PROTECTED SPECIES MITIGATION AND MONITORING REPORT - Survey 02

Marine Geophysical (Seismic) Survey, North Pacific Ocean
Canales ROV, *R/V Marcus G. Langseth*

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Contents

Tables

Figures

Appendices

Acronyms and Abbreviations

ADCP – Acoustic doppler current profiler
BioOp – Biological Opinion (US)
BOEM – Bureau of Ocean Energy Management
BSS – Beaufort Sea States
BZ – Buffer Zones
DAQ – Data acquisition
dB - decibels
DSLR – Digital Single Lens Reflex
EA – Environmental Assessment (US)
EPU – Electronic Processing Unit
ESA – Endangered Species Act (US)
EEZ – Economic Exclusion Zone
EZ – Exclusion Zone
FONSI – Finding of No Significant Impact (US)
FWS – Fish and Wildlife Service (US)
GPS – Global Positioning System
HF – High Frequency
HZ - Hertz
IHA – Incidental Harassment Authorization (US)
ITS – Incidental Take Statement (US)
LDEO – Lamont-Doherty Earth Observatory (US)
LF – Low Frequency
MBES – Multibeam Echosounder
MMPA – Marine Mammal Protection Act (US)
NMFS – National Marine Fisheries Service (US)
NRP – Navigation Reference point
NSF – National Science Foundation (US)\
OBN – Ocean-bottom nodes
OBS – Ocean-bottom seismometers
OCS – Outer Continental Shelf
OEIS – Overseas Environmental Impact Statement (US)
PAM – Passive Acoustic Monitoring
PEIS – Programmatic Environmental Impact Statement (US)
PI – Principal Investigator
PTS – Permanent threshold shift
PSO – Protected Species Observer
RME – PAM sound card manufacturer company name (not an acronym)
RMS – Root mean square
RPS- PSO Provider company name (not an acronym)
R/V – Research vessel
ROV – Remote operated vehicle
SBP – Sub bottom Profiler
TOAD – Time of Arrival Distance
TVG – Transverse Gradiometer
US – United States
UTC – Coordinated Universal Time

1 EXECUTIVE SUMMARY

The R/V Marcus G. *Langseth* (*Langseth*), owned and operated by Columbia University's Lamont-Doherty Earth Observatory (LDEO), conducted a two-dimensional (2D) survey in the North Pacific Ocean off the coast of Oregon from 10 to 21 April 2022 (referred to herein as "survey"). The operational activities were conducted as a continuation of the Cascadia Subduction Zone survey, to finish acquiring data that was not collected during initial survey operations in 2021. The Principal Investigator (PI) onboard the vessel for this survey was P. Canales, and the co-PI was D. Lizarralde. The following report includes effort, detections and operational information from this continuation survey. The takes are cumulative for the entire Cascadia Subduction Zone survey because the survey permitting documents remained unchanged for this scheduled continuation.

The purpose of the research was to acquire data examining the depth, geometry, and physical properties of the seismogenic portion and updip extent of the megathrust zone between the subducting Juan de Fuca plate and the overlying accretionary wedge/North American Plate. The data would provide essential constraints for earthquake and tsunami hazard assessment along the Cascadia subduction zone.

This report was prepared to meet the reporting requirements for the survey required under the US Marine Mammal Protection Act (MMPA) and the US Endangered Species Act (ESA). On 8 November 2019, National Science Foundation (NSF) submitted a formal ESA Section 7 consultation request to National Marine Fisheries Service (NMFS) for the proposed action. On 21 November 2019, L-DEO applied to the NMFS for an Incidental Harassment Authorization (IHA) that would allow for the potential harassment of small numbers of protected marine mammals incidental to the seismic survey. On 22 November 2019, L-DEO applied to the US Fish and Wildlife Service (FWS) for an IHA that would allow for the potential harassment of small numbers of protected sea otters and sought a letter of concurrence that the activities may affect but would not adversely affect several species of protected sea birds per Section 7 of the ESA. On 19 May 2021, NMFS issued an IHA, Incidental Take Statement (ITS) and Biological Opinion (BiOp). The FWS issued a BiOp and ITS on 12 April 2021, and an IHA on 20 April 2021.

Mitigation measures were implemented to minimize potential impacts to marine mammals, endangered or threatened sea turtles and sea birds during the survey. These measures included, but were not limited to, the use of NMFS/FWS approved Protected Species Observers (PSOs) for both visual and acoustic monitoring, and the designation of buffer zones (BZ) and exclusion zones (EZ) (where the presence of a protected species would trigger a mitigation action), ramp-up procedures, and mitigation actions (including delayed operations, power-downs, and shut-downs). Continuous protected species observation coverage during the survey was provided by RPS, the environmental consulting company contracted by L-DEO for the project. PSOs monitored and reported on the presence and behavior of protected species and directed the implementation of the mitigation measures as described in the regulatory documents issued for the survey.

PSO activities were consistent with the PSO standards identified in the Programmatic Environmental Impact Statement (PEIS) / Overseas Environmental Impact Statement (OEIS) for Marine Seismic Research funded by the NSF or conducted by the U.S. Geological Survey and Record of Decision (referred to herein as the PEIS), to which the NSF EA tiered. Five PSOs, one of which was designated as the Lead, were present on board the *Langseth* throughout the survey to conduct both visual and acoustic monitoring.

PSOs conducted visual observations for a total of 142 hours 15 minutes and acoustic monitoring for 27 hours 12 minutes. Visual and acoustic monitoring were conducted simultaneously for a total of 17 hours 25 minutes.

The acoustic source was active for a total of 21 hours 39 minutes, which occurred during 9% (12 hours 12 minutes) of the total visual effort and 80% (21 hours 39 minutes) of the total acoustic monitoring effort by the PSOs.

There was a total of 34 visual detections of protected species during this portion of the survey, including 10 sightings of humpback whales, one sighting that included a mixed species pod of humpback whales and fin whales, six sightings of unidentifiable whales, five sightings of northern fur seals, and 12 sightings of Steller sea lions.

There were no acoustic detections of protected species.

There were no sightings of protected sea turtles, sea otters or sea birds during this continuation portion of the survey.

Protected species detections resulted in the implementation of two mitigation actions, both consisting of shutdowns of the acoustic source totaling 44 minutes.

NMFS issued an IHA and ITS authorizing 53,580 takes for 28 species of marine mammals, including nine species listed as endangered. Of this total, 827 individuals from nine of these species were authorized for Level A takes, and 52,753 individuals from 28 species were authorized for Level B takes. These take numbers apply to the entire survey. For this report, Level A and Level B are used in the same definition as found in the MMPA and the NMFS issued BioOp description. Takes for endangered species totaled 9,997 individuals, including 44 level A takes from five species and 9,953 Level B takes from all nine species. Authorized Level A takes for endangered species included 29 humpback whales, 11 blue whales, one fin whale, two sei whales, and one gray whale. Authorized Level B takes for endangered species included: 112 humpback whales, 40 blue whales, 94 fin whales, 30 sei whales, 43 gray whales, 72 sperm whales, 10 southern resident killer whales, 2,049 Guadalupe fur seals, and 7,504 Steller sea lions. NMFS also issued a BiOp authorizing three takes for endangered leatherback sea turtles. In addition, USFWS issued an IHA authorizing 13 takes for endangered northern sea otters and a BiOp authorizing nine takes for endangered marbled murrelets.

During acoustic source operations for both parts of the survey, a total of 320 protected species were observed within the predicted 160 decibel radius (where there is a potential for a behavioral response) while the acoustic source was active, constituting potential Level B takes. This total included 92 humpback whales (one of which was a juvenile), four blue whales, 10 fin whales, six common dolphins, 176 Pacific white-sided dolphins, three northern adult fur seals, 20 unidentifiable whales, and nine unidentifiable dolphins. There were three protected species, all humpback whales, observed within the predicted radius at which there is a potential for auditory injury (based upon each species hearing range and how that overlaps with the frequencies produced by the sound source), constituting a potential Level A take.

2 INTRODUCTION

The following report details protected species monitoring and mitigation as well as seismic survey operations undertaken as part of the 2D marine geophysical survey on board the *Langseth* in the North Pacific Ocean off the coast of Oregon from 10 to 21 April 2022, referred to herein as the “survey”.

This document serves to meet the reporting requirements dictated in the IHA (Appendix A) and ITS (Appendix B) issued to L-DEO by NMFS on 19 May 2021 and in the IHA and ITS issued by FWS on 20 and 12 April 2021, respectively. The IHAs and ITSs authorized takes of specific protected species, incidental to the marine seismic survey. NMFS has stated that seismic source received sound levels equal to or greater than 160 dB re 1 µPa root mean square (rms) (160 dB) could potentially disturb marine mammals, temporarily disrupting behavior, such that they could be considered non-lethal ‘takes’ (Level B harassment). In July 2016, NMFS released new technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing, which established new thresholds for permanent threshold shift (PTS) onset, Level A harassment (auditory injury), for marine mammal species. Predicted distances to Level A harassment vary based on species specific hearing groups – low frequency cetaceans, mid frequency cetaceans, high frequency (HF) cetaceans, phocid pinnipeds, otariid pinnipeds, sea otters, and sea turtles – and how each group’s hearing range overlaps with the frequencies produced by the sound source. For sea turtles, per the ESA, NMFS has stated that received sound levels equal to or greater than 175 dB represents the current best understanding of the threshold at which they exhibit behavioral responses.

NMFS and FWS require that measures such as buffer zones (BZs), exclusion zones (EZs), delayed operations, ramp-ups, power-downs, and shutdowns be implemented to mitigate for potentially adverse effects of the acoustic source sounds on protected species. The BZs and EZs were established from any element on the acoustic source array as areas where the presence of a protected species would trigger the implementation of a mitigation action (delayed operations for the BZ, and power-downs and/or shut-downs for the EZ depending on the species – see section 3.1). For marine mammals, the occurrence of an individual detected approaching, entering, or within their designated EZ would trigger the implementation of a shutdown of the acoustic source. NMFS specified a 500 meter EZ for most marine mammals as it encompasses all zones within which auditory injury (Level A harassment) could occur on the basis of instantaneous exposure, provides additional protection from the potential for more severe behavioral reactions for marine mammals at relatively close range to the acoustic source, provides a consistent area for PSOs to conduct effective observational effort, and is a distance within which detection probabilities are reasonably high for most species under typical conditions. For sea turtles, the occurrence of an individual detected approaching, entering, or within the 500 meter and 100-meter EZ would trigger the implementation of a power-down or shutdown of the acoustic source, respectively. For protected sea birds, the detection of one foraging or diving within the 500 meter and 100-meter EZ would trigger a power-down and shutdown respectively.

