to potential Level B harassment annually.

**Longman’s Beaked Whale (Indopacetus pacificus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA),...
113 exposures of Longman’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates four exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Longman’s beaked whale would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Longman’s beaked whale would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given the medium size (up to 24 ft) of individual Longman’s beaked whale, aggregation of approximately 17.8 animals (Barlow, 2006), it is very likely that lookouts would detect a group of Longman’s beaked whale at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Longman’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Longman’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Longman’s beaked whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Longman’s beaked whale. There may be up to 176 exposures of Longman’s beaked whales to potential Level B harassment annually.

**Melon-headed Whale (Peponocephala electra)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 671 exposures of melon-headed whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 35 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no melon-headed whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No melon-headed whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given their size (up to 8.2 ft) and large group size (mean of 89.2 whales) or more animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of melon-headed whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, melon-headed whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of melon-headed whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of melon-headed whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to melon-headed whales. There may be up to 1,015 exposures of melon-headed whales to potential Level B harassment annually.
Pantropical Spotted Dolphin (*Stenella attenuata*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 2,770 exposures of pantropical spotted dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 133 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pantropical spotted dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates one exposure to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.5.1-2).

Given their frequent surfacing and large group size hundreds of animals (Leatherwood et al., 1982), mean group size of 60.0 animals in Hawaii and probability of trackline detection of 1.00 in Beaufort Sea States of 6 or less (Barlow, 2006), it is very likely that lookouts would detect a group of pantropical spotted dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, pantropical spotted dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pantropical spotted dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pantropical spotted dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pantropical spotted dolphins. There may be up to 4,184 exposures of pantropical spotted dolphins to potential Level B harassment annually.

Pygmy Killer Whale (*Feresa attenuata*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 214 exposures of pygmy killer whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 13 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pygmy killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No pygmy killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given their size (up to 8.5 ft) and mean group size of 14.4 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of pygmy killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, pygmy killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pygmy killer whales reduce the likelihood of exposure.
Based on the model results, behavioral patterns, acoustic abilities of pygmy killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pygmy killer whales. There may be up to 328 exposures of pygmy killer whales to potential Level B harassment annually.

**Pygmy Sperm Whale (Kogia breviceps)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 675 exposures of pygmy sperm whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling indicates 37 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pygmy sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa²-s, which is the threshold indicative of onset PTS. Modeling indicates three exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury (Table 4.1.2.4.1-2).

Given their size (up to 10 ft) and behavior of resting at the surface (Leatherwood et al., 1982), it is very likely that lookouts would detect a pygmy sperm whale at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, pygmy sperm whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pygmy sperm whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pygmy sperm whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pygmy sperm whale. There may be up to 1,048 exposures of pygmy sperm whales to potential Level B harassment annually.

**Risso’s Dolphin (Grampus griseus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 559 exposures of Risso’s dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 29 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Risso’s dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa²-s, which is the threshold indicative of onset PTS. No Risso’s dolphins would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Given their frequent surfacing, light coloration, and large group size of up to several hundred animals (Leatherwood et al., 1982), mean group size of 15.4 dolphins in Hawaii and probability
of trackline detection of 0.76 in Beaufort Sea States of 6 or less (Barlow, 2006), it is very likely that lookouts would detect a group of Risso’s dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, Risso’s dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of Risso’s dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of Risso’s dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Risso’s dolphins. There may be up to 846 exposures of Risso’s dolphins to potential Level B harassment annually.

Rough-Toothed Dolphin (*Steno bredanensis*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 869 exposures of rough-toothed dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 47 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no rough-toothed dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be 47 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.5.1-2).

Given their frequent surfacing and mean group size of 14.8 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of rough-toothed dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, rough-toothed dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of rough-toothed dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of rough-toothed dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to rough-toothed dolphins. There may be up to 1,348 exposures of rough-toothed dolphins to potential Level B harassment annually.

Short-finned Pilot Whale (*Globicephala macrorhynchus*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 2,012 exposures of short-finned pilot whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 106 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no short-finned pilot whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be 2 exposures to impulsive noise or
pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.5.1-2).

Given their size (up to 20 ft), and large mean group size of 22.5 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow 2006). It is very likely that lookouts would detect a group of short-finned pilot whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, short-finned pilot whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of short-finned pilot whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of short-finned pilot whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to short-finned pilot whale. There may be up to 3,046 exposures of short-finned pilot whales to potential Level B harassment annually.

**Spinner Dolphin** (*Stenella longirostris*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 338 exposures of spinner dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 18 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no spinner dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would two exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury massive lung injury (Table 4.1.2.5.1-2).

Given their frequent surfacing, aerobatics, and large mean group size of 31.7 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of spinner dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, spinner dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of spinner dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of spinner dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to spinner dolphins. There may be up to 524 exposures of spinner dolphins to potential Level B harassment annually.

**Striped Dolphin** (*Stenella coeruleoalba*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA),
4,043 exposures of striped dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 194 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no striped dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates three exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.5.1-2).

Given their frequent surfacing, aerobatics and large mean group size of 37.3 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of striped dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, striped dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of striped dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of striped dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to striped dolphins. There may be up to 6,106 exposures of striped dolphins to potential Level B harassment annually.

**Unidentified Beaked Whales**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 33 exposures of unidentified beaked whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling indicates no exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS, would occur. Modeling for all alternatives indicates that no unidentified beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No unidentified beaked whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.5.1-2).

Based on the model results, behavioral patterns, acoustic abilities of unidentified beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to unidentified beaked whales. There may be up to 51 exposures of unidentified beaked whales to potential Level B harassment annually.
4.1.2.5.4 Summary of Compliance with MMPA and ESA—No-action Alternative

Endangered Species Act

Based on analytical modeling results, five endangered marine mammal species occurring within the Hawaii OPAREA may be exposed to acoustic energy that could result in TTS or behavioral modification, including the fin whale, humpback whale, sei whale, sperm whale, and Hawaiian monk seal. Modeling results also indicate a potential for PTS exposures (under the ESA level of >0.05). However, even the sum of exposures at 215 dB from all operations over a year does not exceed 0.32 exposures for any ESA species. Implementation of mitigation measures would further reduce the potential for TTS and PTS exposures. Based on the analysis presented in the previous section, the Navy concludes that HRC ASW operations may affect fin whale, humpback whale, sei whale, sperm whale and Hawaiian monk seal.

Two other listed cetaceans, the blue whale and North Pacific right whale may be found in the HRC. Due to the lack of density data for the blue whale and the North Pacific right whale, they were not included in the acoustic effects exposure model. Very few sightings have been recorded in the Hawaiian Islands, and they are not expected to be encountered during ASW operations. Therefore, there is a low probability of exposure to mid-frequency active tactical sonar. Available information on blue whale and North Pacific right whale vocalizations indicate a variety of low frequency sounds in the 10 to 300 Hz band for blue whales and low frequency sounds less than 400 Hz for North Pacific right whales. Because the mid-frequency active tactical sonar proposed for HRC ASW training is outside the frequency typically used by these whales, they are not likely to hear or have a physiological or behavioral response to the sonar (National Oceanic and Atmospheric Administration, 2006). HRC ASW operations would therefore result in no effect to blue whales and North Pacific right whales.

Mitigation measures would be implemented to prevent exposure of marine mammals to impulsive sound or sound pressures from underwater detonations that would cause injury.

Five species of sea turtles could potentially occur within the HRC. All are protected under the ESA. All available acoustic information suggests that sea turtles are likely not capable of hearing mid-frequency (2.6 kHz and 3.3 kHz) sounds in the range produced by the active tactical sonar. Mitigation measures would be implemented to prevent exposure of sea turtles to impulsive sound or sound pressures from underwater detonations that would cause injury.

In accordance with ESA requirements, the Navy has initiated Section 7 consultation with NMFS on the potential that HRC operations may affect fin whales, Hawaiian monk seals, humpback whales, sei whales, and sperm whales.

Marine Mammal Protection Act

Level A Harassment of Cetaceans

Modeling results for the sum of exposures for all ASW operations for a year indicate one humpback exposure that exceeds the Level A harassment threshold. However, given implementation of mitigation measures, it is unlikely that ASW operations would result in injury to marine mammals. Therefore, the Navy concludes that HRC operations would not result in Level A harassment of humpback whales. In addition, the following considerations further reduce the potential for injury from tactical sonar and underwater explosions:
4.0 Environmental Consequences, Open Ocean Area

- Level A zone of influence radii for tactical sonar are so small that on-board observers would readily observe an approaching marine mammal.
- Species are large or travel in large pods and are easily visible from an elevated platform; a ship or aircraft would readily see a marine mammal in time to implement mitigation measures.

**Level B Harassment of Cetaceans**

As shown in Table 4.1.2.5.1-1, quantitative modeling results indicate potential for exposures at thresholds that equate to Level B harassment of cetaceans (TTS and sub-TTS behavioral). However, modeling assumptions are very conservative, and overestimate the number of Level B exposures. Mitigation measures will be in place to further minimize the potential for temporary harassment, although there is currently no data to quantify the mitigation efforts to successfully reduce the number of marine mammal exposures. The Navy has begun development of a comprehensive Monitoring Plan to determine the effectiveness of these measures. Many species of small cetaceans travel in very large pods, and therefore would be easily observed from an elevated platform. In addition, large baleen whales travel slowly and are easily observed on the surface. In the years of conducting major operations in the HRC, there have been no documented incidences of harassments or beach strandings of marine mammals associated with active sonar or underwater detonations. In the one event associated with RIMPAC 2004, sonar was suggested to be a plausible contributing factor (Southall et al., 2006) although a similar event occurred on the same day in a bay at Rota Island, Northern Marianas Islands with no associated sonar (Jefferson et al., 2006) and may be related to oceanographic changes that influenced prey distribution (Southall, 2006; Ketten, 2006). The HRC open ocean waters continue to support diverse and stable populations of cetaceans.

**4.1.2.5.5 HRC Training Operations—No-action Alternative**

The HRC training operations involving sonar include ASW TRACKEX and ASW TORPEX as described in Table 2.2.2.3-1 and Appendix D. The No-action Alternative modeling included 1,440 hours of 53C surface ship sonar and associated sonobuoys per year. The modeled exposures for marine mammals during TRACKEX and TORPEX training operations, without consideration of mitigation measures are presented in Tables 4.1.2.5.5-1 and 4.1.2.5.5-2. Effects on marine mammals from these exposures are included in the discussion in Sections 4.1.2.5.2 for ESA listed species and 4.1.2.5.3 for non-ESA listed species. Exposures from underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are presented in the summary numbers in Table 4.1.2.5.1-2.
<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>69</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>22</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>22</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>6,777</td>
<td>99</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale&lt;sup&gt;3&lt;/sup&gt;</td>
<td>313</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>670</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>274</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>407</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>46</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>156</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>13</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>363</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>22</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>22</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>88</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinsmed pilot whale</td>
<td>830</td>
<td>43</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>231</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>277</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>352</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>407</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>1,137</td>
<td>54</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>137</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>1,659</td>
<td>79</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>145</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>14,439</td>
<td>454</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: 1 Endangered Species  
<sup>2</sup> Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.  
Dose Function Curve  
195 dB – TTS 195-215 dB re 1 μPa<sup>-2</sup>-s  
215 dB- PTS >215 dB re 1 μPa<sup>-2</sup>-s  
dB = decibel  
TTS = temporary threshold shift  
PTS = permanent threshold shift
### Table 4.1.2.5.5-2. No-action Alternative Sonar Modeling Summary—Yearly Marine Mammal Exposures from Torpedo Exercises

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Behavioral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bryde’s whale</td>
<td>15</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale(^1,2)</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale(^1,2)</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale(^1)</td>
<td>2,161</td>
<td>41</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale(^1)</td>
<td>78</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>166</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>68</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>83</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>35</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>91</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>22</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>214</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>59</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>71</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>87</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>100</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>287</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>34</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>419</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal(^1)</td>
<td>32</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4,059</strong></td>
<td><strong>131</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Note:  
1. Endangered Species  
2. Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.  

Dose Function Curve  
195 dB – TTS 195-215 dB re 1 μPa\(^2\)-s  
215 dB- PTS >215 dB re 1 μPa\(^2\)-s  

dB = decibel  
TTS = temporary threshold shift  
PTS = permanent threshold shift
4.1.2.5.6 HRC RDT&E Operations—No-action Alternative

Other sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect marine animals. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish, sea turtles, and marine mammals.

4.1.2.5.7 Major Exercises—No-action Alternative

RIMPAC

The operations and impacts to marine mammals from RIMPAC Exercises have been summarized in the RIMPAC 2006 Supplement to the 2002 RIMPAC EA (U.S. Department of the Navy Commander Third Fleet, 2006). The No-action Alternative modeling included 532 hours of 53C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes per RIMPAC (conducted every other year). The modeled exposures for marine mammals during RIMPAC, without consideration of mitigation measures are presented in Table 4.1.2.5.7-1. Effects on marine mammals from these exposures are included in the discussion in Sections 4.1.2.5.1 for ESA listed species and 4.1.2.5.3 for non-ESA listed species. Exposures from underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are included in the summary numbers in Table 4.1.2.5.7-2. Sections 4.1.2.2 and 4.1.2.3 discuss the potential effects on fish and sea turtles respectively.

USWEX

The operations and impacts to marine mammals from USWEX have been summarized in the USWEX Programmatic EA/OEA (U.S. Department of the Navy, 2007b). The No-action Alternative modeling included 1,167 hours of 53C surface ship sonar and associated dipping sonar and sonobuoys per year. The modeled exposures for marine mammals during up to six USWEX per year, without consideration of mitigation measures, are presented in Table 4.1.2.5.7-2. Effects on marine mammals from these exposures are included in the discussion in Sections 4.1.2.5.1 for ESA listed species and 4.1.2.5.3 for non-ESA listed species. Exposures from underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are included in the summary numbers in Table 4.1.2.5.7-2. Sections 4.1.2.2 and 4.1.2.3 discuss the potential effects on fish and sea turtles respectively.
### Table 4.1.2.5.7-1. No-action Alternative Sonar Modeling Summary—Yearly Marine Mammal Exposures for RIMPAC (Conducted Every Other Year)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>24</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale&lt;sup&gt;1, 2&lt;/sup&gt;</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale&lt;sup&gt;1, 2&lt;/sup&gt;</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sperm whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>115</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>218</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>89</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>157</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>16</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>54</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>128</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>7</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>30</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>289</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>80</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>96</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>115</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>133</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>409</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>45</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>596</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>49</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2,676</strong></td>
<td><strong>135</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Note:  
1. Endangered Species  
2. Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.  
Dose Function Curve  
195 dB – TTS 195-215 dB re 1 μPa²-s  
215 dB- PTS >215 dB re 1 μPa²-s  
3. dB = decibel  
4. TTS = temporary threshold shift  
5. PTS = permanent threshold shift
Table 4.1.2.5.7-2. No-action Alternative Sonar Modeling Summary - Yearly Marine Mammal Exposures from USWEX (6 per year)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>65</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>19</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>19</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>19,421</td>
<td>261</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>262</td>
<td>8</td>
<td>0</td>
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<tr>
<td>Dwarf sperm whale</td>
<td>599</td>
<td>31</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>244</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>378</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>41</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>145</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>305</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>19</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>19</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>74</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>679</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>189</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>226</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>315</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>363</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>938</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>122</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>1,368</td>
<td>64</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>136</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>25,958</strong></td>
<td><strong>556</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Note: <sup>1</sup> Endangered Species  
<sup>2</sup> Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.

Dose Function Curve  
195 dB – TTS 195-215 dB re 1 μPa<sup>2</sup>-s  
215 dB - PTS >215 dB re 1 μPa<sup>2</sup>-s  
DB = decibel  
TTS = temporary threshold shift  
PTS = permanent threshold shift
4.1.2.6 MARINE MAMMALS ALTERNATIVE 1 (BIOLOGICAL RESOURCES—OPEN OCEAN)

The discussion under the No-action Alternative regarding potential non-acoustic impacts (Section 4.1.2.5.1) and potential ASW Impacts (Section 4.1.2.5.2) also apply for Alternative 1.

4.1.2.6.1 Alternative 1 Summary of Exposures

The increased operations under Alternative 1 result in an increase in the number of hours of ASW training. The modeling input includes a total of 4,027 hours of AN/AQS 53C mid-frequency active tactical sonar and the associated DICASS sonobuoy, MK-48 torpedo, and dipping sonar modeling inputs. These exposure numbers are generated by the model without consideration of mitigation measures that would reduce the potential for marine mammal exposures to sonar. Table 4.1.2.6.1-1 provides a summary of the total sonar exposures from all Alternative 1 ASW Exercises that would be conducted over the course of a year. The number of exposures from each type of exercise are presented separately in Sections 4.1.2.6.5, 4.1.2.6.6, and 4.1.2.6.7, 4.1.2.6.8, and 4.1.2.6.9.

Table 4.1.2.6.1-1. Alternative 1 Sonar Modeling Summary—Yearly Marine Mammal Exposures from All ASW (TRACKEX, TORPEX, RIMPAC, USWEX)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>198</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale¹,²</td>
<td>61</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale¹,²</td>
<td>61</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale⁴</td>
<td>28,359</td>
<td>444</td>
<td>1</td>
</tr>
<tr>
<td>Sperm whale¹</td>
<td>882</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>1,871</td>
<td>105</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>764</td>
<td>43</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>1,182</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>130</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>444</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>38</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>1,015</td>
<td>53</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>61</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>61</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>243</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>2,301</td>
<td>123</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 4.1.2.6.1-1  Alternative 1 Sonar Modeling Summary - Yearly Marine Mammal Exposures From all ASW (TRACKEX, TORPEX, RIMPAC, USWEX) (Continued)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risso’s dolphin</td>
<td>639</td>
<td>34</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>767</td>
<td>41</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>984</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>1,136</td>
<td>63</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>3,179</td>
<td>153</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>383</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>4,639</td>
<td>224</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal¹</td>
<td>411</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>49,809</strong></td>
<td><strong>1,467</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

Note: ¹ Endangered Species

Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.