2.1 Project Overview and Location

The research activities involved a 2D seismic survey and deployment and retrieval of ocean bottom nodes (OBN) utilizing a remote operated vehicle (ROV) along one survey line between approximately 44.4045 degrees North and 124.3079 degrees West, and 44.5458 degrees North and 126.1004 degrees West. The survey location was within the exclusive economic zones (EEZ) of the U.S. off the coast of Oregon (Figure 1). Water depths in the survey area ranged between approximately 50 meters and 3,000 meters.

The purpose of this survey was to finish acquiring survey data that was unable to be completed during the original survey in 2021. This survey line was acquired utilizing a streamer and ocean bottom seismometers (OBSs) during the original survey. However, the OBNs that were originally planned to also be on the sea floor for data collection were unable to deployed at that time. This survey consisted of re-acquiring the survey line with only the OBN deployed for data acquisition.

All operations for the survey, including ROV/OBN deployment and retrieval operations and acoustic source data acquisition, were conducted solely by the *Langseth*. The vessel is 72 meters (235 feet) in length and utilizes a particularly quiet propulsion system to avoid interference with the seismic signals. *Langseth*' s cruising speed was approximately 10 to 11 knots during transits and varied between three and five knots during the seismic surveys.

ROV/OBN deployment operations were conducted between 10 and 16 April 2022, with the nodes placed along the middle of the survey line (black section of the line on the map in Figure 1). Seismic data acquisition operations were conducted between 17 and 18 April 2022, with the one survey line acquired totaling approximately 125 kilometers. ROV/OBN retrieval operations began on 18 April 2022 and were completed after the PSOs departed the vessel on 21 April 2022.

A project summary sheet can be found in Appendix C.

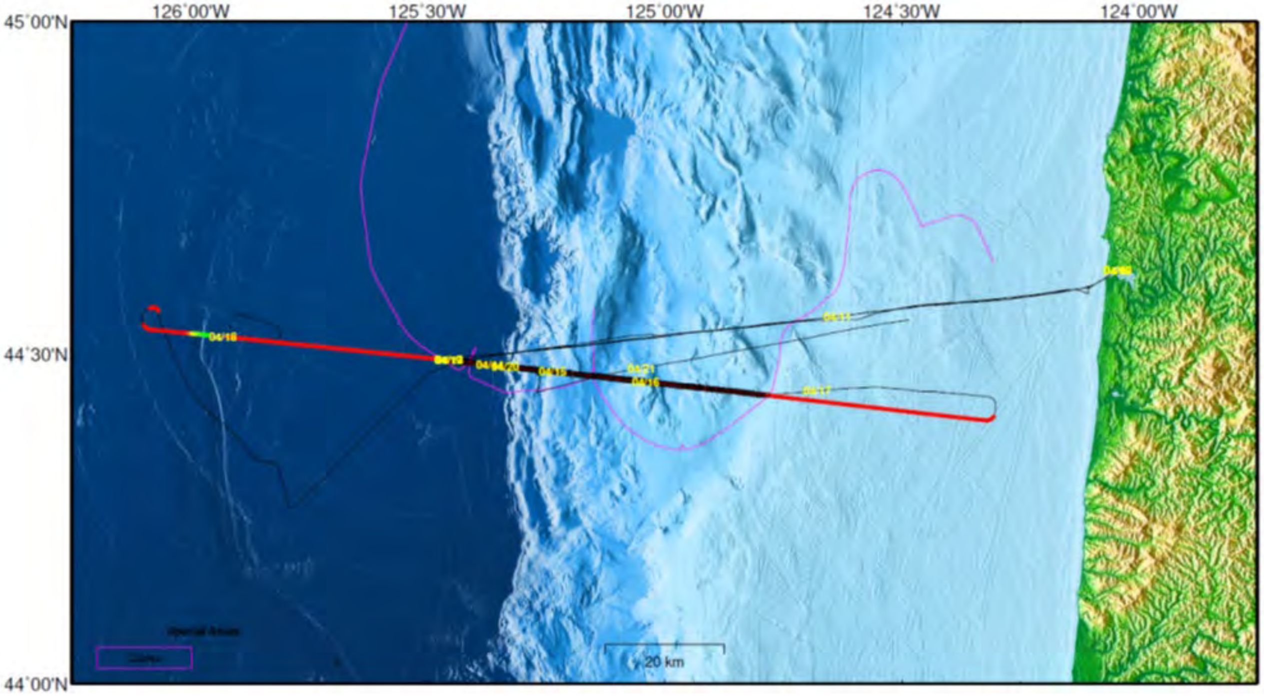

Figure 1: Location and survey points of the marine geophysical survey

2.1.1 Energy Source and Receiving Systems

The energy source utilized during the surveys consisted of four towed acoustic source sub-arrays, each with nine source elements (for a total of 36 source elements), deployed just aft of the vessel. The source array utilized Bolt 1500LL and Bolt 1900LLX elements ranging in size from 40 to 360 cubic inches (in3), with an operating pressure of 1,950 pounds per square inch. The dominant frequency components ranged from two to 188 Hertz (Hz) and nominal source levels ranged from 258 dB re: 1 µPa (zero to peak) to 264 dB re: 1 µPa (peak-to-peak). The source elements were towed at a depth of 12 meters, and the center of the source was situated 230 meters from the Navigation Reference point (NRP), which was located on the PSO observation tower. This positioned the first elements on the arrays 193 meters from the stern of the vessel.

The maximum source volume utilized during the seismic survey was 6600 in3 with 36 active elements. During times when acoustic source arrays were brought on board for maintenance or repair, the total source volume was reduced to varying lower volumes depended on how many of the elements and arrays were disabled. The shot point interval was 37.5 meters (approximately every 123 seconds) During acquisition the source elements emitted a brief (approximately 0.1 second) pulse of sound. During the intervening periods of operations, the source elements were silent.

The9eceiveng system consisted of 107 ocean bottom nodes from Geospace Technologies deployed 500 meters apart by the ROV Odysseus supplied and operated by Pelagic Research Services. Specifications for the nodes and the ROV can be found in Appendix D and Appendix E, respectively. As the acoustic source was operated along the survey line, the nodes receive and store the returning acoustic signals internally for later analysis.

Additional sound sources used in support of research efforts included a Kongsberg EM 122 multi-beam echosounder (MBES), Knudsen Chirp 3260 sub-bottom profiler (SBP), and a Teledyne RDI 75 kHz Ocean Surveyor acoustic Doppler current profiler (ADCP). The hull mounted MBES operated at frequencies between 10.5 and 13 (usually 12) kilohertz. Each ping consisted of eight (in water depths greater than 1,000 meters) or four (in water depths less than 1,000 meters) successive fan-shaped transmissions. The transmitting beam width was one or two degrees fore-aft and 150 degrees perpendicular to the ship’s line of travel. The maximum source level was 242 dB re: 1 µPa (root mean square [rms]). The hull-mounted SBP beam was transmitted as a 27-degree cone, which was directed downward by a 3.5 kilohertz transducer. The nominal power output was 10 kilowatts; however, the actual maximum radiated power was three kilowatts or 222 dB re: 1 µPa m (rms). The ping duration was 64 seconds, and the interval was one second. The hull-mounted ADCP operated at a frequency of 75 kilohertz and a maximum source level of 224 dB re: 1 µPa m (rms) over a conically shaped 30-degree beam. The MBES and SBP operated simultaneously to provide information about near seafloor sedimentary features and to map the topography of the ocean floor. The ADCP was used to measure water current velocities.

3 MITIGATION AND MONITORING METHODS

The PSO monitoring program on the *Langseth* was established to meet the standards set forth in the PEIS, NSF EA, NMFS and FWS IHAs, ITSs, and BiOp requirements. Survey mitigation measures were designed to minimize potential impacts of the *Langseth*'s seismic activities on marine mammals, sea turtles, and other protected species of interest. The following monitoring protocols were implemented to meet these objectives.

- Visual Observations were conducted to provide real-time sighting data, allowing for the implementation of mitigation procedures as necessary.
- A Passive Acoustic Monitoring (PAM) system was operated 24 hours a day to augment visual observations and provide additional marine mammal detection data.
- Effects of marine species exposed to sound levels constituting a take were observed and documents. The nature of the probable consequences was discussed when possible.

In addition to the mitigation objectives outlined in the NSF EA and BiOp, PSOs collected and analyzed necessary data mandated by the NMFS IHAs.

3.1 Mitigation Methodology

Mitigation actions were implemented for visual and acoustic detections of protected species, including marine mammals, sea turtles, and protected sea birds, as outlined in the EA, IHAs, ITS, BiOps. These actions included the establishment of BZs and EZs, and the implementation of delayed operations, power-downs (during which the source volume was reduced to a single active 40 cubic inch element), and shutdowns (during which the source was fully silenced) for protected species detected approaching, entering, or within their designated BZ and EZ. Those zones are listed in Table 1.

Before the acoustic source could be activated from silence (day and night), two PSOs and one PAM operator conducted a 30-minute clearance survey of the BZs and EZs. In the event of a detection of protected species within their designated zones, a delay of source operations would be implemented. Source operations would not be cleared to begin until the protected species were observed exiting their designated zones. If the protected species were not observed exiting their designated zones (i.e., if they dove/submerged within the zone and were not re-sighted), operations would not be cleared to begin until a specific time following the final detection of the animals. For detections of small odontocetes, pinnipeds, sea otters, sea turtles, or sea birds, this time was 15 minutes following last sighting. For detections of mysticetes and other large odontocetes (including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, false killer whales, and Risso's dolphins) this time was 30 minutes following last sighting.

Once the acoustic source was active, the BZ from any element on the acoustic source arrays were established as areas in which the presence of a protected species would initiate an alert to the seismic operators that the animal was detected, and that the implementation of a mitigation action may soon be required. PSOs and the PAM operator would keep in frequent contact with each other and the seismic team, relaying information on the location and movement of the protected species, and the implementation of any needed mitigation actions.

The EZs from any active source element were established as areas in which the detection of a protected species would trigger a power-down or a shutdown of the acoustic source, depending on the species present. For marine mammals, the detection of one approaching, entering, or within their designated zone would trigger a shutdown of the source. For sea turtles, the detection of one approaching, entering, or within the 500 meter or 100-meter exclusion zones would trigger a power-down or a shutdown of the source, respectively. For protected sea birds, the detection of one foraging or diving within the 500 meter or 100-meter exclusion zone would trigger a power-down or a shutdown of the source, respectively.