Dose Function Curve
195 dB – TTS 195-215 dB re 1 μPa²-s
215 dB- PTS >215 dB re 1 μPa²-s

dB = decibel
TTS = temporary threshold shift

The explosive modeling input includes mine neutralization, MISSILEX, BOMBEX, SINKEX, GUNEX, and NSFS. The modeled explosive exposure harassment numbers by species are presented in Table 4.1.2.6.1-2. The table indicates the potential for non-injurious (Level B) harassment, as well as the onset of injury (Level A) harassment to cetaceans. The modeling indicates 58 annual exposures to pressure from underwater detonations that could result in TTS. The modeling indicates no exposures from pressure from underwater detonations that could cause injury. These exposure modeling results are estimates of marine mammal underwater detonation sound exposures without consideration of standard mitigation and monitoring procedures. The implementation of the mitigation and monitoring procedures presented in Chapter 6.0 will minimize the potential for marine mammal exposure and harassment through range clearance procedures.
Table 4.1.2.6.1-2. Alternative 1 Explosives Modeling Summary—Yearly Marine Mammal Exposures from All Explosive Sources

<table>
<thead>
<tr>
<th>Marine Mammal Species</th>
<th>TTS Modeled at &lt; 182 dB re 1 ( \mu \text{Pa}^2\text{–s} ) or 23 psi</th>
<th>Total Exposures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mine Neutralization</td>
<td>Air to Surface Missile Exercise</td>
</tr>
<tr>
<td>Bryde’s whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale(^1, 2)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale(^1)</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale(^1)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal(^1)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note:**
1. Endangered Species
2. Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
3. \( \text{dB} \) = decibel
4. \( \mu \text{Pa}^2\text{–s} \) = squared micropascal-second
5. TM = tympanic membrane
6. TTS = temporary threshold shift
4.1.2.6.2 Estimated Effects on ESA Listed Species—Alternative 1

The endangered species that may be affected as a result of implementation of the HRC Alternative 1 operations include the blue whale (Balaenoptera musculus), fin whale (Balaenoptera physalus), Hawaiian monk seal (Monachus schauinslandi), humpback whale (Megaptera novaeangliae), North Pacific right whale (Eubalaena japonica), sei whale (Balaenoptera borealis) and sperm whale (Physeter macrocephalus).

For Alternative 1, modeling results predict that if there were no mitigation measures in place, exposures that that are temporary, non-injurious physiological effects (TTS) or behavioral effects would occur. The modeling predicts one exposure to energy in excess of 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

The following sections discuss the exposure of ESA listed species to sonar and underwater detonations from all Alternative 1 exercises per year. The exposure numbers are given without consideration of mitigation measures. However, mitigation measures that are implemented during the ASW and Underwater Detonation Exercises would reduce the potential for marine mammal exposures.

Blue Whale (Balaenoptera musculus)

There is no density information available for blue whales in Hawaiian waters given they have not been seen during survey. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any blue whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No blue whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury.

Based on the model results, behavioral patterns, acoustic abilities of blue whales, results of past training operations, and the implementation of mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to blue whales.

Fin Whale (Balaenoptera physalus)

There is no density information for fin whales in the Hawaiian Islands (Barlow, 2006). For purposes of acoustic effects analysis estimates, it was assumed that the number and density of fin whales did not exceed that of false killer whales, and the modeled number of exposures for both species would therefore be the same.

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 61 exposures of fin whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1).

Modeling also indicates that there would be four exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates no exposures for fin whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No fin whales would be
exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.6.1-2).

Based on the model results, behavioral patterns, acoustic abilities of fin whales, results of past HRC training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would likely not result in any death or injury to fin whales. The proposed ASW Exercises may affect fin whales.

**Humpback Whale (Megaptera novaeangliae)**

The acoustic effects analysis for Alternative 1 based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 28,359 exposures of humpback whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates there would be 444 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates one exposure for humpback whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be 14 exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold, and no exposures that would exceed the injury threshold or the massive injury threshold (Table 4.1.2.6.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no humpback whales within the safety zone, and therefore potential exposure of humpback whales to sound levels that exceed TTS or injury levels is highly unlikely.

Based on the model results, behavioral patterns, acoustic abilities of humpback whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to humpback whales. The proposed ASW Exercises may affect humpback whales.

**North Pacific Right Whale (Eubalaena japonica)**

There is no density information available for North Pacific right whales in Hawaiian waters given they have not been seen during survey. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any right whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No right whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury.

Based on the model results, behavioral patterns, acoustic abilities of North Pacific right whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to North Pacific right whales.

**Sei Whale (Balaenoptera borealis)**

For purposes of the acoustic effects analysis, the same assumptions made previously regarding fin whales are also made for sei whales. It was therefore assumed that the number and density of sei whales did not exceed that of false killer whales, and the modeled number of exposures

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for both species would therefore be the same. Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 61 exposures of sei whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling also predicts four exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling predicts no exposures for sei whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No sei whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.6.1-2).

Based on the model results, behavioral patterns, acoustic abilities of sei whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to sei whales. The proposed ASW Exercises may affect sei whales.

**Sperm Whales (Physeter macrocephalus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 882 exposures of sperm whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1).

Modeling predicts 27 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling predicts no exposures for sperm whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be five exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold (Table 4.1.2.6.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no sperm whales within the safety zone, and therefore potential exposure of sperm whales to sound levels that exceed TTS is highly unlikely.

Based on the model results, behavioral patterns, acoustic abilities of sperm whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to sperm whales. The proposed ASW Exercises may affect sperm whales.

**Hawaiian Monk Seal (Monachus schauinslandi)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 411 exposures of Hawaiian monk seals would result in responses that would be classified as harassment (Table 4.1.2.6.1-1).

Modeling predicts eight exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling predicts there would be no exposures for monk seals to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.
Without consideration of clearance procedures, there would be no exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold and no exposures that exceed the injury threshold (Table 4.1.2.6.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no monk seals within the safety zone, and therefore potential exposure of monk seals to sound levels that exceed TTS is highly unlikely.

Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Hawaiian monk seals that move into the Hawaii OPAREA would be insignificant. Critical habitat was designated 1986 as the area extending out to the 10-fathom depth (60 ft) for the Northwestern Hawaiian Islands (National Marine Fisheries Service, 1986). Critical habitat was extended out to the 20-fathom depth in 1988 (National Marine Fisheries Service, 1988).

Based on the model results, behavioral patterns, acoustic abilities of monk seals, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the proposed ASW Exercises may affect monk seals.

**4.1.2.6.3 Estimated Exposures for Non-ESA Species—Alternative 1**

_Bryde’s Whale (Balaenoptera edeni)_

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 198 exposures of Bryde’s whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates there would be two exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Bryde’s whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Bryde’s whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given the large size (up to 46 ft) of individual Bryde’s whales, pronounced blow, and mean group size of approximately 1.5 animals and (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less; Barlow, 2003; 2006), it is very likely that lookouts would detect a group of Bryde’s whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Bryde’s whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Bryde’s whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Bryde’s whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Bryde’s whales. There may be up to 276 exposures of Bryde’s whale to potential Level B harassment annually.
Minke Whale (*Balaenoptera acutorostrata*)

There is no density information available for minke whales in Hawaiian waters given they have rarely been seen during surveys. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any minke whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB (Table 4.1.2.6.1-2). No minke whales would be exposed to impulsive noise or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.6.1-2).

Given the large size (up to 27 ft) of individual minke whales, pronounced blow, breaching behavior and mean group size of approximately 1.4 animals (Barlow, 2003), it is very likely that lookouts would detect a group of minke whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, minke whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a minke whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of minke whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to minke whales.

Blainville’s Beaked Whale (*Mesoplodon densirostris*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 444 exposures of Blainville’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 18 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Blainville’s beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be two exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given the size (up to 15.5 ft) of individual Blainville’s beaked whales, aggregation of 2.3 animals, it is likely that lookouts would detect a group of Blainville’s beaked whales at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Blainville’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large Blainville’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Blainville’s beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Blainville’s beaked whales. There may be up to 613 exposures of Blainville’s beaked whale to potential Level B harassment annually.
Bottlenose Dolphin (*Tursiops truncatus*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,015 exposures of bottlenose dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1).

Modeling indicates 67 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2^-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no bottlenose dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2^-s, which is the threshold indicative of onset PTS. No bottlenose dolphins would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given the frequent surfacing, aggregation of approximately nine animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of bottlenose dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, bottlenose dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting bottlenose dolphins reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of bottlenose dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to bottlenose dolphins. There may be up to 1,348 exposures of bottlenose dolphins to potential Level B harassment annually.

Cuvier’s Beaked Whale (*Ziphius cavirostris*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,182 exposures of Cuvier’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 16 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2^-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Cuvier’s beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2^-s, which is the threshold indicative of onset PTS. Modeling indicates there would 10 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury (Table 4.1.2.6.1-2).

Given the medium size (up to 23 ft) of individual Cuvier’s beaked whales, aggregation of approximately two animals (Barlow, 2006), it is likely that lookouts would detect a group of Cuvier’s beaked whales at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Cuvier’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Cuvier’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.
Based on the model results, behavioral patterns, acoustic abilities of Cuvier’s beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Cuvier’s beaked whales. There may be up to 1,593 exposures of Cuvier’s beaked whales to potential Level B harassment annually.

**Dwarf Sperm Whale (Kogia sima)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,871 exposures of dwarf sperm whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 105 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no dwarf sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates nine exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or onset of massive lung injury (Table 4.1.2.6.1-2).

Based on the model results, behavioral patterns, acoustic abilities of dwarf sperm whales, results of past training, and the implementation of mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to dwarf sperm whale. There may be up to 2,565 exposures of dwarf sperm whales to potential Level B harassment annually.

**False Killer Whale (Pseudorca crassidens)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 61 exposures of false killer whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates four exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no false killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No false killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given their size (up to 19.7 ft) and large mean group size of 10.3 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow 2003), it is very likely that lookouts would detect a group of false killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, false killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of false killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of false killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to false killer whales. There may be up to 82 exposures of false killer whales to potential Level B harassment annually.
Fraser’s Dolphin (Lagenodelphis hosei)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,136 exposures of Fraser’s dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 63 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Fraser’s dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be four exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or onset of massive lung injury (Table 4.1.2.6.1-2).

Given their large aggregations, mean group size of 286.3 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow 2006), it is very likely that lookouts would detect a group of Fraser’s dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Fraser’s dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of Fraser’s dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of Fraser’s dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Fraser’s dolphins. There may be up to 1,556 exposures of Fraser’s dolphins to potential Level B harassment annually.

Killer Whale (Orcinus orca)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 61 exposures of killer whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates four exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given their size (up to 23 ft), conspicuous coloring, pronounce dorsal fin and large mean group size of 6.5 animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the
HRC training events would not result in any death or injury to killer whales. There may be up to 82 exposures of killer whales to potential Level B harassment annually.

**Longman’s Beaked Whale (Indopacetus pacificus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 130 exposures of Longman’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates five exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Longman’s beaked whale would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Longman’s beaked whale would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given the medium size (up to 24 ft) of individual Longman’s beaked whale, aggregation of approximately 17.8 animals (Barlow, 2006), it is very likely that lookouts would detect a group of Longman’s beaked whale at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Longman’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Longman’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Longman’s beaked whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Longman’s beaked whale. There may be up to 176 exposures of Longman’s beaked whales to potential Level B harassment annually.

**Melon-headed Whale (Peponocephala electra)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 767 exposures of melon-headed whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 41 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no melon-headed whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No melon-headed whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given their size (up to 8.2 ft) and large group size (mean of 89.2 whales) or more animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of melon-headed whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, melon-headed whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of melon-headed whales reduce the likelihood of exposure.
Based on the model results, behavioral patterns, acoustic abilities of melon-headed whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to melon-headed whales. There may be up to 1,015 exposures of melon-headed whales to potential Level B harassment annually.

**Pantropical Spotted Dolphin** (*Stenella attenuata*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 3,176 exposures of pantropical spotted dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 153 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pantropical spotted dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates two exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.6.1-2).

Given their frequent surfacing and large group size hundreds of animals (Leatherwood et al., 1982), mean group size of 60.0 animals in Hawaii and probability of trackline detection of 1.00 in Beaufort Sea States of 6 or less (Barlow 2006), it is very likely that lookouts would detect a group of pantropical spotted dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, pantropical spotted dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pantropical spotted dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pantropical spotted dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pantropical spotted dolphins. There may be up to 4,184 exposures of pantropical spotted dolphins to potential Level B harassment annually.

**Pygmy Killer Whale** (*Feresa attenuata*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 243 exposures of pygmy killer whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 15 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pygmy killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No pygmy killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Given their size (up to 8.5 ft) and mean group size of 14.4 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of pygmy killer whales at the surface. Additionally, mitigation measures
call for continuous visual observation during operations with active sonar; therefore, pygmy killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pygmy killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pygmy killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pygmy killer whales. There may be up to 328 exposures of pygmy killer whales to potential Level B harassment annually.

**Pygmy Sperm Whale (Kogia breviceps)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 764 exposures of pygmy sperm whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 43 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pygmy sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates four exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury (Table 4.1.2.6.1-2).

Given their size (up to 10 ft) and behavior of resting at the surface (Leatherwood et al., 1982), it is very likely that lookouts would detect a pygmy sperm whale at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, pygmy sperm whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pygmy sperm whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pygmy sperm whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pygmy sperm whale. There may be up to 1,048 exposures of pygmy sperm whales to potential Level B harassment annually.

**Risso’s Dolphin (Grampus griseus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 639 exposures of Risso’s dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 34 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Risso’s dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Risso’s dolphins would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).
Given their frequent surfacing, light coloration and large group size of up to several hundred animals (Leatherwood et al., 1982), mean group size of 15.4 dolphins in Hawaii and probability of trackline detection of 0.76 in Beaufort Sea States of 6 or less (Barlow, 2006), it is very likely that lookouts would detect a group of Risso’s dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, Risso’s dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of Risso’s dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of Risso’s dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Risso’s dolphins. There may be up to 846 exposures of Risso’s dolphins to potential Level B harassment annually.

**Rough-Toothed Dolphin (Steno bredanensis)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 984 exposures of rough-toothed dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 55 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no rough-toothed dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2-s, which is the threshold indicative of onset PTS. Modeling indicates there would be three exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.6.1-2).

Given their frequent surfacing and mean group size of 14.8 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of rough-toothed dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, rough-toothed dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of rough-toothed dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of rough-toothed dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to rough-toothed dolphins. There may be up to 1,348 exposures of rough-toothed dolphins to potential Level B harassment annually.

**Short-finned Pilot Whale (Globicephala macrorhynchus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 2,301 exposures of short-finned pilot whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 123 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no short-finned pilot whales would be
exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be 2 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.6.1-2).

Given their size (up to 20 ft), and large mean group size of 22.5 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of short-finned pilot whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, short-finned pilot whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of short-finned pilot whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of short-finned pilot whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to short-finned pilot whale. There may be up to 3,046 exposures of short-finned pilot whales to potential Level B harassment annually.

**Spinner Dolphin (Stenella longirostris)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 383 exposures of spinner dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 21 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no spinner dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be 2 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury massive lung injury (Table 4.1.2.6.1-2).

Given their frequent surfacing, aerobatics and large mean group size of 31.7 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of spinner dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, spinner dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of spinner dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of spinner dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to spinner dolphins. There may be up to 524 exposures of spinner dolphins to potential Level B harassment annually.
Striped Dolphin (*Stenella coeruleoalba*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 4,639 exposures of striped dolphins would result in responses that would be classified as harassment (Table 4.1.2.6.1-1). Modeling indicates 224 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates one exposure to accumulated acoustic energy at or above 215 dB re 1 µPa²-s, which is the threshold indicative of onset PTS. Modeling indicates three exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.6.1-2).

Given their frequent surfacing, aerobatics and large mean group size of 37.3 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of striped dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, striped dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of striped dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of striped dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to striped dolphins. There may be up to 6,106 exposures of striped dolphins to potential Level B harassment annually.

Unidentified Beaked Whales

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 38 exposures of unidentified beaked whales would result in responses that would be classified as harassment (Table 4.1.2.6.1-1).

Modeling indicates one exposure to accumulated acoustic energy between 195 dB and 215 dB re 1 µPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no unidentified beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 µPa²-s, which is the threshold indicative of onset PTS. No unidentified beaked whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.6.1-2).

Based on the model results, behavioral patterns, acoustic abilities of unidentified beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to unidentified beaked whales. There may be up to 51 exposures of unidentified beaked whales to potential Level B harassment annually.
4.1.2.6.4 Summary of Compliance with MMPA and ESA—Alternative 1

Endangered Species Act

Based on analytical modeling results, five endangered marine mammal species occurring within the Hawaii OPAREA may be exposed to acoustic energy that could result in TTS or behavioral modification, including the fin whale, humpback whale, sei whale, sperm whale, and Hawaiian monk seal. Modeling results also indicate a potential for PTS exposures (under the ESA level of >0.05). However, even the sum of exposures at 215 dB from all operations over a year does not exceed 0.55 exposures for any ESA species. Implementation of mitigation measures would further reduce the potential for TTS and PTS exposures. Based on the analysis presented in the previous section the Navy concludes that HRC ASW Exercises may affect fin whale, humpback whales, sei whales, sperm whales, and Hawaiian monk seals.

As described in the No-action Alternative, two other listed cetaceans, the blue whale and North Pacific right whale may be found in the HRC. Very few sightings have been recorded in the Hawaiian Islands, and they are not expected to be encountered during ASW Exercises. Because the mid-frequency active tactical sonar proposed for HRC ASW training is outside the frequency typically used by these whales, they are not likely to hear or have a physiological or behavioral response to the sonar (National Oceanic and Atmospheric Administration, 2006). HRC ASW operations would therefore result in no effect to blue whales and North Pacific right whales.

Mitigation measures would be implemented to prevent exposure of marine mammals to impulsive sound or sound pressures from underwater detonations that would cause injury.

Five species of sea turtles could potentially occur within the HRC. All are protected under the ESA. All available acoustic information suggests that sea turtles are likely not capable of hearing mid-frequency (2.6 kHz and 3.3 kHz) sounds in the range produced by the active tactical sonar. Mitigation measures would be implemented to prevent exposure of sea turtles to impulsive sound or sound pressures from underwater detonations that would cause injury.

Marine Mammal Protection Act

Level A Harassment of Cetaceans

Modeling results for the sum of exposures for all ASW Exercises for a year indicate one humpback exposure that exceeds the Level A harassment threshold. However, given implementation of mitigation measures, it is unlikely that ASW operations would result in injury to marine mammals. Therefore, the Navy concludes that HRC operations would not result in Level A harassment of humpback whales. In addition, the following considerations further reduce the potential for injury from tactical sonar and underwater explosions:

- Level A zone of influence radii for tactical sonar are so small that on-board observers would readily observe an approaching marine mammal.
- Species are large or travel in large pods and are easily visible from an elevated platform; a ship or aircraft would readily see a marine mammal in time to implement mitigation measures.
**Level B Harassment of Cetaceans**

As shown in Table 4.1.2.6.1-1, quantitative modeling results indicate potential for exposures at thresholds that equate to Level B harassment of cetaceans (TTS and sub-TTS behavioral). However, modeling assumptions are very conservative, and overestimate the number of Level B exposures. Mitigation measures will be in place to further minimize the potential for temporary harassment, although there is currently no data to quantify the mitigation efforts to successfully reduce the number of marine mammal exposures. The Navy has begun development of a comprehensive Monitoring Plan to determine the effectiveness of these measures. Many species of small cetaceans travel in very large pods, and therefore would be easily observed from an elevated platform. In addition, large baleen whales travel slowly and are easily observed on the surface. In the years of conducting Major Exercises in the HRC, there have been no documented incidences of harassments or beach strandings of marine mammals associated with active sonar or underwater explosives. In the one event associated with RIMPAC 2004, sonar was suggested to be a plausible contributing factor (Southall et al., 2006) although a similar event occurred on the same day in a bay at Rota Island, Northern Marianas Islands with no associated sonar (Jefferson et al., 2006) and may be related to oceanographic changes that influenced prey distribution (Southall 2006; Ketten, 2006). The HRC Open Ocean waters continue to support diverse and stable populations of cetaceans.

**4.1.2.6.5 Increased Tempo and Frequency of Training Operations—Alternative 1**

The HRC training operations for Alternative 1 involving sonar include ASW TRACKEX and ASW TORPEX as described in Table 2.2.2.3-1 and Appendix D. The number of hours of sonar modeled for Alternative 1 is the same as the No-action Alternative, which included 1,440 hours of S3C surface ship sonar and associated sonobuoys per year. The modeled exposures for marine mammals during TRACKEX and TORPEX training operations, without consideration of mitigation measures are presented in Table 4.1.2.6.1-1. Effects on marine mammals from these exposures are included in the discussion in Sections 4.1.2.6.2 for ESA listed species and 4.1.2.6.3 for non-ESA listed species. Exposures from underwater detonations (i.e. SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are included in the summary numbers in Table 4.1.2.6.1-2.

**4.1.2.6.6 Enhanced and Future RDT&E Operations—Alternative 1**

There are no new or future RDT&E operations that would affect marine animals. Sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect marine animals. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish, sea turtles, and marine mammals.

**4.1.2.6.7 HRC Enhancements—Alternative 1**

There are no new HRC enhancement operations that would affect marine animals. Other sources such as underwater communications and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect marine animals.
4.1.2.6.8 Major Exercises—Alternative 1

RIMPAC

The operations and impacts to marine mammals from RIMPAC Exercises have been summarized in the RIMPAC 2006 Supplement to the 2002 RIMPAC EA (U.S. Department of the Navy, Commander Third Fleet, 2006). The Alternative 1 modeling assumes two Strike Groups and included 1,064 hours of 53C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes per RIMPAC (conducted every other year). The modeled exposures for marine mammals during RIMPAC, without consideration of mitigation measures are presented in Table 4.1.2.6.9-1. Effects on marine mammals from these exposures are included in the discussion in Sections 4.1.2.6.2 for ESA listed species and 4.1.2.6.3 for non-ESA listed species. Exposures from underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are included in the summary numbers in Table 4.1.2.6.1-2. Sections 4.1.2.2 and 4.1.2.3 discuss the potential effects on fish and sea turtles, respectively.

USWEX

The operations and impacts on marine mammals from USWEX have been summarized in the USWEX Programmatic EA/OEA (U.S. Department of the Navy, 2007b). The Alternative 1 number of hours modeled is the same as the No-action Alternative, and included 1167 hours of 53C surface ship sonar and associated dipping sonar and sonobuoys per year. The modeled exposures for marine mammals during up to six USWEX per year, without consideration of mitigation measures are presented in Table 4.1.2.5.7-2. Effects on marine mammals from these exposures are included in the discussion in Sections 4.1.2.5.2 for ESA listed species and 4.1.2.5.3 for non-ESA listed species. Exposures from underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are included in the summary numbers in Table 4.1.2.6.1-2. Sections 4.1.2.2 and 4.1.2.3 discuss the potential effects on fish and sea turtles respectively.

4.1.2.7 Marine Mammals Alternative 2 (Biological Resources—Open Ocean)

The discussion under the No-action Alternative regarding potential non-acoustic impacts (Section 4.1.2.5.1) and potential ASW Impacts (Section 4.1.2.5.2) also apply for Alternative 2.

4.1.2.7.1 Alternative 2 Summary of Exposures

The increased operations under Alternative 2 result in an increase in the number of hours of ASW training. The modeling input includes a total of 5,179 hours of AN/AQS 53C mid-frequency active tactical sonar and the associated DICASS sonobuoy, MK-48 torpedo, and dipping sonar modeling inputs. These exposure numbers are generated by the model without consideration of mitigation measures that would reduce the potential for marine mammal exposures to sonar. Table 4.1.2.7.1-1 provides a summary of the total sonar exposures from all Alternative 2 ASW Exercises that would be conducted over the course of a year. The number of exposures from each type of exercise are presented separately in Sections 4.1.2.7.5, 4.1.2.7.6, and 4.1.2.7.7, 4.1.2.7.8, and 4.1.2.7.9.
Table 4.1.2.6.9-1. Alternative 1 Sonar Modeling Summary - Yearly Marine Mammal Exposures for RIMPAC with 2 Strike Groups (Conducted Every Other Year)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>49</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>15</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>15</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sperm whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>230</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>436</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>178</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>314</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>32</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>108</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>10</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>256</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>15</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>15</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>59</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>578</td>
<td>33</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>160</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>193</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>229</td>
<td>15</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>265</td>
<td>17</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>817</td>
<td>41</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>89</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>1,193</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>98</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5,354</strong></td>
<td><strong>274</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Note: 1 Endangered Species
2 Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.

Dose Function Curve
195 dB – TTS 195-215 dB re 1 μPa<sup>2</sup>
215 dB- PTS >215 dB re 1 μPa<sup>2</sup>-s

DB = decibel
TTS = temporary threshold shift
PTS = permanent threshold shift
### Table 4.1.2.7.1-1. Alternative 2 Sonar Modeling Summary - Yearly Marine Mammal Exposures From all ASW (TRACKEX, TORPEX, RIMPAC, USWEX, Multiple Strike Group)

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>273</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale$^{1,2}$</td>
<td>82</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale$^{1,2}$</td>
<td>82</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale$^{1}$</td>
<td>34,797</td>
<td>482</td>
<td>1</td>
</tr>
<tr>
<td>Sperm whale$^{1}$</td>
<td>1,154</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>2,565</td>
<td>134</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>1,048</td>
<td>55</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>1,593</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>176</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>613</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>51</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>1,348</td>
<td>67</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>82</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>82</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>328</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>3,046</td>
<td>157</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>846</td>
<td>44</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>1,015</td>
<td>52</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>1,348</td>
<td>70</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>1,556</td>
<td>81</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>4,184</td>
<td>196</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>524</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>6,106</td>
<td>287</td>
<td>1</td>
</tr>
<tr>
<td>Monk seal$^1$</td>
<td>570</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>63,468</strong></td>
<td><strong>1,788</strong></td>
<td><strong>2</strong></td>
</tr>
</tbody>
</table>

Note:  
$^1$ Endangered Species  
$^2$ Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.

Dose Function Curve  
- 195 dB – TTS 195-215 dB re 1 μPa²-s
- 215 dB- PTS > 215 dB re 1 μPa²-s

Assumes 3 Strike Group Exercise in winter  

dB = decibel

TTS = temporary threshold shift

PTS = permanent threshold shift
The explosive modeling input includes mine neutralization, MISSILEX, BOMBEX, SINKEX, GUNEX, and NSFS. The modeled explosive exposure harassment numbers by species are presented in Table 4.1.2.7.1-2. The table indicates the potential for non-injurious (Level B) harassment, as well as the onset of injury (Level A) harassment to cetaceans. The modeling indicates 58 annual exposures to pressure from underwater detonations that could result in TTS. The modeling indicates no exposures from pressure from underwater detonations that could cause injury. These exposure modeling results are estimates of marine mammal underwater detonation sound exposures without consideration of standard mitigation and monitoring procedures. Implementation of the mitigation and monitoring procedures presented in Chapter 6.0 will minimize the potential for marine mammal exposure and harassment through range clearance procedures.

4.1.2.7.2 Estimated Effects on ESA Listed Species—Alternative 2

The endangered species that may be affected as a result of implementation of the HRC Alternative 2 operations include the blue whale (Balaenoptera musculus), fin whale (Balaenoptera physalus), Hawaiian monk seal (Monachus schauinslandi), humpback whale (Megaptera novaehollandiae), North Pacific right whale (Eubalaena japonica), sei whale (Balaenoptera borealis), and sperm whale (Physeter macrocephalus).

For Alternative 2, modeling results predict that if there were no mitigation measures in place, exposures that are temporary, non-injurious physiological effects (TTS) or behavioral effects would occur. The modeling predicts one exposure to energy in excess of 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

The following sections discuss the exposure of ESA listed species to sonar from all Alternative 2 ASW Exercises per year. The exposure numbers are given without consideration of mitigation measures. However, mitigation measures that are implemented during the ASW Exercises would reduce the potential for marine mammal exposures to sonar.

Blue Whale (Balaenoptera musculus)

There is no density information available for blue whales in Hawaiian waters given they have not been seen during survey. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any blue whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No blue whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury.

Based on the model results, behavioral patterns, acoustic abilities of blue whales, results of past training operations, and the implementation of mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to blue whales.
### Table 4.1.2.7.1-2. Alternative 2 Explosives Modeling Summary - Yearly Marine Mammal Exposures From all Explosive Sources

<table>
<thead>
<tr>
<th>Marine Mammal Species</th>
<th>TTS Modeled at &lt; 182 dB re 1 μPa²-s or 23 psi</th>
<th>Total Exposures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mine Neutralization Air to Surface Missile Exercise</td>
<td></td>
</tr>
<tr>
<td>Bryde’s whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Fin whale¹ ²</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Sei whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Humpback whale¹</td>
<td>1 0 0 7 0 6 1 15 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Sperm whale¹</td>
<td>0 0 0 2 3 0 0 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>0 0 0 4 4 1 0 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>0 0 0 2 2 0 0 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>0 0 0 5 5 0 0 10 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>0 0 0 1 1 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>False killer whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Killer whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>0 0 0 1 1 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Rissío’s dolphin</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>0 0 0 2 1 0 0 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>0 0 0 2 2 0 0 4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>0 0 0 1 0 1 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>0 0 0 1 1 0 0 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>0 0 0 1 1 0 0 3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Monk seal¹</td>
<td>0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1 0 0 29 21 9 1 61 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

1. Endangered Species
2. Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
3. $dB = \text{decibel}$
4. $\mu Pa^2-s = \text{squared micropascal-second}$
5. $TM = \text{tympanic membrane}$
6. $TTS = \text{temporary threshold shift}$
Fin Whale (*Balaenoptera physalus*)

There is no density information for fin whales in the Hawaiian Islands (Barlow, 2006). For purposes of acoustic effects analysis estimates, it was assumed that the number and density of fin whales did not exceed that of false killer whales, and the modeled number of exposures for both species would therefore be the same.

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 82 exposures of fin whales would result in responses that would be classified as harassment (Table 4.1.2.7.1-1). Modeling also indicates there would be five exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates no exposures for fin whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No fin whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.7.1-2).

Based on the model results, behavioral patterns, acoustic abilities of fin whales, results of past HRC training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would likely not result in any death or injury to fin whales. The proposed ASW Exercises may affect fin whales.

Humpback Whale (*Megaptera novaeangliae*)

The acoustic effects analysis for Alternative 2 predicts that without consideration of mitigation, the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 34,797 exposures of humpback whales would result in responses that would be classified as harassment (Table 4.1.2.7.1-1). Modeling indicates there would be 482 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling indicates one exposure for humpback whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be 15 exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold, and no exposures that would exceed the slight injury threshold or the massive injury threshold (Table 4.1.2.7.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no humpback whales within the safety zone, and therefore potential exposure of humpback whales to sound levels that exceed TTS or injury levels is highly unlikely.

Based on the model results, behavioral patterns, acoustic abilities of humpback whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to humpback whales. The proposed ASW Exercises may affect humpback whales.
North Pacific Right Whale (*Eubalaena japonica*)

There is no density information available for North Pacific right whales in Hawaiian waters given they have not been seen during survey. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any right whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB. No right whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury.

Based on the model results, behavioral patterns, acoustic abilities of North Pacific right whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to North Pacific right whales.

Sei Whale (*Balaenoptera borealis*)

For purposes of the acoustic effects analysis, the same assumptions made previously regarding fin whales are also made for sei whales. It was therefore assumed that the number and density of sei whales did not exceed that of false killer whales, and the modeled number of exposures for both species would therefore be the same.

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 82 exposures of sei whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling also predicts five exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling predicts no exposures for sei whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No sei whales would be exposed to impulsive sound or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.7.1-2).

Based on the model results, behavioral patterns, acoustic abilities of sei whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not likely result in any death or injury to sei whales. The proposed ASW Exercises may affect sei whales.

Sperm Whales (*Physeter macrocephalus*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,154 exposures of sperm whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling predicts 35 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling predicts there would be no exposures for sperm whales to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.
Without consideration of clearance procedures, there would be five exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold (Table 4.1.2.7.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no sperm whales within the safety zone, and therefore potential exposure of sperm whales to sound levels that exceed TTS is highly unlikely.

Based on the model results, behavioral patterns, acoustic abilities of sperm whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to sperm whales. The proposed ASW Exercises may affect sperm whales.

**Hawaiian Monk Seal (Monachus schauinslandi)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 570 exposures of Hawaiian monk seals would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).

Modeling predicts nine exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling predicts there would be no exposures for monk seals to accumulated acoustic energy above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS.

Without consideration of clearance procedures, there would be no exposures from impulsive sound or pressures from underwater detonations that would exceed the TTS threshold and no exposures that exceed the injury threshold (Table 4.1.2.7.1-2). Target area clearance procedures described in Section 4.1.2.5.1 would make sure there are no monk seals within the safety zone, and therefore potential exposure of monk seals to sound levels that exceed TTS is highly unlikely.

Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Hawaiian monk seals that move into the Hawaii OPAREA would be insignificant. Critical habitat was designated 1986 as the area extending out to the 10-fathom depth (60 ft) for the Northwestern Hawaiian Islands (National Marine Fisheries Service, 1986). Critical habitat was extended out to the 20-fathom depth in 1988 (National Marine Fisheries Service, 1988).

Based on the model results, behavioral patterns, acoustic abilities of monk seals, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the training events would not likely result in any death or injury to Hawaiian monk seals. The proposed ASW Exercises may affect monk seals.

**4.1.2.7.3 Estimated Exposures for Non-ESA Species—Alternative 2**

**Bryde’s Whale (Balaenoptera edeni)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 273 exposures of Bryde’s whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates there would be three exposures to...
accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Bryde’s whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Bryde’s whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given the large size (up to 46 ft) of individual Bryde’s whales, pronounced blow, and mean group size of approximately 1.5 animals and (probability of trackline detection = 0.87 in Beaufort Sea States of 6 or less; Barlow 2003; 2006), it is very likely that lookouts would detect a group of Bryde’s whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Bryde’s whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Bryde’s whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Bryde’s whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Bryde’s whales. There may be up to 276 exposures of Bryde’s whale to potential Level B harassment annually.

Minke Whale (*Balaenoptera acutorostrata*)

There is no density information available for minke whales in Hawaiian waters given they have rarely been seen during surveys. Given they are so few in number, it is unlikely that HRC mid-frequency active sonar training events will result in the exposure of any minke whales to accumulated acoustic energy in excess of any energy flux threshold or an SPL in excess of 145 dB (Table 4.1.2.7.1-2). No minke whales would be exposed to impulsive noise or pressures from underwater detonations that would cause TTS or physical injury (Table 4.1.2.7.1-2).