Upon the implementation of a power-down for a detection of protected sea turtles or seabirds, source activity could be resumed at the previous operating volume once the exclusion zones were confirmed to be clear of the protected species. Upon the implementation of a shutdown for a detection of protected species, a ramp-up was required to resume source activity once the protected species were confirmed to have exited their respective exclusion zones. For both power-downs and shut-downs, if the protected species could not be confirmed to have exited their respective exclusion zones (i.e., if they submerged/dove within the zone and were not re-sighted), clearance for source activity to resume would not be given until a specific time following the last sighting of the individuals within the zones. For detections of small odontocetes, pinnipeds, sea otters, sea turtles, or sea birds, this time was 15 minutes following last sighting. For detections of mysticetes and other large odontocetes (including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, false killer whales, and Risso's dolphins) this time was 30 minutes following last sighting.

The IHAs and ITSs also outlined additional mitigation actions for specific protected species while the acoustic source was active as outlined in Table 2. The shutdown requirement was waived for small dolphins in the genera *Tursiops, Delphinus, Stenella, Lagenorhynchus, and Lissodelphis*. If PSOs could identify the dolphins sighted as one of these species, no mitigation action was required if they were observed approaching, entering, or within the 500-meter exclusion zone. If there was any uncertainty regarding the species identification, visual PSOs were to use their best professional judgment in making the decision to call for a shutdown.

Table 1: Separation distances, buffer zones, and exclusion zone sizes for each species/species group expected to occur in the survey area.

Species/Species Groups	Separation Distances	Buffer Zones	Exclusion Zones
North Pacific Right Whale	500m	Any Distance	Any Distance
Mysticetes	100m	1000m[1]	500m[1]
Sperm Whale	100m	1000m[1]	500m[1]
Beaked Whales and Pygmy and Dwarf Sperm Whales	50m	1500m	1500m
Killer Whales	50m	Any Distance	Any Distance
Delphinid/Porpoise	50m	1000m	500m[2]
Pinnipeds	50m	1000m	500m
Sea Turtle	50m	175 dB radius	500m/100m[3]
Sea Otter	50m	1000m	500m
ESA Sea Bird	None	500m	500m/100m[3]

1 Sightings of an aggregation of six or more individuals, or and adult with a calf, have a BZ and EZ of any distance.
2 Except exempt species per the NMFS IHA

4 FOR THESE SPECIES, A POWER-DOWN IS IMPLEMENTED AT THE 500M EZ AND A SHUTDOWN IS IMPLEMENTED AT THE 100M EZ

Table 2: Specific detections of protected species and their required mitigation actions.

Detection of:	Mitigation Action Required
A North Pacific right whale observed at any distance from the vessel.	Delayed operation of inactive source and shutdown of active source.
A large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult and observed in close association with an adult) observed at any distance from the vessel.	Delayed operation of inactive source and shutdown of active source.
An aggregation of six or more large whales observed at any distance from the vessel.	Delayed operation of inactive source and shutdown of active source.
Any marine mammal species not authorized for take observed approaching, entering, or within the 160-decibel radius.	Delayed operation of inactive source and shutdown of active source.
Any marine mammal species for which the total authorized takes has been met observed approaching, entering, or within the 160-decibel radius.	Delayed operation of inactive source and shutdown of active source.
Any other protected species detected approaching, entering, or within their designated buffer zones.	Delayed operation of inactive source and a warning call that a mitigation action may soon be required for an active source.
Any other protected species detected approaching, entering, or within their designated exclusion zones.	Delayed operation of inactive source and shutdown of active source.
Any dolphin species with a shut-down exemption detected approaching, entering, or within their designated exclusion zones.	None.

Specific acoustic source operation procedures outlined in the IHAs and ITSs that were relevant to this specific survey included:

1. Ramp-ups could not be less than 20 minutes and were required to begin with the smallest volume element and continue in stages by doubling the number of active elements, with each stage approximately the same duration. The time between ramp-up completion and start of data acquisition had to be minimized.
2. Testing of individual elements or strings required a 30-minute clearance search period but no ramp-up. Testing of more than one element or string required both a 30-minute clearance search period and a ramp-up to the maximum volume being tested.
3. Brief periods (less than 30 minutes) of operational silence for reasons other than a protected species shut-down did not require a ramp-up to resume full volume source operations provided that: (1) PSOs maintained constant visual and/or acoustic observation, and (2) no visual or acoustic detections of protected species occurred within the applicable exclusion zone during that silent period. For any brief period of silence at night or in periods of poor visibility (e.g., BSS of four or greater), a ramp-up was required, but if constant observation was maintained, a pre-start clearance watch was not required. For any longer shut-down, both a pre-start clearance watches and a ramp-up were required.

4. Brief periods (less than 30 minutes) of reduced volume less than half of the maximum operation volume (i.e., less than two active strings or less than 3300 cubic inches) did not require a ramp-up to resume full volume if monitoring was continuous and no detections occurred within the EZs. Periods longer than 30 minutes required a ramp-up to resume full volume.

Table 3 describes the predicted160 decibel radius (Level B harassment zone for marine mammals) and the predicted 175 decibel radius (Level B harassment zone for sea turtles). Table 4 describes the predicted Level A harassment zones for each protected species hearing group per the NMFS guidelines, and the species that could occur in the survey area assigned to each group; as noted previously however, shutdowns would occur at each species designated EZs (e.g., 500m, 1500m, etc.).

Table 3: Predicted 160 / 175 decibel zones* implemented during the survey.

Source	Volume (in^3)	Water Depth (m)	160 dB radius – Level B harassment zone for marine mammals	175 dB radius – Level B harassment zone for sea turtles
1 element	40	>1,000	431	77
		100-1000	647	116
		<100	1,041	170
36 Elements	6600	>1,000	6,733	1,864
		100-1000	9,468	2,542
		<100	12,650	3,924

*Distances are from any single element on the array

Table 4: Predicted Level A harassment zones* for each marine mammal hearing group implemented during the survey.

Source	Volume (in^3)	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Phocid Pinnipeds (m)	Otariid Pinnipeds/Sea Otters (m)	Sea Turtles (m)	ESA Sea Birds (m)
1 element	40	1.76	0.51	12.5	1.98	0.4	0	0
36 Elements	6600	426.9	13.6	268.3	43.7	10.6	20.5	84
Species anticipated that could occur in the survey area: **Distances are from any single element on the acoustic source arrays* **Shutdowns occur at each species relevant zones (i.e., 1500 meters,*		• North Pacific Right Whale • Humpback Whale • Blue Whale • Fin Whale • Sei Whale • Minke Whale • Gray Whale	• Sperm Whale • Baird’s Beaked Whale • Small Beaked Whale sp. • Bottlenose Dolphin • Striped Dolphin • Short-beaked Common Dolphin • Pacific White-	• Pygmy Sperm Whale • Dwarf Sperm Whale • Dall’s Porpoise • Harbor Porpoise	• Northern Elephant Seal • Harbor Seal	• Northern Fur Seal • Guadalupe Fur Seal • California Sea Lion • Northern Sea Otter	• Leatherback Sea Turtle	• Marbled Murrelet

500 meters, 100 meters) *Dolphin species in blue text are the shut-down exemption species in US EEZ.*		sided Dolphin • Northern Right-whale Dolphin • Risso's Dolphin • False Killer Whale • Killer Whale • Short-finned Pilot Whale					

4.1 Visual Monitoring Survey Methodology

There were five experienced PSOs on board the *Langseth* during the seismic survey to conduct monitoring for protected species, record and report detections, and request mitigation actions in accordance with the PEIS, Eas IHAs, ITS, and BiOps. The PSOs on board were NMFS approved and held certifications from a recognized Bureau of Ocean Energy Management (BOEM) course. Visual monitoring was primarily carried out from an observation tower (Figure 2) located 18.9 meters above the surface of the water, which allowed a 360-degree viewpoint around the vessel and acoustic source.

Figure 2: Protected Species Observer stern view of observation tower with mounted big eye binoculars.

The PSO tower was equipped with Fujinon 7x50 and Steiner Marine 7x50 binoculars, as well as two mounted 25x150 Big-eye binoculars for visual monitoring. A D-300-2MS Night Optics USA, Inc. monocular and two Butler Creek PVS-7-night vision devices were also available for visual monitoring during reduced/restricted lighting conditions if needed. Inside the tarpaulin tent the PSOs were provided a laptop, a telephone for communication with the PAM station, bridge, and main lab, and a monitor that displayed pertinent information about the vessel including position; speed; heading; water depth; sea temperature, wind speed and direction, and air temperature. The monitor also displayed source activity information including survey line number, total number of active elements and volume. Environmental conditions along with vessel and acoustic source activity were recorded at least once an hour, and every time there was a change in one or more of the above variables. Most visual monitoring was held from the tower; however, during severe weather or when the ships exhaust was blowing on the tower, monitoring would be conducted from the bridge (approximately 12.8 meters above sea level) or the catwalk (approximately 12.3 meters above sea level).

Visual monitoring methods were implemented in accordance with the survey requirements outlined in the IHAs and NMFS and FWS ITSs. Two PSOs visually monitored for protected species during daylight hours throughout the survey program, from the moment the vessel departed port to the moment the vessel returned to port. Visual monitoring during the transits between the ports and the survey area were conducted for vessel strike avoidance and to gather baseline data on the presence and abundance of protected species in the areas during periods of acoustic source silence. Throughout the survey program, visual monitoring was conducted each day from 30 minutes before sunrise until 30 minutes after sunset as required by the IHAs and ITSs. Observation times ranged between 13:00 to 03:40 Coordinated Universal Time (UTC) (06:00 to 20:40 local time). Scheduled watches were a maximum of four hours in duration followed by at least one hour of scheduled break time.

Visual observations were conducted around the entire area of the vessel and acoustic source, divided between the two PSOs on watch. The smaller monitoring area for each observer increased the probability of protected species being sighted. PSOs searched for blows, fins, splashes or disturbances of the sea surface, large flocks of feeding sea birds, and other sighting cues indicating the possible presence of a protected species. Upon the visual detection of a protected species, PSOs would identify the animals' range to the vessel and acoustic source. Range estimations were made using reticle binoculars, the naked eye, and by relating the animal(s) to an object at a known distance, such as the acoustic source arrays and streamer head float. PSOs would also identify to species, if possible, upon initial detection to ensure that the proper mitigation measures were implemented, should any be required.