Given the large size (up to 27 ft) of individual minke whales, pronounced blow, breaching behavior, and mean group size of approximately 1.4 animals (Barlow, 2003), it is very likely that lookouts would detect a group of minke whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, minke whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a minke whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of minke whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to minke whales.

Blainville’s Beaked Whale (*Mesoplodon densirostris*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 613 exposures of Blainville’s beaked whale would result in responses that would be classified as harassment (Table 4.1.2.5.1-1).
Modeling indicates 23 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Blainville’s beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be two exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given the size (up to 15.5 ft) of individual Blainville’s beaked whales and aggregation of 2.3 animals, it is likely that lookouts would detect a group of Blainville’s beaked whales at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Blainville’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a large sei whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Blainville’s beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Blainville’s beaked whales. There may be up to 638 exposures of Blainville’s beaked whale to potential Level B harassment annually.

**Bottlenose Dolphin (Tursiops truncatus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,348 exposures of bottlenose dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 67 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no bottlenose dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No bottlenose dolphins would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given the frequent surfacing, aggregation of approximately nine animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of bottlenose dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, bottlenose dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting bottlenose dolphins reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of bottlenose dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to bottlenose dolphins. There may be up to 1,415 exposures of bottlenose dolphins to potential Level B harassment annually.
Cuvier’s Beaked Whale (*Ziphius cavirostris*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,593 exposures of Cuvier’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 20 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Cuvier’s beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would 10 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury (Table 4.1.2.7.1-2).

Given the medium size (up to 23 ft) of individual Cuvier’s beaked whales, aggregation of approximately two animals (Barlow, 2006), it is likely that lookouts would detect a group of Cuvier’s beaked whales at the surface although beaked whales dive for long periods. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Cuvier’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Cuvier’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.

Based on the model results, behavioral patterns, acoustic abilities of Cuvier’s beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Cuvier’s beaked whales. There may be up to 1,623 exposures of Cuvier’s beaked whales to potential Level B harassment annually.

Dwarf Sperm Whale (*Kogia sima*)

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 2,565 exposures of dwarf sperm whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 134 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no dwarf sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates nine exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or onset of massive lung injury (Table 4.1.2.7.1-2).

Based on the model results, behavioral patterns, acoustic abilities of dwarf sperm whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to dwarf sperm whale. There may be up to 2,708 exposures of dwarf sperm whales to potential Level B harassment annually.
4.0 Environmental Consequences, Open Ocean Area

**False Killer Whale (Pseudorca crassidens)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 82 exposures of false killer whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates five exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no false killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No false killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given their size (up to 19.7 ft) and large mean group size of 10.3 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of false killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, false killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of false killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of false killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that HRC training events would not result in any death or injury to false killer whales. There may be up to 87 exposures of false killer whales to potential Level B harassment annually.

**Fraser’s Dolphin (Lagenodelphis hosei)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,556 exposures of Fraser’s dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 81 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Fraser’s dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be four exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or onset of massive lung injury (Table 4.1.2.7.1-2).

Given their large aggregations, mean group size of 286.3 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of Fraser’s dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Fraser’s dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of Fraser’s dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of Fraser’s dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that...
the HRC training events would not result in any death or injury to Fraser’s dolphins. There may be up to 1,641 exposures of Fraser’s dolphins to potential Level B harassment annually.

**Killer Whale (Orcinus orca)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 82 exposures of killer whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 5 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2^-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2^-s, which is the threshold indicative of onset PTS. No killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given their size (up to 23 ft), conspicuous coloring, pronounce dorsal fin and large mean group size of 6.5 animals (probability of trackline detection = 0.90 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to killer whales. There may be up to 87 exposures of killer whale to potential Level B harassment annually.

**Longman’s Beaked Whale (Indopacetus pacificus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 176 exposures of Longman’s beaked whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates six exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa^2^-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Longman’s beaked whale would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa^2^-s, which is the threshold indicative of onset PTS. No Longman’s beaked whale would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given the medium size (up to 24 ft) of individual Longman’s beaked whale, aggregation of approximately 17.8 animals (Barlow, 2006), it is very likely that lookouts would detect a group of Longman’s beaked whale at the surface although beaked whales dive for long periods.

Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, Longman’s beaked whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting a Longman’s beaked whale reduce the likelihood of exposure, such that effects would be discountable.
Based on the model results, behavioral patterns, acoustic abilities of Longman’s beaked whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Longman’s beaked whale. There may be up to 182 exposures of Longman’s beaked whales to potential Level B harassment annually.

**Melon-headed Whale (*Peponocephala electra*)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,015 exposures of melon-headed whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 52 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no melon-headed whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No melon-headed whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given their size (up to 8.2 ft) and large group size (mean of 89.2 whales) or more animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2003), it is very likely that lookouts would detect a group of melon-headed whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, melon-headed whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of melon-headed whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of melon-headed whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to melon-headed whales. There may be up to 1,067 exposures of melon-headed whales to potential Level B harassment annually.

**Pantropical Spotted Dolphin (*Stenella attenuata*)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 4,184 exposures of pantropical spotted dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 196 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pantropical spotted dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates 2 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.7.1-2).

Given their frequent surfacing and large group size hundreds of animals (Leatherwood et al., 1982), mean group size of 60.0 animals in Hawaii and probability of trackline detection of 1.00 in Beaufort Sea States of 6 or less (Barlow, 2006) it is very likely that lookouts would detect a group of pantropical spotted dolphins at the surface. Additionally, mitigation measures call for
continuous visual observation during operations with active sonar and underwater detonations; therefore, pantropical spotted dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pantropical spotted dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pantropical spotted dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pantropical spotted dolphins. There may be up to 4,380 exposures of pantropical spotted dolphins to potential Level B harassment annually.

**Pygmy Killer Whale (Feresa attenuata)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 328 exposures of pygmy killer whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 19 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pygmy killer whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No pygmy killer whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given their size (up to 8.5 ft) and mean group size of 14.4 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow 2003), it is very likely that lookouts would detect a group of pygmy killer whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, pygmy killer whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pygmy killer whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pygmy killer whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pygmy killer whales. There may be up to 347 exposures of pygmy killer whales to potential Level B harassment annually.

**Pygmy Sperm Whale (Kogia breviceps)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,048 exposures of pygmy sperm whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 55 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no pygmy sperm whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates four exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury (Table 4.1.2.7.1-2).
Given their size (up to 10 ft) and behavior of resting at the surface (Leatherwood et al., 1982), it is very likely that lookouts would detect a pygmy sperm whale at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, pygmy sperm whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of pygmy sperm whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of pygmy sperm whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to pygmy sperm whales. There may be up to 1,107 exposures of pygmy sperm whales to potential Level B harassment annually.

**Risso’s Dolphin (Grampus griseus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 846 exposures of Risso’s dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 44 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no Risso’s dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No Risso’s dolphins would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Given their frequent surfacing, light coloration and large group size of up to several hundred animals (Leatherwood et al., 1982), mean group size of 15.4 dolphins in Hawaii and probability of trackline detection of 0.76 in Beaufort Sea States of 6 or less (Barlow, 2006), it is very likely that lookouts would detect a group of Risso’s dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, Risso’s dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting large groups of Risso’s dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of Risso’s dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to Risso’s dolphins. There may be up to 890 exposures of Risso’s dolphins to potential Level B harassment annually.

**Rough-Toothed Dolphin (Steno bredanensis)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 1,348 exposures of rough-toothed dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 70 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no rough-toothed dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be three exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset PTS.
of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.7.1-2).

Given their frequent surfacing and mean group size of 14.8 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of rough-toothed dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar and underwater detonations; therefore, rough-toothed dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of rough-toothed dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of rough-toothed dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to rough-toothed dolphins. There may be up to 1,421 exposures of rough-toothed dolphins to potential Level B harassment annually.

**Short-finned Pilot Whale (Globicephala macrocephalus)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 3,046 exposures of short-finned pilot whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 157 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa2-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no short-finned pilot whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa2-s, which is the threshold indicative of onset PTS. Modeling indicates there would 2 exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.7.1-2).

Given their size (up to 20 ft), and large mean group size of 22.5 animals (probability of trackline detection = 0.76 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of short-finned pilot whales at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, short-finned pilot whales that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of short-finned pilot whales reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of short-finned pilot whale, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to short-finned pilot whale. There may be up to 3,205 exposures of short-finned pilot whales to potential Level B harassment annually.

**Spinner Dolphin (Stenella longirostris)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA),
524 exposures of spinner dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 27 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no spinner dolphins would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates there would be two exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury massive lung injury (Table 4.1.2.7.1-2).

Given their frequent surfacing, aerobatics and large mean group size of 31.7 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of spinner dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, spinner dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of spinner dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of spinner dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to spinner dolphins. There may be up to 553 exposures of spinner dolphins to potential Level B harassment annually.

**Striped Dolphin (Stenella coeruleoalba)**

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 6,106 exposures of striped dolphins would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 287 exposures to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates one exposure to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. Modeling indicates three exposures to impulsive noise or pressures from underwater detonations of 182 dB or 23 psi, which is the threshold indicative of onset TTS, and no exposures to impulsive noise or pressures from underwater detonations that would cause slight physical injury or massive lung injury (Table 4.1.2.7.1-2).

Given their frequent surfacing, aerobatics and large mean group size of 37.3 animals (probability of trackline detection = 1.00 in Beaufort Sea States of 6 or less; Barlow, 2006), it is very likely that lookouts would detect a group of striped dolphins at the surface. Additionally, mitigation measures call for continuous visual observation during operations with active sonar; therefore, striped dolphins that migrate into the Hawaii OPAREA would be detected by visual observers. Implementation of mitigation measures and probability of detecting groups of striped dolphins reduce the likelihood of exposure.

Based on the model results, behavioral patterns, acoustic abilities of striped dolphins, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to striped dolphins. There may be up to 6,396 exposures of striped dolphins to potential Level B harassment annually.
Unidentified Beaked Whales

Based on output of the dose function (which estimates the probability of an exposure resulting in behavioral responses that NMFS would classify as harassment for the purposes of the MMPA), 51 exposures of unidentified beaked whales would result in responses that would be classified as harassment (Table 4.1.2.5.1-1). Modeling indicates 1 exposure to accumulated acoustic energy between 195 dB and 215 dB re 1 μPa²-s, which is the threshold established indicative of onset TTS. Modeling for all alternatives indicates that no unidentified beaked whales would be exposed to accumulated acoustic energy at or above 215 dB re 1 μPa²-s, which is the threshold indicative of onset PTS. No unidentified beaked whales would be exposed to impulsive noise or pressures from underwater detonations that would cause physical injury (Table 4.1.2.7.1-2).

Based on the model results, behavioral patterns, acoustic abilities of unidentified beaked whales, results of past training, and the implementation of procedure mitigation measures, the Navy finds that the HRC training events would not result in any death or injury to unidentified beaked whales. There may be up to 52 exposures of unidentified beaked whales to potential Level B harassment annually.

4.1.2.7.4 Summary of Compliance with MMPA and ESA—Alternative 2

Endangered Species Act

Based on analytical modeling results, five endangered marine mammal species occurring within the Hawaii OPAREA may be exposed to acoustic energy that could result in TTS or behavioral modification, including the fin whale, humpback whale, sei whale, sperm whale, and Hawaiian monk seal. Modeling results also indicate a potential for PTS exposures (under the ESA level of >0.05). However, even the sum of exposures at 215 dB from all operations over a year does not exceed 0.66 exposures for any ESA species. Implementation of mitigation measures would further reduce the potential for TTS and PTS exposures. Based on the analysis presented in the previous section the Navy concludes that HRC ASW Exercises may affect fin whale, humpback whales, sei whales, sperm whales, and Hawaiian monk seals.

As described in the No-action Alternative, two other listed cetaceans, the blue whale and North Pacific right whale may be found in the HRC. Very few sightings have been recorded in the Hawaiian Islands, and they are not expected to be encountered during ASW Exercises. Because the mid-frequency active tactical sonar proposed for HRC ASW training is outside the frequency typically used by these whales, they are not likely to hear or have a physiological or behavioral response to the sonar (National Oceanic and Atmospheric Administration, 2006). HRC ASW operations would therefore result in no effect to blue whales and North Pacific right whales.

Mitigation measures would be implemented to prevent exposure of marine mammals to impulsive sound or sound pressures from underwater detonations that would cause injury.

Five species of sea turtles could potentially occur within the HRC. All are protected under the ESA. All available acoustic information suggests that sea turtles are likely not capable of hearing mid-frequency (2.6 kHz and 3.3 kHz) sounds in the range produced by the active tactical sonar. Mitigation measures would be implemented to prevent exposure of sea turtles to impulsive sound or sound pressures from underwater detonations that would cause injury.
In accordance with ESA requirements, the Navy will initiate Section 7 consultation with NMFS based on the Navy determination that HRC operations may affect fin whales, humpback whales, sei whales, sperm whales, and Hawaiian monk seals.

**Marine Mammal Protection Act**

**Level A Harassment of Cetaceans**

Modeling results for the sum of exposures for all ASW Exercises for a year indicate one humpback exposure that exceeds the Level A harassment threshold. However, given implementation of mitigation measures, it is unlikely that ASW operations would result in injury to marine mammals. Therefore, the Navy concludes that HRC operations would not result in Level A harassment of humpback whales. In addition, the following considerations further reduce the potential for injury from tactical sonar and underwater explosions:

- Level A zone of influence radii for tactical sonar are so small that on-board observers would readily observe an approaching marine mammal.

- Species are large or travel in large pods and are easily visible from an elevated platform; a ship or aircraft would readily see a marine mammal in time to implement mitigation measures.

**Level B Harassment of Cetaceans**

As shown in Table 4.1.2.7.1-1, quantitative modeling results indicate potential for exposures at thresholds that equate to Level B harassment of cetaceans (TTS and sub-TTS behavioral). However, modeling assumptions are very conservative, and overestimate the number of Level B exposures. Mitigation measures will be in place to further minimize the potential for temporary harassment, although there is currently no data to quantify the mitigation efforts to successfully reduce the number of marine mammal exposures. The Navy has begun development of a comprehensive Monitoring Plan to determine the effectiveness of these measures. Many species of small cetaceans travel in very large pods, and therefore would be easily observed from an elevated platform. In addition, large baleen whales travel slowly and are easily observed on the surface. In the years of conducting Major Exercises in the HRC, there have been no documented incidences of harassments or beach strandings of marine mammals associated with active sonar or underwater explosives. In the one event associated with RIMPAC 2004, sonar was suggested to be a plausible contributing factor (Southall et al., 2006) although a similar event occurred on the same day in a bay at Rota Island, Northern Marianas Islands with no associated sonar (Jefferson et al., 2006) and may be related to oceanographic changes that influenced prey distribution (Southall, 2006; Ketten, 2006). The HRC Open Ocean waters continue to support diverse and stable populations of cetaceans. Based on the potential for Level B harassment, the Navy will consult with NMFS and apply for a 5-year Letter of Authorization under the MMPA.

**4.1.2.7.5 Increased Tempo and Frequency of Training Operations—Alternative 2**

The HRC training operations for Alternative 1 involving sonar include ASW TRACKEX and ASW TORPEX as described in Table 2.2.2.3-1 and Appendix D. The number of hours of sonar modeled for Alternative 2 included 1,590 hours of 53C surface ship sonar and associated sonobuoys per year. The modeled exposures for marine mammals during TRACKEX and...
TORPEX training operations, without consideration of mitigation measures are presented in Tables 4.1.2.7.5-1 and 4.1.2.7.5-2. Effects on marine mammals from these exposures are included in the discussion in Section 4.1.2.7.2 for ESA listed species and Section 4.1.2.7.3 for non-ESA listed species. Exposures from underwater detonations (i.e., SINKEX), A-S MISSILEX, S-S MISSILEX, BOMBEX, S-S GUNEX, and NSFS are included in the summary numbers in Table 4.1.2.7.5-2.

4.1.2.7.6 Enhanced and Future RDT&E Operations—Alternative 2

There are no new or future RDT&E operations that would affect marine animals. Sources such as UAVs, underwater communications, and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect marine animals. Other RDT&E operations identified as ASW do not include sonar or include very limited use of sonar and short durations (<1.5 hours). These operations would have minimal effects on fish, sea turtles, and marine mammals.

4.1.2.7.7 HRC Enhancements—Alternative 2

There are no new HRC enhancement operations that would affect marine animals. Other sources such as underwater communications and electronic warfare systems that may be deployed in the ocean are beyond the frequency range or intensity level to affect marine animals.

4.1.2.7.8 Additional Major Exercises—Multiple Strike Group Training—Alternative 2

RIMPAC and USWEX

The number of hours of sonar modeled for Alternative 2 for RIMPAC is the same as Alternative 1. RIMPAC includes 1,064 hours of 53C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes per RIMPAC (conducted every other year). The modeled exposures for marine mammals during RIMPAC for Alternative 2, without consideration of mitigation measures, are presented in Table 4.1.2.6.9-1. Effects on marine mammals from these exposures under Alternative 2 are included in the discussion in Section 4.1.2.7.2 for ESA listed species and Section 4.1.2.7.3 for non-ESA listed species.

The number of hours of sonar modeled for Alternative 2 for USWEX is the same as the No-action Alternative. USWEX includes 1,167 hours of 53C surface ship sonar and associated dipping sonar and sonobuoys per year. The modeled exposures for marine mammals during up to six USWEX per year, without consideration of mitigation measures, are presented in Table 4.1.2.5.7-2. Effects on marine mammals from these exposures under Alternative 2 are included in the discussion in Sections 4.1.2.7.2 for ESA listed species and 4.1.2.7.3 for non-ESA listed species.
### Table 4.1.2.7.5-1. Alternative 2 Sonar Modeling Summary—Yearly Marine Mammal Exposures from Tracking Exercises

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde's whale</td>
<td>76</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale (^1)</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale (^1)</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale (^1)</td>
<td>7,506</td>
<td>110</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale (^1)</td>
<td>346</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>741</td>
<td>40</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>303</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier's beaked whale</td>
<td>449</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Longman's beaked whale</td>
<td>50</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Blainville's beaked whale</td>
<td>173</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>14</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>402</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>24</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>97</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>917</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>Risso's dolphin</td>
<td>255</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>306</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>389</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Fraser's dolphin</td>
<td>449</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>1,256</td>
<td>60</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>151</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>1,834</td>
<td>88</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal (^1)</td>
<td>160</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>15,970</strong></td>
<td><strong>504</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>

Note: \(^1\) Endangered Species
\(^2\) Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.

Dose Function Curve

195 dB – TTS 195-215 dB re 1 μPa²-s
215 dB – PTS >215 dB re 1 μPa²-s

\(\text{dB} = \text{decibel}\)

\(\text{TTS} = \text{temporary threshold shift}\)

\(\text{PTS} = \text{permanent threshold shift}\)
Table 4.1.2.7.5-2. Alternative 2 Sonar Modeling Summary - Yearly Marine Mammal Exposures from Torpedo Exercises

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale&lt;sup&gt;1,2&lt;/sup&gt;</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>2,507</td>
<td>48</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale&lt;sup&gt;1&lt;/sup&gt;</td>
<td>90</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Dwarf sperm whale</td>
<td>192</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>78</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>96</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>40</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>106</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>26</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>248</td>
<td>13</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>69</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>83</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>101</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Fraser’s dolphin</td>
<td>116</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Pantropical spotted dolphin</td>
<td>333</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>39</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Striped dolphin</td>
<td>485</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>37</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4,702</td>
<td>154</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: 1 Endangered Species
2 Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.
3 Dose Function Curve
4 173 dB – sub-TTS (NMFS) 173-195 dB re 1 μPa<sup>2</sup>-s
5 190 dB – sub-TTS (Navy) 190-195 dB re 1 μPa<sup>2</sup>-s
6 195 dB – TTS 195-215 dB re 1 μPa<sup>2</sup>-s
7 215 dB- PTS >215 dB re 1 μPa<sup>2</sup>-s
8 dB = decibel
9 TTS = temporary threshold shift
10 PTS = permanent threshold shift

Multiple Strike Group Training Exercise
Up to three Strike Groups would conduct training operations simultaneously in the HRC. The Strike Groups would not be home ported in Hawaii, but would stop in Hawaii en route to a final destination. The Strike Groups would be in Hawaii for up to 10 days per exercise. Training would be provided to submarine, ship, and aircraft crews in tactics, techniques, and procedures for
ASW, Defensive Counter Air, Maritime Interdiction, and operational level C2 of maritime forces. The three Strike Group marine mammal exposure modeling included 944 hours of 53 C surface ship sonar and associated dipping sonar, sonobuoys, and MK-48 torpedoes. The modeled exposures for marine mammals during the Multiple Strike Group training exercise, without consideration of mitigation measures are presented in Table 4.1.2.7.8-1. Modeling assumed the exercise is conducted during the winter to account for potential humpback whale exposures. Effects on marine mammals from these exposures under Alternative 2 are included in the discussion in Sections 4.1.2.7.2 for ESA listed species and 4.1.2.7.3 for non-ESA listed species.

<table>
<thead>
<tr>
<th>Marine Mammals</th>
<th>Dose Function Behavioral</th>
<th>195 dB TTS</th>
<th>215 dB PTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bryde’s whale</td>
<td>66</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Fin whale</td>
<td>18</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sei whale</td>
<td>18</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Humpback whale</td>
<td>5,364</td>
<td>63</td>
<td>0</td>
</tr>
<tr>
<td>Sperm whale</td>
<td>227</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>Dwarf sperm whale</td>
<td>597</td>
<td>24</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy sperm whale</td>
<td>244</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Cuvier’s beaked whale</td>
<td>355</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Longman’s beaked whale</td>
<td>41</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Blainville’s beaked whale</td>
<td>146</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Unidentified beaked whale</td>
<td>11</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Bottlenose dolphin</td>
<td>280</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>False killer whale</td>
<td>18</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Killer whale</td>
<td>18</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Pygmy killer whale</td>
<td>71</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Shortfinned pilot whale</td>
<td>624</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>Risso’s dolphin</td>
<td>173</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>Melonheaded whale</td>
<td>208</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Roughtoothed dolphin</td>
<td>313</td>
<td>13</td>
<td>0</td>
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<tr>
<td>Fraser’s dolphin</td>
<td>361</td>
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<tr>
<td>Pantropical spotted dolphin</td>
<td>840</td>
<td>35</td>
<td>0</td>
</tr>
<tr>
<td>Spinner dolphin</td>
<td>122</td>
<td>5</td>
<td>0</td>
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<tr>
<td>Striped dolphin</td>
<td>1,226</td>
<td>51</td>
<td>0</td>
</tr>
<tr>
<td>Monk seal</td>
<td>136</td>
<td>1</td>
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<tr>
<td>TOTAL</td>
<td>11,480</td>
<td>298</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: ¹ Endangered Species
² Due to a lack of density data for fin and sei whales, false killer whale results were used because they have a similar size population within the HRC.

Dose Function Curve
195 dB – TTS 195-215 dB re 1 μPa²-s
215 dB- PTS >215 dB re 1 μPa²-s
dB = decibel
TTS = temporary threshold shift
PTS = permanent threshold shift
**4.1.2.8 MARINE MAMMAL MORTALITY REQUEST**

Under the MMPA, the Navy is requesting a Letter of Authorization (LOA) for the incidental harassment of marine mammals pursuant to Section 101 (a)(5)(A) of the Marine Mammal Protection Act (MMPA). The authorization requested is for the incidental harassment of marine mammals by behavioral disruption. It is understood that an LOA is applicable for up 5 years, and is appropriate where authorization for serious injury or mortality of marine mammals is requested. In this case, per Navy policy developed in conjunction with the NMFS based on assessment of prior stranding events, a subset of beaked whales that experience disruption of natural behavioral patterns could experience secondary effects leading to serious injury or mortality. The request is for exercises and training events conducted within the HRC. These include operations that use mid-frequency sonar or underwater detonations. The request is for a 5-year period beginning July 1, 2008.

The acoustic modeling approach taken in the HRC EIS/OEIS and the LOA request attempts to quantify potential exposures to marine mammals resulting from operation of mid-frequency active sonar and underwater detonations. Results from this conservative modeling approach are presented without consideration of mitigation measures employed per Navy SOPs. For example, securing or turning off an active sonar when an animal approaches closer than a specified distance reduces potential exposure since the sonar is no longer transmitting. Modeling results from the HRC analysis does not predict any marine mammal mortalities. Modeling results do predict that one humpback whale could be exposed to sonar in excess of PTS threshold indicative of Level A injury. However, given standard mitigation measures presented in Chapter 6.0, and the increased likelihood that humpback whales can be more readily detected, a single Level A exposure is less likely to occur.

To reiterate an important point, the history of Navy activities in the HRC and analysis in this document indicate that military readiness activities are not expected to realistically result in any sonar–induced Level A injury or mortalities to marine mammals.

There are natural and manmade sources of mortality other than sonar and underwater detonation that may contribute to stranding events as described in the Cetacean Stranding Section (Section 4.1.2.4.11). Documented marine mammal strandings are a regular occurrence within the Hawaiian Islands since early record keeping began in the 1930’s (Mazzuca et al., 1999, Maldini et al., 2005). For instance, 22 cetacean and 14 Hawaiian monk seal strandings or boat strikes were reported in Hawaiian waters during 2006 (National Marine Fisheries Service, Pacific Islands Region, 2007). Of these 22 strandings, 17 are attributed to either vessel strikes or fisheries interaction. In a review of mass strandings within Hawaii, approximately two-thirds occurred during the summer (Mazzuca et al., 1999). The actual cause of a particular stranding may not be immediately apparent when there is little evidence of physical trauma, especially in the case of disease or age-related mortalities. These events require careful scientific investigation by a collaborative team of subject matter experts to determine actual cause of death.

In a letter from NMFS to Navy dated October 2006, NMFS indicated that Section 101(a)(5)(A) authorization is appropriate for mid-frequency active sonar activities because it allows NMFS to consider the potential for incidental mortality. NMFS’ letter indicated, "Because mid-frequency sonar has been implicated in several marine mammal stranding events including some involving serious injury and mortality, and because there is no scientific consensus regarding the causal link between sonar and stranding events, NMFS cannot conclude with certainty the degree to which mitigation measures would eliminate or reduce the potential for serious injury of mortality." In addition, given the frequency of naturally occurring marine mammal strandings in Hawaii (e.g., natural mortality), it is conceivable that a stranding could co-occur with a Navy
Evidence from five beaked whale strandings, all of which have taken place outside the HRC, and have occurred over approximately a decade, suggests that the exposure of beaked whales to mid-frequency sonar in the presence of certain conditions (e.g., multiple units using tactical sonar, steep bathymetry, constricted channels, strong surface ducts, etc.) may result in strandings, potentially leading to mortality. Although these physical factors believed to contribute to the likelihood of beaked whale strandings are not present, in their aggregate, in the Hawaiian Islands, scientific uncertainty exists regarding what other factors, or combination of factors, may contribute to beaked whale strandings. Accordingly, to allow for scientific uncertainty regarding contributing causes of beaked whale strandings and the exact mechanisms of the physical effects, the Navy will also request authorization for take, by mortality, of the beaked whale species present in the Hawaiian Islands. Neither NMFS nor the Navy anticipates that marine mammal strandings or mortality will result from the operation of mid-frequency sonar during Navy exercises within the HRC. However, by authorizing a very small number of mortalities for beaked whales and commonly stranded species, if a single individual of these species is found dead coincident with Navy activities (a statistically likely event, as an average of two wash up per month in Hawaii), a potentially lengthy investigation of the cause(s) of the death would not unnecessarily interfere with Navy training exercises. Additionally, through the MMPA process (which allows for adaptive management), NMFS and the Navy will determine the appropriate way to proceed in the unlikely event that a causal relationship were to be found between Navy activities and a future stranding. The Navy’s LOA application requests the take, by serious injury or mortality, of 2 each of 10 species (bottlenose dolphin, Kogia spp., melon-headed whale, pantropical spotted dolphin, pygmy killer whale, short-finned pilot whale, striped dolphin, Cuvier’s, Longman’s, and Blainville’s beaked whales), however, these numbers may be modified through the MMPA process, based on available data.

4.1.3 CULTURAL RESOURCES—OPEN OCEAN

4.1.3.1 NO-ACTION ALTERNATIVE, ALTERNATIVE 1, AND ALTERNATIVE 2 (CULTURAL RESOURCES OPEN OCEAN)

There are numerous submerged cultural resources (primarily shipwrecks) widely scattered throughout the region of influence for Open Ocean operations (see Figures 3.1.3-1 through 3.1.3-3). There are no dense clusters of resources and, according to NOAA shipwreck maps, the features are situated at considerable depths. With the exception of resources within Naval Station Pearl Harbor (e.g., USS Arizona, USS Utah), there are no shipwrecks listed in the National or State Registers of Historic Places.

The only operation with the potential to affect submerged cultural resources in the open (deep) ocean areas is SINKEX. SINKEX involves the sinking of surface targets (typically excess vessel hulks) by air, surface, or submarine weapons systems. After the target is destroyed, the remaining debris settles to the sea floor. Because of the significant depths and scattered distribution of shipwrecks within this 235,000 nm² area, the likelihood of target debris coming in contact with a shipwreck is very low. In the remote chance that target debris does sink onto a shipwreck, effects on the feature would be minimal because of the size of the debris involved and the cushioning effect that water has on the weight of materials at those depths. In addition, if the exact locations of shipwrecks can be determined prior to the operation, they will be
avoided. As a result, adverse effects on cultural resources within open ocean areas from any of the alternatives are not expected.

Although effects on underwater cultural resources are not anticipated, the potential for unanticipated discovery of underwater resources always exists. To ensure that previously unidentified submerged cultural resources are adequately protected, the Commander, Naval Region (COMNAVREG), the Advisory Council on Historic Preservation (Council), and the Hawaii SHPO entered into a Programmatic Agreement (PA) in 2003 regarding Navy undertakings in Hawaii (Appendix H). Among the stipulations of the PA is one focused on unanticipated discoveries: Stipulation XI(A). The PA stipulates; “If during the performance of an undertaking, historic properties, including submerged archaeological sites and TCPs, are discovered or unanticipated effects are found, or a previously unidentified property which may be eligible for listing on the National Register of Historic Places is discovered, COMNAVREG Hawaii will take all reasonable measures to avoid or minimize harm to the property until it concludes consultation with the State Historic Preservation Office and any Native Hawaiian organization, including OCHCC, which has made known to COMNAVREG Hawaii that it attaches religious and cultural significance to the historic property.”

4.1.4 HAZARDOUS MATERIALS & WASTES—OPEN OCEAN

4.1.4.1 NO-ACTION ALTERNATIVE (HAZARDOUS MATERIALS AND WASTES—OPEN OCEAN)

4.1.4.1.1 HRC Training Operations

Hazardous Materials

Navy training operations conducted under the No-action Alternative will require the use of a variety of solid and liquid hazardous materials. Hazardous materials required on the open ocean ranges can be broadly classified as shipboard materials necessary for normal operations and maintenance, such as fuel and paint, and training materials. Training materials include both live and practice munitions (considered to be hazardous materials because they contain explosives or propellants), and non-munition training materials. Table 4.1.4.1.1-1 lists training operations involving the use of training materials containing hazardous materials.

Under the No-action Alternative, the use of hazardous materials for shipboard operations will not increase from baseline levels. Hazardous materials will continue to be controlled in compliance with OPNAVINST 5090.1B (2002), Chapter 19. The No-action Alternative will not affect hazardous materials management practices aboard ship.

Expended Training Materials

Various types of training items will be shot, launched, dropped, or placed within the Open Ocean Area under the No-action Alternative. Some training materials, including gun ammunition, bombs and missiles, targets, sonobuoys, chaff, and flares, will be expended on the range and not recovered. Items that are expended on the water, and fragments that are not recognizable as training debris (e.g., flare residue or candle mix), typically will not be recovered. Sonobuoys and flares, smoke buoys and markers, and other pyrotechnic training devices expended in the water can leak or leach small amounts of toxic substances as they degrade and decompose. A small percentage of training items containing energetic materials will fail to function properly, and—if not recovered—will remain on the sea floor as unexploded ordnance.

These items will decompose very slowly, so the volume of decomposing training debris within the training areas, and the amounts of toxic substances being released to the environment, will...
Table 4.1.4.1.1-1. HRC Training Operations with Hazardous Materials
No-action Alternative—Open Ocean Areas

<table>
<thead>
<tr>
<th>Training Activity</th>
<th>Training Materials Containing Hazardous Material</th>
<th># per operation</th>
<th>Total #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Combat Maneuver (ACM)</td>
<td>Chaff</td>
<td>6</td>
<td>4,428</td>
</tr>
<tr>
<td></td>
<td>Flare</td>
<td>3</td>
<td>2,214</td>
</tr>
<tr>
<td>Surface-to-Air Gunnery Exercise (S-A GUNEX)</td>
<td>5&quot; projectile</td>
<td>3</td>
<td>258</td>
</tr>
<tr>
<td></td>
<td>7.62-mm projectile</td>
<td>3</td>
<td>258</td>
</tr>
<tr>
<td></td>
<td>JATO bottle</td>
<td>1</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>20-mm projectile</td>
<td>1,900</td>
<td>162,000</td>
</tr>
<tr>
<td>Surface-to-Air Missile Exercise (S-A MISSILEX)</td>
<td>Missile</td>
<td>3</td>
<td>51</td>
</tr>
<tr>
<td></td>
<td>JATO Bottle</td>
<td>1</td>
<td>17</td>
</tr>
<tr>
<td>Chaff Exercise (CHAFFEX)</td>
<td>MK-36 super rapid bloom offboard chaff</td>
<td>7.5</td>
<td>255</td>
</tr>
<tr>
<td>Naval Surface Fire Support (NSFS)</td>
<td>5-in or 76-mm ammunition</td>
<td>82</td>
<td>1,804</td>
</tr>
<tr>
<td></td>
<td>20-mm projectile</td>
<td>8</td>
<td>176</td>
</tr>
<tr>
<td>Visit, Board, Search, and Seizure (VBSS)</td>
<td>0.50 caliber gun ammunition</td>
<td>varies</td>
<td>varies</td>
</tr>
<tr>
<td>Surface-to-Surface Gunnery Exercise (S-S GUNEX)</td>
<td>5-in or 76-mm ammunition</td>
<td>20</td>
<td>1,380</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>0.52</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td>7.62-mm or .50-cal ammunition</td>
<td>150</td>
<td>10,400</td>
</tr>
<tr>
<td>Surface-to-Surface Missile Exercise (S-S MISSILEX)</td>
<td>Missile</td>
<td>2</td>
<td>14</td>
</tr>
<tr>
<td>Air-to-Surface Gunnery Exercise (A-S GUNEX)</td>
<td>0.50-cal or 76.2-mm ammunition</td>
<td>400</td>
<td>51,200</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>1</td>
<td>128</td>
</tr>
<tr>
<td>Air-to-Surface Missile Exercise (A-S MISSILEX)</td>
<td>Missile</td>
<td>2</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>MK-76</td>
<td>9</td>
<td>315</td>
</tr>
<tr>
<td></td>
<td>MK-82</td>
<td>3</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>BDU-45</td>
<td>1.7</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>CBU</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>MK-83</td>
<td>0.5</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>1</td>
<td>35</td>
</tr>
<tr>
<td>Bombing Exercise (BOMBEX) (Sea)</td>
<td>Varies depending on weapons and platform</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-Surface Warfare (ASUW)</td>
<td>MK-48 torpedo</td>
<td>3</td>
<td>105</td>
</tr>
<tr>
<td>Torpedo Exercise (TORPEX) (Submarine-Surface)</td>
<td>Sonobuoys</td>
<td>24-43</td>
<td>6,228</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>1-2</td>
<td>279</td>
</tr>
<tr>
<td></td>
<td>MK-39</td>
<td>0-1</td>
<td>152</td>
</tr>
<tr>
<td>Anti-Submarine Warfare Tracking Exercise (ASW TRACKEX)</td>
<td>REXTORP</td>
<td>1</td>
<td>397</td>
</tr>
<tr>
<td></td>
<td>MK-39</td>
<td>1</td>
<td>397</td>
</tr>
<tr>
<td>Flare Exercise</td>
<td>Flare</td>
<td>1</td>
<td>6</td>
</tr>
</tbody>
</table>

gradually increase over the period of military use. Concentrations of some substances in sediments surrounding the disposed items will increase over time, possibly inhibiting benthic flora and fauna. Within the approximately 235,000 nm² of ocean encompassed by the HRC,
however, the amount of ocean bottom habitat affected by a few tons per year of training debris
will be insignificant, even assuming that some portions of the training areas are used more
heavily than others. Sediment transport via currents can eventually disperse these
contaminants outside of the training areas, where they will be present at very low concentrations
and, thus, have no effect on the environment.