As required by the IHA (section 5(d)(iii)), PSOs recorded the following information for each protected species detection:

1. Date, time of first and last sighting, observers on duty during the detection, location of the observers, vessel information (e.g., position, speed, heading), water depth, and acoustic source activity (e.g., volume and number of active elements).
2. Species, detection cue, group size (including number of adults, juveniles, and calves), visual description (e.g., overall size, shape of the head, position and shape of the dorsal fin, shape of the flukes, height, and direction of the blow), observed behaviors (e.g., Porpoising, logging, diving, etc.), and the initial and final pace, heading, bearing, and direction of travel in relation to both the vessel and the source (e.g., towards, away, parallel, perpendicular, etc.).
3. Initial, closest, and final distance to the vessel and the source, time when entering and exiting the exclusion zones, type of mitigation action implemented, total time of the mitigation action, description of other vessels in the area, and any avoidance maneuvers conducted.

During or immediately after each sighting event, the PSOs recorded the detection details per the requirements of the IHAs and ITSs in a detection datasheet. Each sighting event was linked to an entry on an effort datasheet where specific environmental conditions (e.g., Beaufort Sea state, wind force, swell height, visibility, and glare) and vessel activity were logged.

Species identifications were made whenever the distance from the observer, length of the sighting, and visual observation conditions allowed. Whenever possible during detections, photographs were taken with Canon EOS 80D cameras that had 300-millimeter lenses. Marine mammal identification manuals (*Whales, Dolphins and Other Marine Mammal of the World; Guide to Marine Mammals of the world; Readers Digest Whales, Dolphins, and Porpoises; Seabirds of the world; Sibley Guide to Birds*) were consulted, and photos were examined to confirm identifications were consulted, and photos were examined to confirm identifications.

4.2 Passive Acoustic Monitoring Survey Methodology

Passive Acoustic Monitoring (PAM) was used to augment visual monitoring efforts in the detection, identification, and locating of marine mammals. PAM was very important during periods of time when visual monitoring was not effective (periods of darkness or low visibility). Acoustic monitoring was conducted continuously during all seismic operations and to the maximum extent possible during periods of acoustic source silence. When the acoustic source was activated from any period of silence, acoustic monitoring was conducted for at least 30 minutes prior to the activation of the source for the pre-clearance survey. PAM shifts were a maximum of four hours in duration followed by at least one hour of scheduled break time.

In accordance with the NMFS issued IHA and ITS, in the event of an issue with PAM equipment, acoustic source activity could continue for 30 minutes without acoustic monitoring while the PAM operator diagnosed the issue. If the diagnosis indicated that the PAM system needed maintenance, operations could continue for an additional five hours without acoustic monitoring, during daylight hours only, provided that: (1) the sea state was less than or equal to a BSS 4; (2) with the exception of delphinids (other than killer whales), no marine mammals were acoustically detected in the applicable exclusion zones in the previous two hours; (3) active acoustic source operations without acoustic monitoring did not exceed a cumulative total of five hours within any 24 hour period; and (4) NMFS was notified via email as soon as practicable of the time and location in which operations occurred without an active PAM system.

The PAM system was located in the main science lab which allowed ample space, quick communication with the PSOs and seismic technicians, and access to the vessel's instrumentation screens. Information about the vessel (e.g., position, heading, and speed), water depth, source activity (e.g., line number, total source volume, number of active elements), and the PAM system (e.g., cable deployments/retrievals, changes to the system, background noise score, hydrophone depth) were recorded at least once an hour, and whenever any of the parameters changed.

Acoustic monitoring for marine mammals was conducted aurally, utilizing Sennheiser headphones, and visually with the Pamguard software program. Low frequency (LF) to mid-frequency delphinid whistles, clicks, and burst pulses, as well as sperm whale clicks and baleen whale vocalizations, could be visualized in Pamguard's spectrogram modules. Sperm whale, beaked whale, Kogia species, and delphinid clicks could also be visualized in LF and HF click detector modules. Settings adjustments to amplitude range, amplitude triggers, and spectral content filters, among others, could be made in Pamguard's spectrogram and click detector modules to maximize the distinction between cetacean vocalizations and ambient signal. The map module within Pamguard could be utilized to attempt localizing the position and range of vocalizing marine mammals. Sound recordings could be made using the HF and LF sound recording modules when potential marine mammal vocalizations were detected, or when the operator noted unknown or unusual sound sources.

As required by the IHA (section 5(d)(iv)), PAM operators recorded the following information during acoustic detections of protected species:

1. Date, time of first and last detection, operator on duty, linked to a visual sighting, vessel information (e.g., position, speed, heading), water depth, and acoustic source activity (e.g., volume and number of active elements).
2. Species (if determinable), group size, methods/modules on which vocalizations were detected during the event, and vocalization characteristics (e.g., signal type, frequency and amplitude range, inter-click interval, patterns, etc.)
3. Determinable bearings (to the hydrophones, vessel, and source) estimated and/or attempted localizations, and any ranges determined, type and time of any implemented mitigation actions and any resulting production loss.

4.2.1 Passive Acoustic Monitoring Parameters

A PAM system designed to detect most species of marine mammals was installed on board the *Langseth*. The system was developed by Seiche Measurements Limited and consisted of the following main components: a 255 meter hydrophone cable (configured as a separate 230 meter steel-reinforced tow cable and detachable 25 meter hydrophone array); a 100 meter deck cable; a rack-mounted electronic processing unit (EPU) that incorporated a buffer unit, RME Fireface 800 unit and computer; two desktop monitors; a keyboard and mouse; acoustic analysis software package; and headphones for aural monitoring. A complete spare system of all components was also present on board in the event that any of the main system components became damaged or inoperable. The diagram in Figure 3 is a simplified depiction of the PAM system installed on the *Langseth*, and further PAM system specifications can be found in Appendix F.

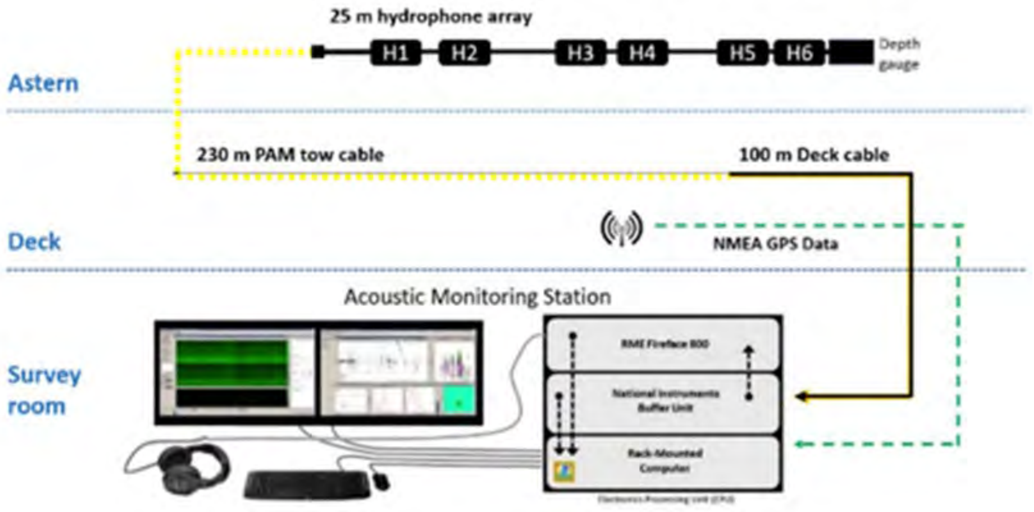

Figure 3: Simplified pathway of data through the PAM system onboard *Langseth*

The hydrophone cable contained six hydrophone elements and a depth gauge molded into a 25-meter section of the cable. The six-element linear hydrophone array allowed the system to sample a large range of marine mammal vocalization frequencies. The hydrophone pair closest to the end by the depth gauge were used for low frequencies between 10 hertz and 24 hertz, the middle hydrophone pair was used for mid frequencies between 200 hertz and 200 kilohertz, and the forward hydrophone pair closest to the connector to the tow cable was used for high frequencies between two kilohertz and 200 kilohertz.

The deck cable interfaced between the hydrophone cable deployed astern of the vessel and the electronics processing unit (EPU) located in the main science lab. The rack-mounted EPU was set up with the two pre-installed, wall-mounted monitors supplied by the Langseth, a keyboard, a mouse, and headphones. The EPU contained a buffer unit with Universal Serial Base (USB) output, an RME Fireface 800 ADC unit with firewire output, and a rack-mounted computer. A Global Positioning System (GPS) feed of GNGGA strings was supplied from the ship's Seapath navigation system and routed to the computer, reading data every five seconds. Data from the hydrophone cable's depth transducer was routed through the buffer unit to the computer, via USB connection. Pamguard Beta version 1.15.11 was the software version utilized for the surveys.

Raw feed from the two high frequency hydrophone elements was digitized in the buffer unit using an analogue-digital National Instruments data acquisition (DAQ) soundcard at a sampling rate of 500 kilohertz. The output was filtered for HF content and visualized using the Pamguard software, which used the difference between the time that a signal arrived at each of the two hydrophones to calculate and display the bearing to the source of the signal. A scrolling bearing/time module displayed the filtered data in real time, allowing for the detection and directional mapping of click trains. Additional components of the HF click detector system in Pamguard led: an amplitude/time display that registered click intensity data in real time, as well as click waveform, click spectrum, and Wigner plot displays, providing the PAM operator immediate review of individual click characteristics in the identification process.

Raw feed from the two low frequency and two mid frequency hydrophone elements was routed from the buffer unit to the RME Fireface 800 unit, where it was digitized at a sampling rate of 48 kilohertz. The relatively low frequency (LF) output was further processed within Pamguard by applying Engine Noise

Fast Fourier Transform (FFT) filters, including click suppression and spectral noise removal filters (e.g., median filter, average subtraction, Gaussian kernel smoothing and thresholding). Filtered LF content was visualized in two spectrograms, one displaying a channel feed at frequency ranges of zero to 24 kilohertz, and another displaying a channel feed at a frequency range of zero to three kilohertz. LF click detector modules allowed for review of individual click characteristics as well as the detection and tracking of click trains.