**Sonobuoys**

Sonobuoys are electromechanical devices used for a variety of ocean sensing and monitoring
tasks. Approximately 6,300 sonobuoys will be deployed annually for training under the No-
action Alternative. Lead solder, lead weights, and copper anodes are used in the sonobuoys.
Sonobuoys also may contain lithium sulfur dioxide, lithium, or thermal batteries.

A sonobuoy’s seawater batteries can release copper, silver, lithium, or other metals. During
operation, the sonobuoy floats in the water column, releasing these materials to the surrounding
marine environment; the amounts released depend upon the type of battery used. Marine
organisms in its vicinity can be exposed to battery effluents for up to 8 hours. Once expended
and scuttled, the sonobuoy sinks to the ocean floor.

Various types of sonobuoys can be used, so the exact amounts of hazardous materials that will
be expended on the ranges are not known. Table 4.1.4.1.1-2 provides estimates of potentially
hazardous sonobuoy materials, based on the types of sonobuoys in use by the Navy on San
Clemente Island.

**Pyrotechnic Residues**

About 300 smoke grenades and about 2,200 flares will be used annually under the No-action
Alternative. Solid flare and pyrotechnic residues may contain, depending on their purpose and
color, aluminum, magnesium, zinc, strontium, barium, cadmium, nickel, and perchlorates. At an
average weight of about 0.85 lb per item, an estimated 1.1 tons per year of these materials will
be deposited on the sea floor. Based on an area of 235,000 nm², the rate of deposition of these
materials will be about 0.01 lb/nm² per year.

Hazardous constituents in pyrotechnic residues are typically present in small amounts or low
concentrations, and are bound up in relatively insoluble compounds. As inert, incombustible
solids with low concentrations of leachable metals, these materials typically do not meet the
Resource Conservation and Recovery Act (RCRA) criteria for characteristic hazardous wastes.
The perchlorate compounds present in the residues are highly soluble, although persistent (i.e.,
do not break down readily into other compounds under natural conditions) in the environment,
and should disperse quickly.

<table>
<thead>
<tr>
<th>Sonobuoy Constituent</th>
<th>Annual Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>lb</td>
</tr>
<tr>
<td>Fluorocarbons</td>
<td>121</td>
</tr>
<tr>
<td>Copper</td>
<td>7,000</td>
</tr>
<tr>
<td>Lead</td>
<td>5,760</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>12,900</strong></td>
</tr>
</tbody>
</table>

*Table 4.1.4.1.1-2: Sonobuoy Hazardous Materials, No-action Alternative (based on average amounts of constituents)*

*Note: values rounded to three significant digits.*

*Source: U.S. Department of the Navy. no date. San Clemente Island Ordnance Database*
Chaff

Chaff is a thin polymer with an aluminum coating used to decoy enemy radars. All of the components of the aluminum coating are present in seawater in trace amounts, except magnesium, which is present at 0.1 percent. The stearic acid coating is biodegradable and nontoxic. The chaff is shot out of launchers using a propellant charge. Under the No-action Alternative, it is estimated that 34 CHAFFEX and 738 ACMs will be held per year, releasing about 4,700 packages of chaff over the Open Ocean Area.

The chaff fibers are well-dispersed upon ejection from the launcher. The fine, neutrally buoyant chaff streamers act like fine particulates upon entering the water, temporarily increasing the turbidity and reducing the clarity of the ocean's surface waters. The fibers are quickly dispersed more widely by wind, waves, and currents.

The fibers are too short and fine to pose an entanglement risk. They may be accidentally or intentionally ingested by marine life, but the fibers are non-toxic. Chemicals leached from the chaff will be diluted by the surrounding seawater, reducing the potential for concentrations of these chemicals to build up to levels that can affect sediment quality and benthic habitats. The widely spaced releases will have no discernable effect on the marine environment. (U.S. Air Force, 1997)

Hazardous Wastes

Used hazardous materials and chemical byproducts generated at sea are not considered to be hazardous wastes until offloaded in port. The accumulation of used hazardous materials aboard ship will not increase. Used and excess hazardous wastes will continue to be managed in compliance with OPNAVINST 5090.1B (2003), Chapter 12. The No-action Alternative will not affect hazardous materials management practices aboard ship. Hazardous wastes will be offloaded upon reaching port in Hawaii, and enter the Navy's shore-side waste management system, which has sufficient long-term capacity for these waste streams.

4.1.4.1.2 HRC RDT&E Operations

HRC RDT&E operations under the No-action Alternative will consist of the Naval Undersea Warfare Center (NUWC) shipboard tests on the Fleet Operational Readiness (FORACS) and Shipboard Electronic Systems Evaluation Facility (SESEF) ranges. Navy vessels engaged in these operations will use small quantities of hazardous materials and generate small quantities of used hazardous materials during routine ship operations. These materials will be managed in accordance with OPNAVINST 5090.1B. Hazardous materials inventories will be replenished and used hazardous materials will be offloaded while the vessels are in port.

4.1.4.1.3 Major Exercises

Major Exercises under the No-action Alternative, such as RIMPAC and USWEX, include ongoing training operations and, in some cases, RDT&E operations. Potential impacts from Major Exercises will be similar to those described earlier for training operations and RDT&E operations.
4.1.4.2 ALTERNATIVE 1 (HAZARDOUS MATERIALS AND WASTES—OPEN OCEAN)

4.1.4.2.1 Increased Tempo and Frequency of Training Operations

Hazardous Materials

Increases in shipboard hazardous materials transport, storage, and use to support increased training operations under Alternative 1 would be managed in compliance with OPNAVINST 5090.1B (2002), Chapter 19. No new types of hazardous materials would be required under Alternative 1, and existing hazardous materials storage and handling facilities, equipment, supplies, and procedures would continue to provide for adequate management of these materials. No releases of hazardous materials to the environment and no unplanned exposures of personnel to hazardous materials are anticipated under this alternative.

Open Ocean Area training operations involving hazardous materials would increase by varying degrees from current levels in support of the Fleet Readiness Training Plan (FRTP). Those increases are described in Table 4.1.4.2.1-1. Only the number of training operations would increase; no new types of training would be introduced. Air-to-surface gunnery and air combat maneuvers would experience the largest percentage increases from baseline levels under Alternative 1. Amounts of expended training materials would increase in rough proportion to the overall increases in these training operations.

Hazardous Wastes

The amounts of hazardous wastes generated by training operations under Alternative 1 would be incrementally greater than those under the No-action Alternative (see Table 4.1.4.2.1-1). These incremental increases, however, would still be well within the capacity of the Navy’s hazardous waste management system. All hazardous wastes would continue to be managed in compliance with OPNAVINST 5090.1B (2003). No substantial changes in hazardous waste management are anticipated for operating Navy assets under Alternative 1.

4.1.4.2.2 Enhanced RDT&E Operations

RDT&E operations under Alternative 1 would consist of the NUWC shipboard tests on the FORACS and SESEF ranges. Navy vessels engaged in these operations would use minor quantities of hazardous materials and generate minor quantities of used hazardous materials during routine ship operations. These materials would be managed in accordance with OPNAVINST 5090.1B. Hazardous materials inventories would be replenished and used hazardous materials would be offloaded while the vessels are in port.

4.1.4.2.3 HRC Enhancements

None of the HRC Enhancements would have a substantial effect on hazardous materials use or hazardous waste generation under Alternative 1.

4.1.4.2.4 Major Exercises

Major Exercises consist of training operations and, in some cases, RDT&E operations, both addressed above. Potential impacts would be similar to those described earlier for training operations and RDT&E operations.
Table 4.1.4.2.1-1. HRC Training Operations with Hazardous Training Materials

<table>
<thead>
<tr>
<th>Training Activity</th>
<th>Training Material</th>
<th>Item</th>
<th>No-action</th>
<th>Alt 1</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Combat Maneuver (ACM)</td>
<td>Chaff</td>
<td>4,428</td>
<td>4,644</td>
<td>216</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Flare</td>
<td>2,214</td>
<td>2,322</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Surface-to-Air Gunnery Exercise (S-A GUNEX)</td>
<td>5&quot; projectile</td>
<td>258</td>
<td>324</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.62-mm projectile</td>
<td>258</td>
<td>324</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td></td>
<td>JATO Bottle</td>
<td>86</td>
<td>108</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20-mm projectile</td>
<td>162,000</td>
<td>203,000</td>
<td>41,000</td>
<td></td>
</tr>
<tr>
<td>Surface-to-Air Missile Exercise (S-A MISSILEX)</td>
<td>Missile</td>
<td>51'</td>
<td>78</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td></td>
<td>JATO Bottle</td>
<td>17</td>
<td>26</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Chaff Exercise (CHAFFEX)</td>
<td>MK-36 Super Rapid Bloom Offboard Chaff</td>
<td>255</td>
<td>255</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Naval Surface Fire Support (NSFS)</td>
<td>5&quot; / 76 mm ammunition</td>
<td>1,804</td>
<td>2,296</td>
<td>492</td>
<td></td>
</tr>
<tr>
<td></td>
<td>20-mm projectile</td>
<td>176</td>
<td>224</td>
<td>48</td>
<td></td>
</tr>
<tr>
<td>Visit, Board, Search, and Seizure (VBSS)</td>
<td>0.50 caliber gun ammunition</td>
<td>Varies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface-to-Surface Gunnery Exercise (S-S GUNEX)</td>
<td>5&quot; / 76 mm ammunition</td>
<td>1,380</td>
<td>1,820</td>
<td>440</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>36</td>
<td>47</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7.62mm / 0.50-cal ammunition</td>
<td>10,400</td>
<td>13,700</td>
<td>3,300</td>
<td></td>
</tr>
<tr>
<td>Surface-to-Surface Missile Exercise (S-S MISSILEX)</td>
<td>Missile</td>
<td>14</td>
<td>24</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Air-to-Surface Gunnery Exercise (A-S GUNEX)</td>
<td>7.62mm / 0.50-cal ammunition</td>
<td>51,200</td>
<td>60,800</td>
<td>9,600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>128</td>
<td>152</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Air-to-Surface Missile Exercise (A-S MISSILEX)</td>
<td>Missile</td>
<td>72</td>
<td>100</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td>Bombing Exercise (BOMBEX) (Sea)</td>
<td>MK-76</td>
<td>315</td>
<td>315</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MK-82</td>
<td>105</td>
<td>105</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BDU-45</td>
<td>60</td>
<td>60</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CBU</td>
<td>35</td>
<td>35</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MK-83</td>
<td>18</td>
<td>18</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>35</td>
<td>35</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Sink Exercise (SINKEX)</td>
<td>varies, depending on weapons and platform</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-Surface Warfare Torpedo Exercise (ASUW TORPEX) (Submarine-Surface)</td>
<td>MK-48 torpedo</td>
<td>105</td>
<td>105</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Anti-Submarine Warfare Tracking Exercise (ASW TRACKEX)</td>
<td>Sonobuoy</td>
<td>6,228</td>
<td>6,228</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>279</td>
<td>279</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MK-39</td>
<td>152</td>
<td>152</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Anti-Submarine Warfare Torpedo Exercise (ASW TORPEX)</td>
<td>REXTORP</td>
<td>397</td>
<td>397</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MK-39</td>
<td>397</td>
<td>397</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Flare Exercise (FLAREX)</td>
<td>Flare</td>
<td>6</td>
<td>6</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Note: Training operations not listed above are assumed to have no hazardous materials associated with them.
4.1.4.3 ALTERNATIVE 2 (HAZARDOUS MATERIALS AND WASTES—OPEN OCEAN)

4.1.4.3.1 Increased Tempo and Frequency of Training Operations

Hazardous Materials

Increases in shipboard hazardous materials transport, storage, and use to support increased training operations under Alternative 2 would be managed in compliance with OPNAVINST 5090.1B (2002). No substantial changes in hazardous materials management practices for ordinary ship operations and maintenance are anticipated under Alternative 2.

Open-ocean training operations involving hazardous materials would increase by varying degrees from current levels in support of the FRTP. Only the number of training operations would increase; no new types of training would be introduced. Amounts of expended training materials would increase in rough proportion to the overall increase in these training operations (see Table 4.1.4.3.1-1). Table 4.1.4.3.1-2 shows the increase in releases of hazardous materials for sonobuoys.

Hazardous Wastes

The overall amount of hazardous waste generated by normal vessel and aircraft operation and maintenance during training under Alternative 2 would be more than that generated under the No-action Alternative. This increase would be due primarily to the increased number of training operations anticipated under Alternative 2. All hazardous wastes would continue to be managed in compliance with OPNAVINST 5090.1B (2003), Chapter 12. No substantial changes in hazardous materials management practices are anticipated under Alternative 2.

4.1.4.3.2 Enhanced RDT&E Operations

RDT&E operations under Alternative 2 would consist of the NUWC shipboard tests on the FORACS and SESEF ranges. Navy vessels engaged in these operations would use minor quantities of hazardous materials and generate minor quantities of used hazardous materials during routine ship operations. These materials would be managed in accordance with OPNAVINST 5090.1B. Hazardous materials inventories would be replenished, and used hazardous materials would be offloaded while the vessels are in port.

4.1.4.3.3 Additional Major Exercises—Multiple Strike Group Training

Hazardous Materials

Up to three Strike Groups would be allowed to conduct training operations simultaneously in the HRC. Vessels, aircraft, and other military assets employed in these operations would carry and use hazardous materials for routine operation and maintenance. Increased hazardous materials storage, transport, or use resulting from these additional training operations would be managed in compliance with OPNAVINST 5090.1B (2002).
### Table 4.1.4.3.1-1. HRC Training Operations with Hazardous Training Materials Alternative 2—Open Ocean Areas

<table>
<thead>
<tr>
<th>Training Activity</th>
<th>Training Material Item</th>
<th>Annual Quantity (#)</th>
<th>No-action</th>
<th>Alt 2</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Combat Maneuver (ACM)</td>
<td>Chaff</td>
<td>4,428</td>
<td>4,644</td>
<td></td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>Flare</td>
<td>2,214</td>
<td>2,322</td>
<td></td>
<td>108</td>
</tr>
<tr>
<td>Surface-to-Air Gunnery Exercise (S-A GUNEX)</td>
<td>5&quot; projectile</td>
<td>258</td>
<td>324</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>7.62-mm projectile</td>
<td>258</td>
<td>324</td>
<td></td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>JATO Bottle</td>
<td>86</td>
<td>108</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>20-mm projectile</td>
<td>162,000</td>
<td>203,000</td>
<td></td>
<td>41,000</td>
</tr>
<tr>
<td>Surface-to-Air Missile Exercise (S-A MISSILEX)</td>
<td>Missile</td>
<td>51</td>
<td>78</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>JATO Bottle</td>
<td>17</td>
<td>26</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>Chaff Exercise (CHAFFEX)</td>
<td>MK-36 Super Rapid Bloom Offboard Chaff</td>
<td>255</td>
<td>278</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Naval Surface Fire Support (NSFS)</td>
<td>5&quot; / 76 mm ammunition</td>
<td>1,804</td>
<td>2,296</td>
<td></td>
<td>492</td>
</tr>
<tr>
<td></td>
<td>20-mm projectile</td>
<td>176</td>
<td>224</td>
<td></td>
<td>48</td>
</tr>
<tr>
<td>Visit, Board, Search, and Seizure (VBSS)</td>
<td>0.50 caliber gun ammunition</td>
<td>varies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surface-to-Surface Gunnery Exercise (S-S GUNEX)</td>
<td>5&quot; / 76 mm ammunition</td>
<td>1,380</td>
<td>1,820</td>
<td></td>
<td>440</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>36</td>
<td>47</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>7.62mm / 0.50-cal ammunition</td>
<td>10,400</td>
<td>13,700</td>
<td>3,300</td>
<td></td>
</tr>
<tr>
<td>Surface-to-Surface Missile Exercise (S-S MISSILEX)</td>
<td>Missile</td>
<td>14</td>
<td>24</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Air-to-Surface Gunnery Exercise (A-S GUNEX)</td>
<td>7.62mm / 0.50-cal ammunition</td>
<td>51,200</td>
<td>60,800</td>
<td>9,600</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>128</td>
<td>152</td>
<td></td>
<td>24</td>
</tr>
<tr>
<td>Air-to-Surface Missile Exercise (A-S MISSILEX)</td>
<td>Missile</td>
<td>72</td>
<td>100</td>
<td></td>
<td>28</td>
</tr>
<tr>
<td>Bombing Exercise (BOMBEX) (Sea)</td>
<td>MK-76</td>
<td>315</td>
<td>342</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>MK-82</td>
<td>105</td>
<td>114</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>BDU-45</td>
<td>60</td>
<td>65</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>CBU</td>
<td>35</td>
<td>38</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>MK-83</td>
<td>18</td>
<td>19</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>35</td>
<td>38</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Sink Exercise (SINKEX)</td>
<td>varies, depending on weapons and platform</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-Surface Warfare Torpedo Exercise (ASUW TORPEX)</td>
<td>MK-48 torpedo</td>
<td>105</td>
<td>114</td>
<td></td>
<td>9</td>
</tr>
<tr>
<td>(Submarine-Surface)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anti-Submarine Warfare Tracking Exercise (ASW TRACKEX)</td>
<td>Sonobuoy</td>
<td>6,228</td>
<td>6,965</td>
<td></td>
<td>737</td>
</tr>
<tr>
<td></td>
<td>Smoke canister</td>
<td>279</td>
<td>312</td>
<td></td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>MK-39</td>
<td>152</td>
<td>170</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>Anti-Submarine Warfare Torpedo Exercise (ASW TORPEX)</td>
<td>REXTORP</td>
<td>397</td>
<td>440</td>
<td></td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>MK-39</td>
<td>397</td>
<td>440</td>
<td></td>
<td>43</td>
</tr>
<tr>
<td>Flare Exercise (FLAREX)</td>
<td>Flare</td>
<td>6</td>
<td>7</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Training operations not listed above are assumed to have no hazardous materials associated with them.
Table 4.1.4.3.1-2. Sonobuoy Hazardous Materials, Alternative 2 (based on average amounts of constituents)