A map module on the LF system interfaced with GPS data provided by the vessel to display the vessel location and could be used to determine range and bearing estimates based on clicks tracked in the click detector module. Pamguard contained a function for calculating the range to vocalizing marine mammals based upon the least squares fit test. This method is most effective with animals that are relatively stationary in comparison to the moving vessel, such as sperm whales. The mathematical function estimated the range to vocalizing marine mammals by calculating the most likely crossing of a series of bearing lines generated from tracked clicks or whistles and plotted on a map display. The bearings of detected whistles and moans were calculated using a Time-of-Arrival-Distance (TOAD) method (where the signal time delay between the arrival of a signal on each hydrophone was compared), and presented on a radar display, along with amplitude information for the detected signal as a proxy for range.

Additional modules displayed on the LF monitor included a LF sound recorder and clip generator. The clip generator module within Pamguard could be used to generate short sound clips in response to either an automatic detection or the operator manually selecting a portion of the spectrogram display. This module was useful in the event that the whistle-and-moan detector falsely triggered and identified a non-biological sound (i.e., echosounder) or if it missed detecting tonal signatures that the operator determined to be vocalizations.

4.2.2 Hydrophone Deployment

The hydrophone cable was deployed from a hydraulic winch on the port stern of the vessel’s aft deck where the acoustic source arrays were deployed. Two deck cables, a main and a spare, were installed along the deck-head running from the winch to the main science lab. A Chinese finger attached to the tow cable approximately 125 meters ahead of the connector to the hydrophone array was secured to the port side boom via lifting rope. This reduced the tension on the cable remaining on the winch, and also served as a method to pull the cable further to port and away from the source arrays. This deployment method placed the trailing end of the hydrophone cable approximately 125 meters from the port stern of the vessel, and approximately 68 meter forward of the first elements on the acoustic source arrays (Figure 4). Two pieces of chain of seven kilograms each were attached and secured to the tow cable to increase tow depth and to decrease the chance of entanglement with the source arrays’ umbilicals. The tow depth of the hydrophones varied between 14.4 and 34.2 meters and averaged 22.7 meters throughout the seismic survey.

A more detailed description of the hydrophone deployment method can be found in Appendix G.

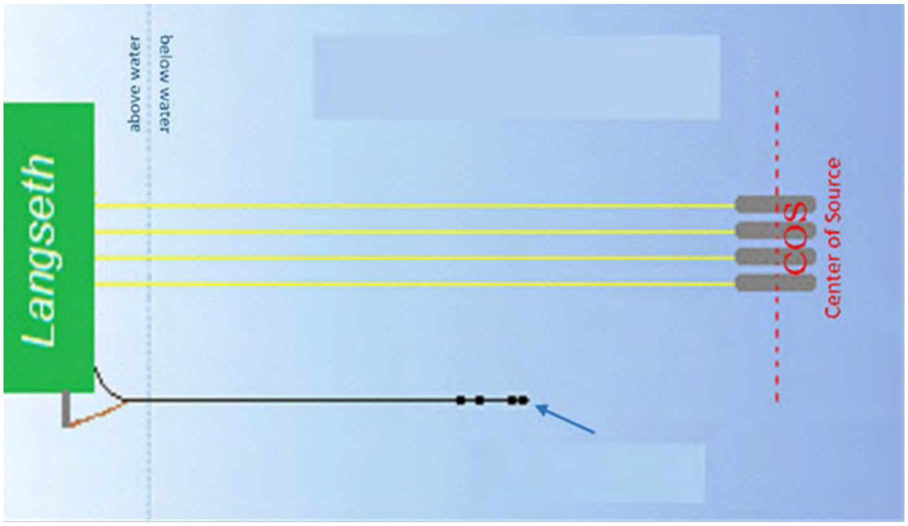

Figure 4: Location of the PAM cable in relation to the seismic gear during the survey.

5 MONITORING SUMMARY

5.1 Survey Operations Summary

5.1.1 General Survey Parameters

The Canales ROV seismic survey began on 10 April 2022 when the *Langseth* departed the port in Newport, Oregon. ROV OBN deployment operations were conducted between 10 and 16 April 2022 and were briefly suspended between 11 and 12 April 2022 while the vessel returned to port due to inclement weather and a medical issue with a crew member. There were no suspended source operations during data acquisition between 17 and 18 April 2022 for reasons other than for protected species mitigation actions. There was however an infill of missing data from a mitigation action that was not acquired after the main survey line was completed due to inclement weather. ROV OBN retrieval operations commenced on 18 April 2022 but were suspended for inclement weather on 20 April 2022. On 21 April 2022, the vessel returned to port again to acquire a new generator for the ROV. At this time, the PSOs demobilized from the vessel, and they were not onboard when the vessel again departed port to complete the OBN retrieval operations. See Table 5 for dates of major survey activities.

Table 5: Major Survey Dates

Survey Parameter	Date	Time (UTC)	Location
Mobilization	10 April 2022	02:57	Newport, Oregon
Start OBN Deployment	10 April 2022	13:20	Survey area
End OBN Deployment	16 April 2022	22:54	Survey area
First Source Activity	17 April 2022	03:04	Survey area
Start of Acquisition	17 April 2022	03:33	Survey area
End of Acquisition	18 April 2022	02:48	Survey area
Start OBN Retrieval	18 April 2022	20:47	Survey area
Demobilization	21 April 2022	04:50	Newport, Oregon

5.1.2 Additional Operations

The multi-beam echosounder (MBES), sub-bottom profiler (SBP), acoustic Doppler current profiler (ADCP), and ultra-short baseline (USBL) systems were active throughout the majority of the seismic survey while the vessel was within the survey area for a total of 206 hours 20 minutes. The sound sources were active for the first time on 10 April 2022 at 13:35 UTC (USBL) and 14:30 UTC (MBES, SBP, ADCP), and each source was disabled and re-activated multiple times throughout the survey for node deployment and retrieval operations. The last recorded active times before the PSOs demobilized was at 08:22 UTC on 20 April 2022 (USBL), and at 00:59 UTC on 21 April 2022 (MBES, SBP, ADCP). None of these sound sources were operated outside of the survey area during the transits to and from port.

5.1.3 Acoustic Source Operations

The acoustic source was active for a total of 21 hours 39 minutes throughout the seismic survey. This total included: one hour 14 minutes of ramp-up, 19 hours 30 minutes of operations on a survey line (three minutes at full volume and 19 hours 27 minutes at a reduced volume), and 55 minutes of operations not on a survey line (eight minutes at full volume and 47 minutes at a reduced volume. There was no source testing conducted. Table 6 summarizes the acoustic source operations over the course of the seismic survey.

The acoustic source was ramped up three times, including one time for the start of data acquisition operations and two times to resume operations from a mitigation shutdown for protected species detected within the exclusion zones. All three ramp-ups were conducted during daylight hours and cleared by both visual and acoustic monitoring. Ramp-ups averaged 21 and 32 minutes in duration and were conducted using the automated controller program, Gun Link 2000, which added source elements sequentially to achieve the full source volume over the required period.

There were no operations with only a single 40 in3 source element conducted for protected species mitigation power-downs.

The geospatial data for source operations are provided as a shapefile attachment to this report. The volume of the acoustic source was changed (reduced or increased) on one occasion during active source operations due to an issue with an individual source element. The initial ramp-up, approach to and start of the survey line was at a full volume of 6600 cubic inches with 36 active elements, and the remainder of the source operations were at a volume of 6560 cubic inches with 35 active elements.

Table 6: Total acoustic source operations during the survey.

Acoustic Source Operation	Number	Duration
Source Tests	0	00:00
Ramp-up	3	01:14
Day-time ramp-ups from source silence	3	01:14
Night-time ramp-ups from source silence	0	00:00
Full (6600 in^3)/Reduced Volume on a Survey Line[1]		19:03
Full (6600 in^3)/Reduced Volume not on a Survey Line[2]		00:55
Single Source Element (40 in^3)		00:00
Total Time Acoustic Source Was Active		**21:39**

1. **On a Survey Line:** 00:03 (full volume), 19:27 (reduced volume)
2. **Not on a Survey Line:** 00:08 (full volume), 00:47 (reduced volume)

5.1.4 Interactions with Other Vessels

In addition to visually monitoring for protected species, PSOs also observed and documented interactions with other marine vessel traffic. Such interactions included but were not limited to another vessel or another vessels' towed gear/equipment interacting with the *Langseth's* towed gear/equipment, and the *Langseth* having to deviate from planned survey operations (i.e., diverge from the survey line, increase/decrease speed) because of another vessel.

Over the course of the survey, there were no instances where the *Langseth* had such an interaction with another vessel.

5.2 Visual Monitoring Survey Summary

Visual monitoring was conducted by two PSOs during all daylight hours, beginning 30 minutes before sunrise and ending 30 minutes after sunset each day, initiating when the vessel left the port at the beginning of the program and terminating upon the vessels return to port at the end of the program (Table 7). There was a brief period at the beginning of the survey where the vessel returned to port, during which time visual monitoring was suspended while the vessel was docked. Visual monitoring resumed when the vessel departed dock to return to the survey site. Visual monitoring during transit was conducted for vessel strike avoidance, and visual monitoring during times with no source operations was conducted to collect baseline data about protected species abundance in the survey areas.

Table 7: Initiation and termination of visual monitoring during the survey.

Visual Monitoring	Date	Time (UTC)
Initiation for the survey	10 April 2022	02:57
Termination when vessel returned to dock	11 April 2022	02:57
Initiation when vessel departed dock again	12 April 2022	16:04
Termination for the survey	21 April 2022	03:40

Visual monitoring on the *Langseth* was conducted over a period of 12 days for a total of 142 hours 15 minute. Of the overall total visual monitoring effort, 9% (12 hours 13 minutes) was undertaken while the acoustic source was active, and 91% (130 hours two minutes) was undertaken while the acoustic source was silent. Visual monitoring while the acoustic source was silent was mainly conducted during the transits to and from the survey sites, and during equipment deployment, recovery, and maintenance. Table 8 details visual monitoring with acoustic source operations on the *Langseth* throughout the seismic survey.

Table 8: Total visual monitoring effort during the survey.

Visual Monitoring Effort	Duration (hh:mm)	% of Overall Effort
Total monitoring while acoustic source active	12:13	9
Total monitoring while acoustic source silent	130:02	91
Total monitoring effort	**142:15**	**-**

Visual observations on the *Langseth* were preferentially conducted from the PSO tower, which provided a 360-degree view of the water around the vessel and the acoustic source. Visual watches were conducted from other locations, including the catwalk, bridge, and stern if monitoring conditions could not be undertaken from the tower, such as during rough weather and sea conditions which made the tower unsafe, or when the vessel was heading directly into the wind, blowing the engine exhaust onto the tower. PSOs conducted visual monitoring from the tower (33.16%) and from the bridge (66.44%) more often than any other location (Table 9).