<table>
<thead>
<tr>
<th>Sonobuoy Constituent</th>
<th>Annual Amount (lb)</th>
<th>Annual Amount (kg)</th>
<th>Increase Over Baseline (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluorocarbons</td>
<td>135</td>
<td>61</td>
<td>11</td>
</tr>
<tr>
<td>Copper</td>
<td>7,780</td>
<td>3,540</td>
<td>11</td>
</tr>
<tr>
<td>Lead</td>
<td>6,410</td>
<td>2,910</td>
<td>11</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>14,300</strong></td>
<td><strong>6,510</strong></td>
<td><strong>11</strong></td>
</tr>
</tbody>
</table>

Note: values rounded to three significant digits.
Source: U.S. Department of the Navy, no date. San Clemente Island Ordnance Database

Hazardous Wastes

Vessels, aircraft, and other military assets employed in the Strike Group Exercises would generate hazardous wastes from routine operation and maintenance activities. Increased hazardous wastes storage, transport, and disposal resulting from these additional training operations would be managed in compliance with OPNAVINST 5090.1B (2002), Chapter 19. This alternative would not affect hazardous materials management practices aboard ship.

4.1.5 HEALTH AND SAFETY—OPEN OCEAN

4.1.5.1 NO-ACTION ALTERNATIVE (HEALTH AND SAFETY—OPEN OCEAN)

4.1.5.1.1 HRC Training Operations

Public Safety

Training operations that occur over the Open Ocean Area will continue to be conducted mainly in Warning Areas. Range Safety officials will ensure that projectiles, lasers, targets, and missiles are operated safely, and that air operations and other potentially hazardous training operations are safely executed in controlled areas. The Navy’s standard range safety procedures are designed to minimize risks to the public and to Navy operations and its personnel. Before any potentially hazardous training operation is allowed to proceed, the overwater target area will be determined to be clear using inputs from ship sensors, visual surveillance of the range from aircraft and range safety boats, and radar and acoustic data.

Target areas will be cleared of personnel prior to conducting training operations, so the only public health and safety issue will be if an operation has a significant failure leading to debris outside the expected area. Risks to public health and safety are minimized by clearing a hazard area that accounts for potential failures. For some vehicles, the hazard area is sufficiently contained due to physical limits of the vehicle (such as an unguided rockets) that flight termination system is not required. For other test vehicles (such as guided missiles), a flight termination system is required, which provides high reliability that no debris will exit the hazard area.

In addition, all training operations must comply with DoD Directive 4540.1, “Use of Airspace by U.S. Military Seas” and OPNAVINST 3770.4A, “Use of Airspace by U.S. Military Aircraft and Firing Over the High Seas” which specify procedures for conducting aircraft operations and for firing missiles and projectiles. Safety procedures include:
Missile and projectile firing areas are to be selected, "so that trajectories are clear of
established oceanic air routes or areas of known surface or air activity."

During use of ordnance from aircraft or surface vessels, range procedures, and
safety practices ensure that there are no vessels or aircraft in the intended path or
impact area of the ordnance.

For operations with a large hazard footprint (e.g., MISSILEXs), special sea and air
surveillance measures are taken to search for, detect, and clear the area of intended
operations.

Aircraft are required to make a clearing pass over the intended target area to ensure
that it is clear of boats, divers, or other non-participants.

The Navy notifies the public of hazardous operations through the use of NOTAMs
and NOTMARs.

Aircraft carrying ordnance are not allowed to over-fly surface vessels.

The remoteness of the offshore ranges provides a large degree of isolation from population
centers. The Navy establishes temporary access limitations for areas with risk of injury or
property damage to the public.

Demolition operations will be conducted in accordance with Commander, Naval Surface Force,
U.S. Pacific Fleet Instruction 3120.8F. Commander, Naval Surface Force, U.S. Pacific Fleet
Instruction 3120.8F specifies detonation procedures for underwater ordnance to avoid
endangering the public or impacting other non-military operations, such as possible shipping,
recreational boating, diving, and commercial or recreational fishing.

Recreational diving within the Open Ocean Area takes place primarily at known diving sites.
The locations of popular diving sites are well-documented, dive boats are typically well-marked,
and diver-down flags will be visible from the ships conducting the proposed training, so possible
interactions between training operations within the offshore areas and scuba diving will be
minimized. The Navy will also notify the public of hazardous operations through NOTAMs and
NOTMARs. Recreational dives typically take place in waters less than 125 ft deep, and usually
within 3 mi of shore, while most Navy training occurs in deep waters more than 3 mi from shore,
so popular dive sites and Navy training activities will overlap very little.

Offshore Operations include the use of mid-frequency sonar. The effect of sonar on humans
varies with the frequency of sonar involved. Of the three types of sonar (high-, mid-, and low-
frequency), mid-frequency and low-frequency are the two with the greatest potential to affect
humans. Research was conducted for mid-frequency sonar at the Naval Submarine Medical
Research Laboratory and the Navy Experimental Diving Unit to determine permissible limits of
exposure to mid-frequency sonars. Based on this research, an unprotected diver could safely
operate for over 1 hour at a distance of 1,000 yards from the Navy’s most powerful sonar. At this
distance, the sound pressure level will be approximately 190 dB. At 2,000 yards or approximately
1 nm, this same unprotected diver could operate for over 3 hours. Exposure to mid-frequency
sonar in excess of 190 dB could result in slight visual-field shifts, fogging of the faceplate,
spraying of any water within the mask, and general ear discomfort associated with loud sound.
Prior public notification of Navy Training operations, use of known training areas, avoidance of non-military vessels and personnel, and the remoteness of the Open Ocean Area reduce the potential for interaction between the public and Navy vessels. To date, these safety strategies have been effective.

Public Health

Management of hazardous materials and hazardous wastes in conjunction with Navy training operations on the Open Ocean Area was addressed in Section 4.1.4. Materials expended on the sea ranges during Navy training operations will include liquid and soluble hazardous constituents that will quickly disperse in the water column. These materials also will include solid hazardous constituents that will quickly settle to the ocean floor and soon become buried in sediment, coated by corrosion, or encrusted by benthic organisms. Due to the very small quantities of these materials relative to the extent of the sea ranges (see Section 4.1.4.1.1), the volume of the ocean, and the remoteness of the sea ranges relative to human populations, their concentrations in areas of potential human contact generally will be undetectable. The analysis in Section 4.1.4 identified no significant impacts from use of hazardous materials or generation, transportation, and disposal of hazardous wastes in the HRC.

Sources of EMR include radar, navigational aids, and Electronic Warfare (EW). These systems are the same as, or similar to, civilian navigational aids and radars at local airports and television weather stations throughout the United States. EW systems emit EMR similar to that from cell phones, hand-held radios, commercial radio, and television stations. SOPs in place to protect Navy personnel and the public include setting the heights and angles of EMR transmission to avoid direct exposure, posting warning signs, establishing safe operating levels, and activating warning lights when radar systems are operational. To avoid excessive exposures from EMR, military aircraft are operated in accordance with standard procedures that establish minimum separations distances between EMR emitters and people, ordnance, and fuels. Based on the power levels emitted, the minimum safe separation distances established, and the additional measures identified above, no substantial adverse effects are anticipated.

4.1.5.1.2 HRC RDT&E Operations

RDT&E operations under the No-action Alternative will consist of the NUWC shipboard tests on the SESEF range and missile defense operations. Navy vessels engaged in operations on the SESEF range will pose no public health or safety risk during routine ship operations. Missile defense operations include aerial targets launched from PMRF, mobile sea-based platforms, or military cargo aircraft. During missile defense RDT&E operations, a ballistic missile target vehicle is launched from PMRF and intercepted by a ship-launched missile. Missile launches by their very nature involve some degree of risk, and it is for this reason that DoD and PMRF have specific launch and range safety policies and procedures to assure that any potential risk to the public and government assets (launch support facilities) are minimized.

Ship and Aircraft Exclusion Areas ensure that vehicles are not in areas of unacceptable risk. These areas include the places where planned debris may impact (such as dropped stages of multi-stage vehicles or debris from hit-to-kill intercept engagements) and also the regions at risk if there is a failure (such as under the planned flight path). Aircraft regions are designed in a similar fashion. The specific definition of each of these regions is determined by a probabilistic risk analysis that incorporates modeling of the vehicle response to malfunctions, mission rules (such as Destruct Limits), and the vulnerability of vehicles to debris. NOTMARs and NOTAMs
are issued for the entire region that may be at risk, encompassing both exclusion areas and warning areas (areas with very remote probability of hazard). Surveillance by aircraft and satellite is used to ensure that there are no ships or aircraft in cleared areas, and also that the collective risk meets acceptable risk criteria for the mission.

Many procedures are in place to mitigate the potential hazards of an accident during the flight of one of these missiles. The PMRF Flight Safety Office prepares Range Safety Operational Procedures (RSOPs) for missions involving missiles, supersonic targets, or rockets. This RSOP addresses the safety aspects of debris from hit-to-kill intercept tests where an interceptor missile impacts a target missile. The Commanding Officer of PMRF approves each RSOP, which includes specific requirements and mission rules. The Flight Safety Office has extensive experience in analyzing the risks posed by such operations. In spite of the developmental nature of missile operations (which leads to a significant probability of mission failure), the United States has an unblemished record of public safety during missile and rocket launches. Appendix K describes the general approach to protect the public and involved personnel from launch accident hazards.

Prior to each mission, a comprehensive analysis of the proposed mission, including flight plans, planned impact areas, vehicle response to malfunctions, and effects of flight termination action is performed. A probabilistic analysis is performed with sufficient conservative assumptions incorporated to ensure that the risks from the mission are acceptable. The guidance of the Range Commanders’ Council (RCC) for acceptable risk (in RCC-321) is followed. These acceptable risk criteria are designed to ensure that the risk to the public from range operations is lower than the average background risk for other third-party activities (for example, the risk of a person on the ground being injured from an airplane crash).

4.1.5.1.3 Major Exercises

Major Exercises consist of training operations and, in some cases, RDT&E operations, both addressed above. Potential impacts will be similar to those described earlier for training operations and RDT&E operations.

4.1.5.2 ALTERNATIVE 1 (HEALTH AND SAFETY—OPEN OCEAN)

4.1.5.2.1 Increased Tempo and Frequency of Training Operations

Offshore operations proposed under Alternative 1 would have all the components of the No-action Alternative, but training operations would increase and new weapons platforms and systems would be employed. The safety procedures implemented under this alternative are the same as those described under the No-action Alternative.

Public Safety

Several training operations would experience increases from current levels in support of the FRTP. Table 2.2.3.1-1 describes those increases. Only the number of training operations would increase; no new types of training would be introduced. Increases in the number of individual training operations would increase the potential for conflicts with non-participants. Given the Navy’s comprehensive safety procedures and its safety record for these operations, however, the actual potential for public safety impacts from training operations would remain low.
Public Health

Management of hazardous materials and hazardous wastes in conjunction with Navy training operations on the Open Ocean Area is addressed in Section 4.1.4. The quantities of materials expended on the sea ranges during Navy training operations would increase moderately under Alternative 1, as compared to the quantities expended under the No-action Alternative.

Expended training materials would include liquid or soluble hazardous materials that would quickly disperse in the water column. They also would include solid hazardous constituents that would quickly settle to the ocean floor and soon become buried in sediment, coated by corrosion, or encrusted by benthic organisms. Due to the very small quantities of these materials relative to the extent of the sea ranges, the volume of the ocean, and the remoteness of the sea ranges relative to human populations, their concentrations in areas of potential human contact generally would be low to undetectable.

Sources of EMR include radar, navigational aids, and EW. These systems are the same as, or similar to, civilian navigational aids and radars at local airports and television weather stations throughout the United States. EW systems emit EMR similar to that from cell phones, hand-held radios, commercial radio, and television stations. SOPs in place to protect Navy personnel and the public include setting the heights and angles of EMR transmission to avoid direct exposure, posting warning signs, establishing safe operating levels, and activating warning lights when radar systems are operational. To avoid excessive exposures from EMR, military aircraft are operated in accordance with standard procedures that establish minimum separations distances between EMR emitters and people, ordnance, and fuels. Based on the power levels emitted, the minimum safe separation distances established, and the additional measures identified above, no substantial adverse effects are anticipated.

Enhanced RDT&E Operations

RDT&E operations under Alternative 1 would consist of the NUWC shipboard tests on the FORACS and SESEF ranges and missile defense operations. Navy vessels engaged in NUWC operations would pose no public health or safety risk during routine ship operations. Proposed launches associated with enhanced and future operations would have a similar impact on health and safety as those described for the No-action Alternative.

HRC Enhancements and Major Exercises

Major Exercises consist of training operations and, in some cases, RDT&E operations, both addressed earlier. Potential impacts would be similar to those described earlier for training operations and RDT&E operations.

ALTERNATIVE 2 (HEALTH AND SAFETY—OPEN OCEAN)

Increased Tempo and Frequency of Training Operations

Public Safety

Several training operations would experience increases from current levels in support of the FRTP. Table 2.2.4.1-1 describes those increases. Only the number of training operations would increase; no new types of training would be introduced. Increases of over 100 percent in the number of individual training operations would increase the potential for conflicts with non-participants. Given the Navy’s safety procedures and its safety record for these operations,
however, the actual potential for public safety impacts from training operations would remain low.

**Public Health**

Management of hazardous materials and hazardous wastes in conjunction with Navy training operations on the Open Ocean Area is addressed in Section 4.1.4. The quantities of materials expended on the sea ranges during Navy training operations would increase substantially under Alternative 2, as compared to the quantities expended under the No-action Alternative. Expended training materials would include liquid and soluble hazardous constituents that would quickly disperse in the water column. They also would include solid hazardous constituents that would quickly settle to the ocean floor and soon become buried in sediment, coated by corrosion, or encrusted by benthic organisms. Due to the very small quantities of these materials relative to the extent of the sea ranges, the volume of the ocean, and the remoteness of the sea ranges relative to human populations, their concentrations in areas of potential human contact generally would be low to undetectable.

Sources of EMR include radar, navigational aids, and EW. These systems are the same as, or similar to, civilian navigational aids and radars at local airports and television weather stations throughout the United States. EW systems emit EMR similar to that from cell phones, handheld radios, commercial radio, and television stations. SOPs in place to protect Navy personnel and the public include setting the heights and angles of EMR transmission to avoid direct exposure, posting warning signs, establishing safe operating levels, and activating warning lights when radar systems are operational. To avoid excessive exposures from EMR, military aircraft are operated in accordance with standard procedures that establish minimum separations distances between EMR emitters and people, ordnance, and fuels. Based on the power levels emitted, the minimum safe separation distances established, and the additional measures identified above, no substantial adverse effects are anticipated.

**4.1.5.3.2 Enhanced RDT&E Operations**

RDT&E operations under Alternative 2 would consist of the NUWC shipboard tests on the FORACS and SESEF ranges and missile defense operations. Navy vessels engaged in NUWC operations would pose no public health or safety risk during routine ship operations. Proposed launches associated with enhanced and future operations would have a similar impact on health and safety as those described for the No-action Alternative.

**4.1.5.3.3 Future RDT&E Operations**

Future RDT&E operations for the Open Ocean Area would include directed energy. PMRF would develop the necessary SOPs and range safety requirements necessary to provide safe training operations associated with future high energy laser tests. PMRF Range Safety would require the proposed high-energy laser program to provide specific information about the proposed usage so that a safety analysis of all types of hazards could be completed and appropriate remedial procedures would be taken before initiation of potentially hazardous laser activities.

The high-energy laser program office would be responsible for providing all necessary documentation to PMRF prior to issuance of the Range Safety Approval (RSA) or RSOP. These include:
Letter of Approval or a Letter of No Concern from the FAA for the use of the laser within Honolulu FAA airspace,

Letter of Approval or a Letter of No Concern for the use of their laser if it will or has the potential of lasing above the horizon from United States Space Command (USSPACECOM) as well as clearance from USSPACECOM for each intended laser firing,

Letter of Approval from the Laser Safety Review Board (LSRB) at Dahlgren for the use for their laser on Navy Ranges (this letter entails a survey and certification of the laser by the LSRB), and

Range Safety Laser Data Package.