Table 9: Total visual monitoring effort from observation locations during the survey.

Observation Location During Visual Effort	Duration (hh:mm)	% of Overall Effort
Tower	47:10	33.16
Bridge	94:31	66:44
Catwalk	00:34	0.40

5.3 Acoustic Monitoring Survey Summary

Acoustic monitoring was conducted continuously throughout acoustic source operations and to the maximum extent possible while the acoustic source was silent (Table 10). Brief periods of source activity without acoustic monitoring were conducted for any needed assessments, adjustments, or maintenance to the PAM system. Periods without source activity or acoustic monitoring occurred when the PAM hydrophone cable was secured on board the vessel during transits, during deployment and recovery of the seismic gear, and during times when operations were suspended due to rough weather and sea conditions.

Table 10: Initiation and termination of acoustic monitoring watches during the survey.

Acoustic Monitoring	Date	Time (UTC)
Initiation for the survey	17 April 2022	00:51
Termination for the survey	18 April 2022	04:03

Acoustic monitoring was conducted on 2 days for a total of 27 hours 12 minutes. Of the overall total acoustic monitoring effort, 80% (21 hours 39 minutes) was undertaken while the acoustic source was active, and 20% (five hours 33 minutes) was undertaken while the acoustic source was silent. Acoustic monitoring while the acoustic source was silent was mainly conducted during the brief periods of time between recovery/deployment of the seismic gear and recovery/deployment of the PAM cable. Table 11 details acoustic monitoring with acoustic source operations.

Table 11: Total acoustic monitoring effort during the survey.

Acoustic Monitoring Effort	Duration (hh:mm)	% of Overall Effort
Total nighttime monitoring	09:47	36
Total day time monitoring	17:23	64
Total monitoring while the acoustic source was active	21:39	80
Total monitoring while the acoustic source was silent	05:33	20
Total acoustic monitoring	**27:12**	**-**

There were no instances of acoustic monitoring downtime or acoustic source activity without acoustic monitoring throughout the survey program.

5.4 Simultaneous Visual and Acoustic Monitoring Summary

Simultaneous visual and acoustic monitoring was conducted to the maximum extent possible for a total of 17 hours 25 minutes. Of the overall simultaneous monitoring effort, 70% (12 hours 13 minutes) was conducted while the acoustic source was active (Table 12). Additional visual monitoring conducted during transit periods was not accompanied by acoustic monitoring as the increased vessel speed would causes the hydrophone cable to migrate to the water surface, out of the ideal tow position, where increased background noise would impair acoustic detection capabilities.

Table 12: Simultaneous visual and acoustic monitoring effort during the survey.

Simultaneous Visual and Acoustic Monitoring	Duration (hh:mm)	% of Overall Downtime
Source Active	12:13	70
Source Silent	05:12	30
Overall Total	**17:25**	**-**

5.5 Environmental Conditions

Environmental conditions can have an impact on the probability of detecting protected species. The environmental conditions present during visual observations undertaken were generally considered to be moderate to good. Visibility was classified as ‘excellent’ if it extended greater than ten kilometers and “very good” if it was between seven and 10 kilometers. 69% of monitoring effort on the *Langseth* was undertaken at ‘very good’ visibility levels (Table 13). The entire predicted harassment zone radii, BZs, and EZs were not visible on multiple occasions, mainly due to precipitation and the large size of the 160 dB radii, which in shallow water was never fully visible. During these times, it is possible that protected species were not detected within these zones.

Table 13: Visibility during the survey in kilometers.

Total	<0.05	0.05-0.1	0.1-0.3	0.3-0.5	0.5-1	1-2	2-5	5-7	7-10	>10
Duration (hh:mm)	00:00	00:00	00:00	01:24	02:58	07:27	09:15	22:46	98:25	00:00

Reduced visibility was mainly attributed to periods of rain and fog, and the brief periods of reduced lighting before sunrise and after sunset. Precipitation was recorded during visual monitoring on the *Langseth* for a total of 33 hours 19 minutes. Most of the precipitation recorded was light rain (13%) (Table 14).

Table 14 Precipitation during the survey.

Total	None	Heavy Rain	Moderate Rain	Light Rain	Heavy Fog	Moderate Fog	Thin Fog	Haze
Duration (hh:mm)	108:56	01:16	10:00	17:59	01:46	00:50	01:20	00:08

The Beaufort Sea state recorded during visual monitoring ranged from level one to level nine. Most visual observations on the *Langseth* were undertaken in conditions where the Beaufort state was level three (37%) or level four (26%), which were considered good to moderate conditions for the detection of protected species (Table 15).

Table 15: Beaufort Sea State during the survey.

Total	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9
Duration (hh:mm)	00:00	03:22	14:17	51:56	36:17	13:04	06:10	10:16	05:53	01:00

Wind speeds recorded visual monitoring ranged between one and 40 knots. Most of the visual monitoring on the *Langseth* occurred during recorded wind speeds of less than 10 knots (35%) and between 10 and 15 knots (25%) (Table 16).

Table 16: Wind speed during the survey.

Total	<10	10-15	16-20	21-25	26-30	>30
Duration (hh:mm)	50:00	35:38	29:07	15:08	05:58	06:24

Swell heights during visual observations were generally low, with swells of less than two meters recorded for the majority of visual observations (54%) (Table 17).

Table 17: Swell height during the survey.

Total	<2m	2-4m	>4m
Duration (hh:mm)	77:15	55:23	09:37

The majority of visual monitoring effort on both vessels was conducted while no glare was present (41%) (Table 18). During times of moderate to severe glare, it is possible that the detections of protected species was hindered.

Table 18: Glare during the survey.

Total	None	Mild	Moderate	Severe
Duration (hh:mm)	59:15	19:51	23:47	39:22

6 MONITORING AND DETECTION RESULTS

6.1 Visual Detections

Visual monitoring efforts during the survey resulted in a total of 34 visual detections of protected species totaling 58 individuals (Summarized in Appendix H). This total included 17 detections of whales and 17 detections of pinnipeds. Table 19 lists the total number of detections and total number of animals recorded for each protected species observed during the survey. Photographs taken of visual detections can be found in Appendix I.

Maps of the detections of the protected species are shown in Figure 5.

Table 19: Number of visual detection records collected for each protected species during the survey.

Species	Total Number of Detection Records	Total Number of Animals
Humpback Whale	10	20
Mixed Species (Humpback and Fin Whales)	1	7 (4 Humpback, 3 Fin)
Unidentifiable Whale	6	9
Whale totals	**17**	**36**
Northern Fur Seal	5	5
Steller Sea Lion	12	17
Pinniped totals	**17**	**22**
Total	**34**	**58**

Of the 34 detections, three detections occurred while the acoustic source was deployed and active, two detections occurred while the acoustic source was deployed but silent, and 29 detections occurred while the acoustic source was not deployed. Table 20 lists the number of each species detected during each different source activity described above as well as the species average closest approach to the source during those times.

The three detections that occurred while the acoustic source was deployed and active included one sighting of a juvenile humpback whale and two sightings of adult northern fur seals. The humpback whale had the closest observed distance of 2,614 meters to the active source, while the northern fur seals had closest observed distances of 240 and 247 meters to the active source. The two sightings of northern fur seals within the 500-meter exclusion zone both resulted in shutdown mitigation actions. After the source had been silenced, these individuals had closest observed distances of 193 meters and 200 meters to the silent elements respectively.

The two detections that occurred while the acoustic source was deployed but silent for the entire detections included one sighting of two adult humpback whales and one sighting of an adult northern fur seal. The humpback whales were sighted while the source arrays were being deployed, and they had the closest observed distance of 1,885 meters to the silent elements. The norther fur seal was observed while the source was silent from another detections mitigation action and had the closest observed distance of 277 meters to the silent elements.

There were 18 detections that occurred during node deployment/retrieval operations including five sightings of humpback whales, the one sighting of a mixed species pod of humpback and fin whales, five sightings of unidentifiable whales, and seven sightings of Steller sea lions. There were five detections that occurred while the vessel was running weather patterns with operations suspended within the survey area including two sightings of northern fur seals and three sightings of Steller sea lions. There were six detections that occurred during transit to/from port including three sightings of humpback whales, one sighting of an unidentifiable whale, and two sightings of Steller sea lions. These 29 detections occurred while the acoustic source was silent and secured onboard the vessel, and therefore no distances to the elements was recorded.

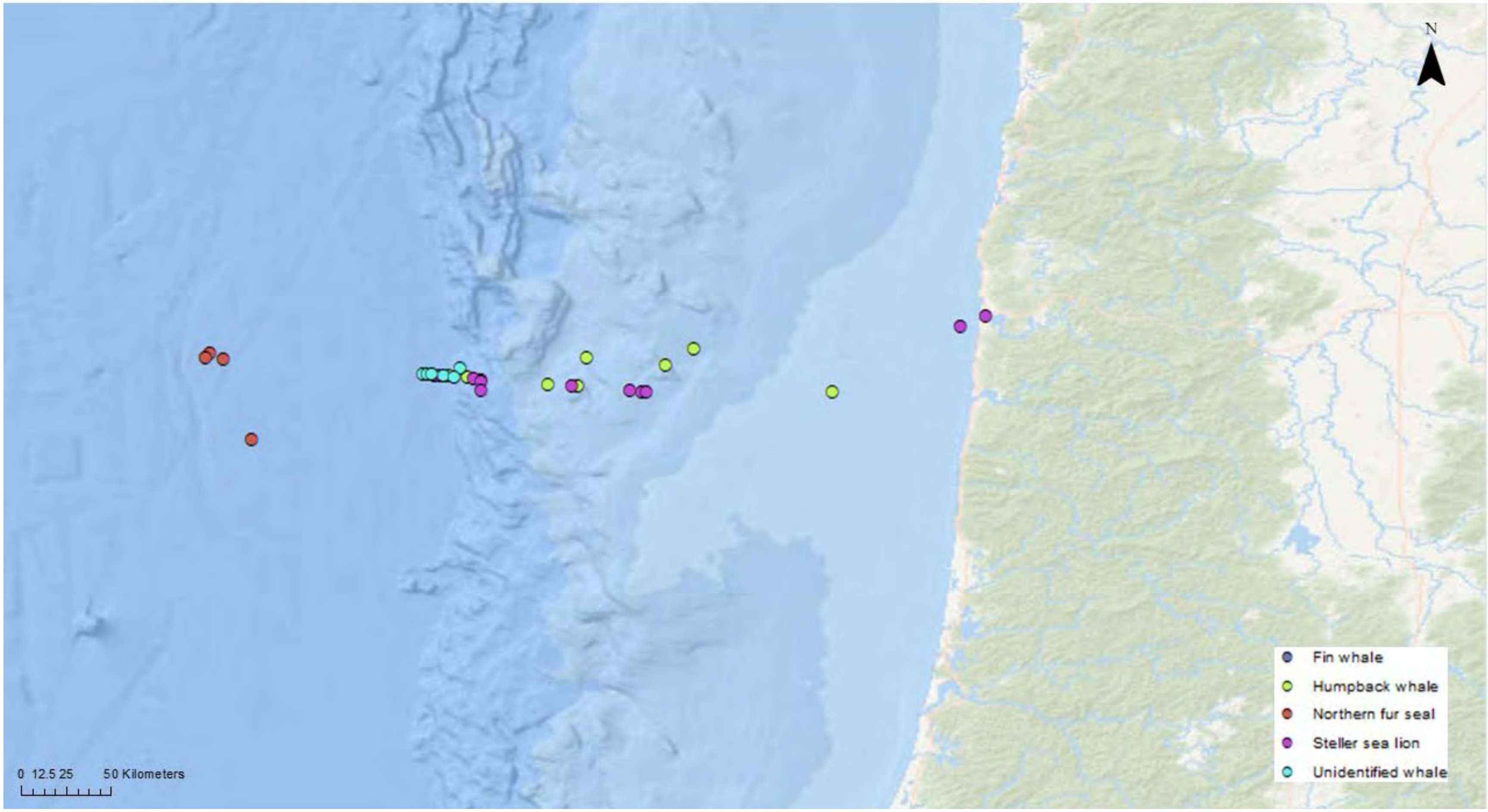

Figure 5: All protected species detections during the survey.

Table 20: Average closest approach of protected species to the source during the survey.

Species Detected	Regulated Source Active		Regulated Source Inactive	
	Number of detections	Mean closest observed approach to source (meters)	Number of detections	Mean closest observed approach to source (meters)
Humpback Whale	1	2,614	1	1,885
Northern Fur Seal	2	243.5	1	277

6.1.1 Other Wildlife Sighted

Observations of other wildlife during the survey included 22 species of birds and one species of marine invertebrates. A complete list of birds and other marine wildlife observed and identified, in addition to the approximate number of individuals observed and the number of days on which they were observed, can be found in Appendix J. No impacts to any other wildlife species because of research activities were observed during the survey.

There were no detections of ESA (US) protected bird species during the survey, including tufted puffin (ESA--candidate species).

6.2 Acoustic Detections

There were no acoustic detections of protected species during the survey.

7 MITIGATION ACTION SUMMARY

There were two mitigation actions implemented during the survey due to protected species being observed approaching, entering, or within their designated exclusion zones. This included two shutdowns for northern fur seals observed within their 500-meter exclusion zone totaling 44 minutes (17 minutes for the first shutdown and 27 minutes for the second) (Table 21). Overall, however, there was a total of two hours five minutes of silence associated with these mitigation actions as ramp-up was further delayed after clearance had been given by the seismic operations (one hour 36 minutes for the first shutdown and 29 minutes for the second). For both detections, the pinnipeds were last observed within the EZ, and a 15-minute delay from the last observation was implemented before clearance was given for ramp-up.

There were no mitigation actions for protected sea turtles or sea birds during this survey.

Table 21: Number and duration of mitigation actions implemented during the survey.

Mitigation Action	Dolphins		Whales		Porpoises		Pinnipeds		All Species	
	No	Mitigation Downtime	No.	Mitigation Downtime	No.	Mitigation Downtime	No.	Mitigation Downtime	No.	Mitigation Downtime
Delay of Initiation of Operation	-	-	-	-	-	-	-	-	-	-
Shutdown of Operation	-	-	-	-	-	-	2	00:44	2	00:44
Total Mitigation	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**00:44**	**2**	**00:44**

7.1 Protected Species Known to Have Been Exposed to 160 Decibels or Greater of Received Sound Levels

NMFS granted an IHA and ITS for the marine seismic survey authorizing a total of 53,580 takes from 28 species, including six species of whales, one species of dolphins, and two species of pinnipeds listed as endangered or threatened for the entire Cascadia survey. Of this total, 827 individuals from nine of these species were authorized for Level A harassment takes (exposure to sound pressure levels where there is a potential for auditory injury based upon each species hearing range), including 44 takes for endangered/threatened species. A total of 52,753 individuals from all 28 species were authorized for Level B harassment takes (exposure to sound pressure levels equal to or greater than 160 dB re: 1 μPa (rms) where there is a potential for behavioral changes), including 9,953 takes for endangered/threatened species. NMFS also issued a BiOp/ITS granting three takes for leatherback sea turtles, where behavioral harassment was expected to occur in the 175-decibel zone. The FWS granted an IHA authorizing 13 takes for northern sea otters. FWS also issued a BiOp authorizing nine takes for marbled murrelets. FWS determined it is unlikely that all of these birds will be incidentally taken at the same location, rather the takings will be dispersed across the survey area. Based on the effects of the action analysis above, a very limited number of marbled murrelets are likely to be present in close proximity to the airgun arrays or survey vessels, exposed to significant sound pressure levels and respond in a manner that conforms to take.

Throughout the seismic survey, 320 protected species, were observed within the Level B harassment zone while the acoustic source was active. This total included 92 humpback whales (one of which was a juvenile), four blue whales, 10 fin whales, six common dolphins, 176 Pacific white-sided dolphins, three northern fur seals, 20 unidentifiable whales, and nine unidentifiable dolphins. There were three protected species, all humpback whales, observed within the Level A harassment zone while the acoustic source was active. Table 22 details the authorized and the cumulative potential Level A and Level B takes for the entire research program (2021 and 2022).

The number of potential takes may be an underestimation and, therefore, may be a minimum estimate of the actual number of protected species potentially exposed to received sound levels within the predicted Level A and Level B harassment zones. It is possible that the estimated numbers of animals recorded were underestimates due to some individuals not being visually sighted or having moved away before they were observed, or some individuals not vocalizing and therefore not detected acoustically.

Table 22: Number of authorized and potential level A and B harassment takes during the survey.

Species	IHA Authorized Level A Takes	Potential Level A Takes/PTS During the Program	IHA Authorized Level B Takes	Potential Level B Takes/TTS During the Program	Total IHA Authorized Takes	Total Potential Takes During the Program
Humpback Whale	29	3	112	92	141	95
Blue Whale	11	-	40	4	51	4
Fin Whale	1	-	94	10	95	10
Sei Whale	2	-	30	-	32	-
Minke Whale	7	-	96	-	103	-
Gray Whale	1	-	43	-	44	-
Sperm Whale	-	-	72	-	72	-
Baird's Beaked Whale	-	-	84	-	84	-
Small Beaked Whale	-	-	242	-	242	-
Bottlenose Dolphin	-	-	13	-	13	-
Striped Dolphin	-	-	46	-	46	-
Short-beaked Common Dolphin	-	-	179	6	179	6
Pacific White-sided Dolphin	-	-	6084	176	6084	176
Northern Right-whale Dolphin	-	-	4318	-	4318	-
Risso's Dolphin	-	-	1664	-	1664	-
False Killer Whale	-	-	5	-	5	-
Killer Whale (Southern Resident)	-	-	10	-	10	-
Killer Whale	-	-	73	-	73	-
Short-finned Pilot Whale	-	-	29	-	29	-
Pygmy/Dwarf Sperm Whale	5	-	125	-	130	-
Dall's Porpoise	488	-	9762	-	10250	-
Harbor Porpoise	283	-	7958	-	8241	-
Northern Fur Seal	-	-	4592	3	4592	3
Guadalupe Fur Seal	-	-	2048	-	2048	-
California Sea Lion	-	-	889	-	889	-
Steller Sea Lion	-	-	7504	-	7504	-
Northern Elephant Seal	-	-	2754	-	2754	-
Harbor Seal	-	-	3887	-	3887	-
Northern Sea Otter	-	-	13	-	13	-
Leatherback Sea Turtle	-	-	3	-	3	-
Marbled Murrelet	-	-	9	-	9	-

Species	IHA Authorized Level A Takes	Potential Level A Takes/PTS During the Program	IHA Authorized Level B Takes	Potential Level B Takes/TTS During the Program	Total IHA Authorized Takes	Total Potential Takes During the Program
Unidentifiable Whale	-	-	-	20	-	20
Unidentifiable Dolphin	-	-	-	9	-	9
Unidentifiable Porpoise	-	-	-	-	-	-
Unidentifiable Pinniped	-	-	-	-	-	-
Unidentifiable Sea Turtle	-	-	-	-	-	-

*The above survey totals in this table also include the totals from the initial Cascadia survey conducted in 2021 as this continuation survey was utilizing the same NMFS IHA.

7.2 Implementation and Effectiveness of the Biological Opinion’s ITS and IHA

In order to minimize the potential impacts to marine mammals, sea turtles, and protected sea birds during the seismic survey, LDEO and PSOs were prepared to implement mitigation measures whenever these protected species were detected approaching, entering, or within their designated exclusion zones as outlined in the IHAs, ITSs, BiOp and Final EA. There were two mitigation actions implemented for protected species, including two shutdowns totaling 44 minutes. The confirmation of the implementation of each term and condition of the project permit documents are described in this report.

As noted in Section 3.1, there were several additional mitigation measures for certain detections of protected species as well as mitigation exemption for five species of delphinids in the US EEZ. There were no instances during the survey where these extra mitigation measures or exemptions were implemented.

In the event that an injured or dead protected species was discovered, the incident was to be reported to the NMFS Office of Protected Resources (OPR), and the NMFS West Coast Regional Stranding Coordinator as soon as possible. Sighting of an injured or dead northern sea otter was to be reported to the Washington Fish and Wildlife Office’s sea otter stranding coordinator. The report would include a detailed description of the incident (time, date, location, species identification, description of the animal, condition of the animal/carcass, observed behaviors if the animal was alive, and general circumstances under which the animal was discovered), including pictures when possible. There were no sightings of dead or injured protected species during the seismic survey.