The Range Safety Laser Data Package is intended to provide the Range Safety Office with sufficient information to perform an evaluation of the safety of the laser and the proposed lasing activity and to approve the laser and its operation, and any risk mitigations required.

The PMRF Range Safety Office would analyze the submittal to ensure that it is in compliance with PMRF safety criteria, which is based on Range Commanders Council document RCC-316, OPNAVINST 5100.27A, and 2004 Laser Safety Survey Report for the Pacific Missile Range Facility Open Ocean Range. PMRF would be responsible for publishing an RSA or an RSOP specifying hazard areas and safety guidelines for the operation of the laser. The RSA/RSOP process would include an onsite safety inspection of the system by a PMRF Laser Safety Specialist to ensure that it complies with the Navy guidelines for lasers. As appropriate, the Range Safety Office would review the proposed laser systems for other non-optical hazard mechanisms, such as toxic releases.

Safety assurance would include defining exclusion areas, ensuring that the NOTAM and NOTMAR requests are submitted to the responsible agencies (FAA and Coast Guard respectively), ensuring that the laser operation falls within the approved operational areas, surveillance/clearance of the operational area and scheduling of the appropriate airspace and surface space.

For general training scenarios of the proposed high-energy laser, the Range Safety Office would build on the 2004 Laser Safety Survey Report performed by the Corona Division of the Naval Surface Warfare Center (Solis, 2004). This document defines the boundaries of the two laser target areas at PMRF: the outer W-186 Area and the outer W-188 Area are multipurpose bombing and laser target ranges used for aerial lasing. Only airborne laser designators may be used on the laser target areas. Procedures and restrictions for use of these areas are defined in this survey.

4.1.5.3.4 Additional Major Exercises—Multiple Strike Group Training

Vessels, aircraft, and other military assets employed in the Strike Group Exercises would increase the overall intensity and duration of Navy training operations on the sea ranges. The Strike Group training would be similar to other large-exercise training operations held on the range, and similarly would consist of a number of individual training activities spread over large areas among several ranges. As with those other operations, the Multiple Strike Group training operations are not anticipated to pose a substantial risk to public safety.
4.1.6 NOISE—OPEN OCEAN

4.1.6.1 NO-ACTION ALTERNATIVE, ALTERNATIVE 1, AND ALTERNATIVE 2 (NOISE—OPEN OCEAN)

Potential airborne sound as a result of Navy training operations was examined to determine what effect the operations produced would have in the overall ambient sound levels within the HRC that resulted in an effect on the traditionally analyzed sensitive human sound receptors (i.e., schools, hospitals, etc.).

The factors considered in determining the significance of sound effects on marine mammals, birds, and fish are discussed within other sections of this chapter. Potential sound effects on fish (to the extent that sound introduced into the sea can affect catch) and marine mammals are discussed in Section 4.1.2.

While HRC training operations do generate airborne sound, sound-generating events in the Open Ocean Area do not result in perceptible changes to the overall sound environment. In addition, training operations do not have an effect on sensitive sound receptors because these operations are typically conducted away from populated areas and most sensitive sound receptors. For operations that involve the expenditure of munitions either from aircraft or surface vessels, the Navy uses advance notice and scheduling, and strict on-scene procedures to ensure the area is clear of civilian vessels or other non-participants. The public is notified of the location, date, and time of the hazardous operations via NOTMARs, thereby precluding any acoustical impacts on sensitive receptors. Proposed increases in operations under Alternative 1 and Alternative 2 would result in increases in sound events. The increases would contribute a negligible level of increased sound, however, because they would continue to occur within the open ocean where typically no sensitive sound receptors are present.

The HRC is approved for supersonic flight; however, no data are available that describe the exact location of supersonic operations. Supersonic activity in the HRC is generally restricted to altitudes greater than 30,000 ft above sea level or in areas at least 30 nm from shore. These restrictions prevent most sonic booms from reaching the ground. There would be no perceptible increase in long-term sound levels as a result of sonic booms, and populated areas are not likely to be affected since such flights would typically be conducted in areas greater than 30 nm offshore and above 30,000 ft. More detailed information on sonic booms is provided in Appendix G.

4.1.7 WATER RESOURCES—OPEN OCEAN

4.1.7.1 NO-ACTION ALTERNATIVE (WATER RESOURCES—OPEN OCEAN)

4.1.7.1.1 HRC Training Operations

Under the No-action Alternative, Navy training operations in the Open Ocean Area (see Table 4.1-1) will expend a wide variety of materials, a substantial portion of which will not be recovered. Types of unrecovered materials include the following:

- Incidental release of materials
Potential impacts on water quality will primarily be associated with the incidental release of materials from aircraft, surface ships, submarines, or other vessels. Hazardous constituents of concern, possibly emitted from the surface ship or submarine (i.e., fuel, oil), are less dense than seawater; they will remain near the surface and, therefore, will not affect the benthic community. Sheens produced by these incidental releases will not cause any significant long-term impact on water quality because most of the toxic components (e.g., benzene, xylene) will evaporate within several hours to days or will be degraded by biogenic organisms (e.g., bacteria, phytoplankton, zooplankton).

The debris and discharges resulting from training may also affect the physical and chemical properties of benthic habitats and the quality of surrounding marine waters. Hazardous constituents can be released from sonobuoys, targets, torpedoes, missiles, and underwater explosions. Hazardous constituents, primarily from batteries, may affect water quality in the vicinity of the debris. The metal ions (e.g., lead, copper, and silver) released during operation of the seawater batteries or as a result of the corrosion of sonobuoy or target components are a source of potential environmental degradation for marine invertebrates. In general, exposure of marine invertebrates to high concentrations of heavy metals can result in either immediate mortality (acute effect) or the bio-accumulation of heavy metals by these species. Benthic communities exposed to high concentrations of heavy metals (e.g., copper, zinc) are characterized by reduced species richness (number of species), reduced abundance (number of organisms), and a shift in community composition from sensitive to more tolerant species.

Sonobuoys are expendable devices used to detect underwater acoustic sources and to measure vertical water column temperatures. The primary source of contaminants in a sonobuoy is the seawater battery. These batteries have a maximum operational life of 8 hours, during which the chemical constituents in the battery are consumed. Long-term releases of lead and other metals from the remaining sonobuoy components will be substantially slower than the release during seawater battery operation. Lead may accumulate in bottom sediments, but the potential concentrations will be well below sediment quality criteria based on thresholds for relatively biological effects. By far the greatest amount of material will likely be deposited in a relatively inert form, as the lead ballast weights will become encrusted with lead oxide and other salts and be covered by the bottom sediments. Sonobuoy emissions will not accumulate or result in additive effects on water or sediment quality, as may occur in an enclosed body of water, because the constituents of sonobuoys will be widely dispersed in space and time throughout the training areas. In addition, dispersion of released metals and other chemical constituents by currents near the ocean floor will help minimize any long-term degradation of water and sediment quality. Therefore, long-term marine water or sediment quality likely will not be substantially degraded by sonobuoy operations.

Most air targets contain jet fuel, oils, hydraulic fluid, batteries, and explosive cartridges as part of their operating systems. Following a training operation, targets are generally flown (using remote
control) to a pre-determined recovery point. Fuel is shut off by an electronic signal, the engine stops, and the target descends. A parachute is activated and the target descends to the ocean surface, where it is retrieved by range personnel using helicopters or range support boats.

Some targets are hit by missiles. These targets fall into the ocean, and can cause temporary, local impacts on water quality. Most of the hazardous constituents of concern (i.e., fuel, oil) are less dense than seawater; they will remain near the surface and, therefore, will not affect sediment quality. Ocean currents at the surface and within the water column will also rapidly dilute the concentrations of any metal ions or other chemical constituents released by the target. Sheens (e.g., oil or fuel) produced by these releases have a less-than-significant long-term effect on water quality because most of the toxic components (e.g., aromatics) will evaporate within several hours to days or be degraded by biogenic organisms. The rate of degradation will depend, in part, on sea conditions (e.g., wind and waves).

Potential effects of torpedoes on water or sediment quality are associated with propulsion systems, chemical releases, or expended accessories. The potentially hazardous or harmful materials are not normally released into the marine environment because the torpedo is sealed and, at the end of a run, the torpedoes are recovered. The OTTO Fuel II in a torpedo will not normally be released into the marine environment. In the worst-case scenario of a catastrophic failure, however, up to 59 lb of OTTO fuel can be released from a MK-46 torpedo (U.S. Department of the Navy, 1996). In the event of such a maximum potential spill, temporary impacts on water quality may occur. No long-term significant impacts on water quality are anticipated because:

- The water volume will dilute the spill;
- Although OTTO Fuel II may be toxic to marine organisms (U.S. Department of the Navy, 1996), in particular to sessile benthic animals and vegetation, mobile organisms may move away from areas of high OTTO Fuel II concentrations; and

Missiles contain hazardous materials as normal parts of their functional components. In general, the largest single hazardous material type is solid propellant, but there are numerous hazardous materials used in igniters, explosive bolts, batteries, and warheads. For missiles falling into the ocean, the principal source of potential impacts on water and sediment quality will be the unburned solid propellant residue and batteries. The remaining solid propellant fragments will sink to the ocean floor and change in the presence of seawater. Tests demonstrate that water penetrates only 0.6 inch into the propellant during the first 24 hours of immersion, and that fragments will very slowly release ammonium and perchlorate ions (Aerospace Corporation, 1998). These ions will rapidly disperse into the surrounding water such that local concentrations will be extremely low. Assuming that all of the propellant on the ocean floor will be in the form of 4-inch cubes, however, only 0.42 percent of it will be wetted during the first 24 hours. If all of the ammonium perchlorate leaches out of the wetted propellant, then approximately 0.01 lb (4.5 grams) will enter the surrounding seawater. The concentration will decrease over time as the leaching rate decreases and further dilution occurs. The aluminum will remain in the propellant binder, and will eventually be oxidized by seawater to aluminum oxide. The remaining binder...
material and aluminum oxide will not pose a threat to the marine environment. Therefore, missile propellant may have temporary, minimal impacts on water quality.

Both chaff and flares are used during aircraft training operations. Chaff is described in Section 3.1.4, and its potential hazardous and toxic effects are addressed in Section 4.1.4.1.1. Based on that analysis, the potential for chaff to have a long-term adverse impact on water quality is considered to be very low. (U.S. Air Force, 1997)

Flares are used over water during training. They are composed of magnesium pellets that burn quickly at very high temperatures, leaving ash, end caps, and pistons. Laboratory leaching tests of flare pellets and residual ash using synthetic seawater found barium in the pellets, while boron and chromium were found in the ash. The pH of the test water was raised in both tests. Ash from flares will be dispersed over the water surface and then settle out. Chemicals will leach from the flare debris into the water column while it is settling. Any chemicals leaching from the particles after they reach the bottom will be dispersed by currents. Therefore, local and temporary impacts on water quality may occur, but no long-term impacts are anticipated.

4.1.7.1.2 HRC RDT&E Operations

RDT&E operations under the No-action Alternative are listed in Table 4.1-1. Unrecovered materials associated with RDT&E operations will be similar to those discussed above for training operations, with the exception of Missile Operations and Missile Defense operations. Therefore, the discussion presented above would apply here. Potential water quality impacts associated with Missile Operations and Missile Defense operations include hydrocarbon chloride deposition and solid propellants released into the open ocean.

The effects of hydrogen chloride deposition were modeled from the Advanced Solid Rocket Motor (ASRM). Under nominal launch conditions, when the relative humidity is less than 100 percent, deposition of hydrogen chloride gas on the surface of the sea will not be significant. Analyses for the most conservative case, where rain will be present soon after test firing the ASRM, concluded that acid deposition on surface water will not affect larger surface water bodies in the area. This analysis was based on the buffering capacity of fresh water, which is considerably lower than the buffering capacity of sea water. It is expected, therefore, that even for the most conservative case, where all of the hydrogen chloride emissions fall over the Open Ocean Area, the pH will not be depressed by more than 0.2 standard units for more than a few minutes. (U.S. Army Space and Strategic Defense Command)

Mathematical modeling of ASRM tests indicate that the maximum deposition of aluminum oxide will be about 1.6 milligrams per square meter (mg/m²) (0.0007 ounces per square inch (oz./in²)). Aluminum oxide is not toxic under natural conditions, but may contribute potentially harmful species of soluble aluminum forms under acidic conditions. The portion of aluminum oxide that reacts with hydrogen chloride to form additional toxic aluminum species is difficult to quantify. The most conservative approach assumes that all of the deposited aluminum oxide reacts with hydrogen chloride. With this extremely conservative assumption, the deposition of about 1.6 mg/m² (0.0007 oz./in²) of aluminum oxide equals approximately 0.0054 mg per liter (mg/L) (5.4 parts per billion) of aluminum at a water depth of 0.5 ft. This analysis assumes that rain will not be falling at the time of the test event or within 2 hours after the event. Rainfall will increase the amount of deposition. (U.S. Army Space and Strategic Defense Command, 1994) Even in the most conservative scenario of an on-ship or early flight failure, where all of the propellant is
ignited and all of the hydrogen chloride and aluminum oxide are deposited, any toxic concentration of these products will be buffered and diluted by seawater to non-toxic levels within minutes. Consequently, any impacts of an accidental release will be very transient.

Solid propellant is primarily composed of rubber (polybutadiene) mixed with ammonium perchlorate. The ammonium perchlorate contained within the matrix of rubber will dissolve slowly. While there is no definitive information on the solubility or toxicity of the propellant material in seawater, its toxicity is expected to be relatively low. In a most conservative case, toxic concentrations of ammonium perchlorate will be expected only within a few yards of the source. (U.S. Department of the Air Force, 2000) In the event of an ignition failure or other launch mishap, a fueled rocket motor or portions of the unburned fuel will likely fall into ocean waters. In that case, small fragments of fuel may float on the surface of the sea for a time, and some dissolution may occur. However, the fragments will become waterlogged and sink (U.S. Department of the Air Force, 2000). In terms of the potential for cumulative impacts, the effect of any hydrogen chloride deposition in the Open Ocean Area will be very transient due to the buffering capacity of seawater. Similarly, deposition of aluminum compounds will be very small and dispersal by surface mixing will be rapid. Therefore, no incremental, additive impacts are anticipated.

NASA conducted a thorough evaluation of the effects of missile systems that are deposited in seawater. It concluded that the release of hazardous materials aboard missiles into seawater will not be significant. Materials will be rapidly diluted and, except in the vicinity of the debris, will not be found at concentrations identified as producing any adverse effect. The Pacific Ocean is thousands of feet deep in the vicinity of the launch area; consequently, the water quality impact from the fuel is expected to be minimal. Any area affected by the slow dissolution of the propellant will be relatively small due to the size of the rocket motor or propellant pieces relative to the quantity of seawater (U.S. Department of the Air Force, 2000).

4.1.7.1.3 Major Exercises

Major Exercises under the No-action Alternative, such as RIMPAC and USWEX, include ongoing training operations and, in some cases, RDT&E operations (see Table 4.1-1). Therefore, the potential impacts of Major Exercises will be the same as those described earlier for training operations and RDT&E operations.

4.1.7.2 ALTERNATIVE 1 (WATER RESOURCES—OPEN OCEAN)

4.1.7.2.1 Increased Tempo and Frequency of Training Operations

Under Alternative 1, several training operations would increase from current levels. Only the number of training operations would increase; no new types of training would be introduced in the Open Ocean Area. Increases in the number of individual training operations would proportionately increase the amounts of water pollutants released. However, the quantities of these materials would still be very small, relative to the extent of the sea ranges, and the large volume of ocean waters into which they would disperse. Therefore, the potential for water quality effects from these constituents would not be significant.
4.1.7.2.2  Enhanced and Future RDT&E Operations

Water quality effects of RDT&E operations under Alternative 1 would be the same as those described under the No-action Alternative. Future RDT&E operations (see Table 4.1-1) would not introduce any new types of expended materials or debris into the Open Ocean Area.

4.1.7.2.3  HRC Enhancement

No new types of expended material or debris would be introduced into the Open Ocean Area. Therefore, proposed HRC enhancements would have no effect on open ocean water quality.

4.1.7.2.4  Major Exercises

Major Exercises under Alternative 1, such as RIMPAC and USWEX, include ongoing training operations and, in some cases, RDT&E operations (see Table 4.1-1). Although training operations associated with Major Exercises would increase under Alternative 1, potential impacts would still be the same as those described under the No-action Alternative.

4.1.7.3  ALTERNATIVE 2 (WATER RESOURCES—OPEN OCEAN)

4.1.7.3.1  Increased Tempo and Frequency of Training Operations

Under Alternative 2, several training operations would increase from current levels. Only the number of training operations would increase; no new types of training would be introduced in the Open Ocean Area. Increases in the number of individual training operations would proportionately increase the amounts of water pollutants released. However, the quantities of these materials would still be very small, relative to the extent of the sea ranges, and the large volume of ocean waters into which they would disperse. Therefore, the potential water quality effects of these constituents would not be significant.

4.1.7.3.2  Enhanced and Future RDT&E Operations

Water quality effects of RDT&E operations under Alternative 2 would be the same as those described under the No-action Alternative. Future RDT&E operations (see Table 4.1-1) would not introduce any new types of expended materials or debris into the Open Ocean Area.

4.1.7.3.3  Additional Major Exercises—Multiple Strike Group Training

Vessels, aircraft, and other military assets employed during Multiple Strike Group training operations would increase the overall intensity and duration of Navy training operations on the sea ranges. The Strike Group training would be similar to other large-exercise training operations held on the range. Although the intensity of training operations associated with Multiple Strike Group Training would increase under Alternative 2, potential impacts would still be the same as those described under the No-action Alternative and no new types of expended material or debris would be introduced into the open ocean.