In order to prevent the occurrence of the vessel striking a marine mammal during transits, PSOs and vessel crew members maintained a vigilant watch for marine mammals, and the vessel was prepared to slow down, stop, or alter course as appropriate to avoid striking a protected species. The vessel speed had to be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of cetaceans were observed near the vessel. The vessel had to maintain the minimum separation distances as described in Table 1 in Section 3.1. If a marine mammal was sighted during transits, the vessel was to act as necessary to avoid violating the relevant separation distances (e.g., attempt to remain parallel to the animal’s course, avoid excessive speed or abrupt changes in direction until the animal left the area). If marine mammals were sighted within the relevant separation distances, the vessel was required to reduce speed, shift the engines to neutral, and not engage the engines until the animals were clear of the area. These requirements did not apply in any case where compliance would create an imminent and serious threat to a person or vessel, or if the vessel was restricted in maneuverability due to towed equipment. There were no instances during the survey where avoidance maneuvers were required to be implemented for protected species detections.

In the event of a ship strike of a marine mammal, the incident was to be reported to NMFS OPR, and to the West Coast Regional Stranding Coordinator as soon as feasible. Reports of ship strike of northern sea otters was to be to the Washington Fish and Wildlife Office's sea otter stranding coordinator. The report would include a detailed description of the incident (date, time, location, species identification, description of the animal(s) involved, vessel speed leading up to the incident, vessel's course/heading and what operations were being conducted, status of all sound sources in use, description of avoidance measures taken if any, environmental conditions, description of the animals behavior preceding and following the strike, and estimated fate of the animal), including pictures when possible. There were no instances of the vessel striking a protected species during the seismic survey.

In the event of a sighting of a species of concern, which included North Pacific right whales and southern resident killer whales, the sighted was to be reported to NMFS OPR as soon as feasible. The report would include a detailed description of the sighting (time, date, location, description of the animals, behaviors observed, direction of travel, and vessel and source activity), including pictures when possible. There were no sightings of species of concern during the seismic survey.

In the event of a live stranding (or near-shore atypical milling) event of marine mammals within 50 kilometers of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return the animals to the water, LDEO would be advised by NMFS OPR (or designee) of the need to implement shutdown procedures for all active acoustic sources operating within 50 kilometers of the stranding. The shutdown procedures would be implemented until all of the live animals had left the area, or until the marine mammals died or were euthanized. NMFS OPR (or designee) did not contact LDEO for the need to implement shutdown procedures in response to a stranding event.

PAM was conducted for acoustic source operations during the survey and the majority of monitoring was undertaken while the source was active. Vessel speeds greater than six knots can result in high levels of background noise, which made it impractical to conduct acoustic monitoring while the vessel was in transit both within and outside of the survey area while visual monitoring was ongoing for baseline data collection purposes. There were no acoustic detections of protected species.

PSOs likely did not detect all animals present; however, it is highly unlikely that the actual number of animals present during survey operations reached anywhere near the fully authorized levels for all species. The combination of conservative predicted mitigation zones combined with conservative take estimation by NMFS (i.e., the precautionary approach), appears for most species to have resulted in an overestimation of take and of overall impact on marine species from the activity. The monitoring and mitigation measures required by the IHAs and ITSs appear to have been an effective means to protect the marine species encountered during survey operations.

8 LITERATURE CITED

NOAA, 2020. Endangered Species Act Section 7 Consultation Biological Opinion for a marine seismic survey by Lamont-Doherty Earth Observatory in the North Pacific Ocean and NFMS IHA issuance.

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Crone, T.J., M. Tolstoy, and H. Carton. 2017. Utilizing the R/V Marcus G. Langseth's streamer to measure the acoustic radiation of its seismic source in the shallow waters of New Jersey's continental shelf. PloS ONE 12(8): e0183096. http://doi.org/10.1371/journal.pone.018

Appendix A: Incidental Harassment Authorization

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1315 East-West Highway
Silver Spring, Maryland 20910

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a geophysical survey in the Northeast Pacific Ocean, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for geophysical survey activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Northeast Pacific Ocean along the Cascadia Subduction Zone.

3. General Conditions

   (a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO) and any other relevant designees of L-DEO operating under the authority of this IHA.

   (b) The species authorized for taking are listed in Table 1. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

   (c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

   (d) During use of the acoustic source, if any marine mammal species that are not listed in Table 1 appear within or enter the Level B harassment zone (Table 2) or a species for which authorization has been granted but the takes have been met, is observed within or approaching the Level A or Level B harassment zones (Tables 2-3), the acoustic source must be shut down.

   (e) L-DEO must ensure that relevant vessel personnel and PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Measures

   The holder of this Authorization is required to implement the following mitigation measures:

(a) L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

(b) At least one visual and two acoustic PSOs aboard the R/V *Langseth* and at least one visual PSO aboard the second vessel (see condition 4(c)(iii)) must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

(c) Visual Observation

  (i) During survey operations *(e.g.*, any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

  (ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Estimated harassment zones are provided in Tables 2-3 for reference.

  (iii) During survey operations in water depths shallower than 200 m between Tillamook Head, Oregon (45.9460903° N) and Barkley Sound, British Columbia (48.780291° N), and while surveying within Olympic Coast National Marine Sanctuary, a second vessel with additional visual PSOs must accompany the R/V *Langseth* and survey approximately 5 km ahead of the R/V *Langseth*. Two visual PSOs must be on watch on the second vessel during all such survey operations (according to the requirements provided in 4(c)(i) of this IHA) and communicate all observations of marine mammals to PSOs on the R/V *Langseth*.

  (iv) Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(v) During good conditions (*e.g.*, daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(vi) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids (other than killer whales), no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

(e) Exclusion zone and buffer zone

(i) Except as provided below in 4(e)(ii), the PSOs must establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1,000 m). The 1,000-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the exclusion zone and buffer zone for a minimum of 30 minutes prior to ramp-up (*i.e.*, pre-start clearance).

(ii) An extended 1,500-m exclusion zone must be established for all beaked whales, and dwarf and pygmy sperm whales. No buffer zone is required.

(f) Pre-start clearance and Ramp-up

(i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, false killer whales, and Risso's dolphins).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (*i.e.*, less than 30 minutes) for reasons other than that described for shutdown (*e.g.*, mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (*e.g.*, BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

(g) Shutdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (*i.e.*, anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the genera described in 4(g)(v)) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

(iv) The airgun array must be shut down if any of the following are detected at any distance:

a. North Pacific right whale.

b. Killer whale (of any ecotype).

c. Large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).

d. Aggregation of six or more large whales.

(v) The shutdown requirements described in 4(g)(iii) shall be waived for small dolphins of the following genera: *Tursiops, Delphinus, Stenella, Lagenorhynchus,* and *Lissodelphis*.

a. If a small delphinid (individual of the Family Delphinidae, which includes the aforementioned dolphin genera), is visually and/or acoustically detected and localized within the exclusion zone, no shutdown is required unless the acoustic PSO or a visual PSO confirms the individual to be of a genera other than those listed above, in which case a shutdown is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shutdown.

(vi) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (*i.e.*, animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, false killer whales, and Risso's dolphins) with no further observation of the marine mammal(s).

(h) Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (*i.e.*, PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

(i) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

(ii) Vessels must maintain a minimum separation distance of 500 m from North Pacific right whales and 100 m from other large whales (*i.e.*, sperm whales and all other baleen whales).

(iii) The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (*e.g.*, for animals that approach the vessel).

(iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (*e.g.*, attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

(v) These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

(i) Survey operations in waters shallower than 200 m between Tillamook Head, Oregon (45.9460903° N) and Barkley Sound, British Columbia (48.780291° N), and survey operations within Olympic Coast National Marine Sanctuary, must be conducted in daylight hours only (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset).

(j) On each day of survey operations, L-DEO must contact NMFS Northwest Fisheries Science Center (206-860-3200), NMFS West Coast Regional Office (206-526-6150), The Whale Museum (800-562-8832), Orca Network (360-331-3543), Canada's Department of Fisheries and Oceans (604-666-9965), and Olympic Coast National Marine Sanctuary (208-410-0260), to obtain any available information regarding the whereabouts of Southern Resident killer whales.

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring must be conducted in accordance with the following requirements:

(a) The operator must provide PSOs with bigeye binoculars (*e.g.*, 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

(b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

(i) PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) Reticle binoculars (*e.g.*, 7 x 50) of appropriate quality (at least one per PSO, plus backups).

(iii) Global Positioning Unit (GPS) (plus backup).

(iv) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

(v) Compass (plus backup).

(vi) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

(vii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(ii) NMFS must review and approve PSO resumes.

(iii) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(iv) One visual PSO with experience as shown in condition 4(b) of this authorization shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(v) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(vi) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

(vii) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

  a. Vessel names (source vessel and other vessels associated with survey) and call signs;

  b. PSO names and affiliations;

  c. Date and participants of PSO briefings (as discussed in General Requirement);

  d. Dates of departures and returns to port with port name;

  e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

  f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

  g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

  h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

  i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (*e.g.*, vessel traffic, equipment malfunctions); and

  j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.*, pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any marine mammal, the following information must be recorded:

  a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

  b. PSO who sighted the animal;

  c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

f. Direction of vessel's travel (compass direction);

g. Direction of animal's travel relative to the vessel;

h. Pace of the animal;

i. Estimated distance to the animal and its heading relative to vessel at initial sighting;

j. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

k. Estimated number of animals (high/low/best);

l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

p. Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other); and

q. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information must be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (*e.g.*, clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

(ii) Summary of all data required to be collected (see condition 5(d));

(iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iv) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

(v) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (*e.g.*, when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(vi) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and

(vii) Raw observational data.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS West Coast Regional Stranding Coordinator (866-767-6114) as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to the West Coast Regional Stranding Coordinator as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the incident;

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

g. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

h. Estimated size and length of animal that was struck;

i. Description of the behavior of the marine mammal immediately preceding and following the strike;

j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

k. Estimated fate of the animal (*e.g.*, dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

l. To the extent practicable, photographs or video footage of the animal(s).

(c) Reporting Species of Concern – L-DEO must immediately report all observations of Southern Resident killer whales and North Pacific right whales to OPR, NMFS (301-427-8401). If Southern Resident killer whales or North Pacific right whales are observed within Olympic Coast National Marine Sanctuary, L-DEO must also immediately report the sightings to the Sanctuary (208-410-0260). The report must include the following information:

(i) Time, date, and location (latitude/longitude, water depth) of the observation;

(ii) Description of the animal(s) seen, including estimated number of animals, estimated age and sex classes observed, and distinguishing features;

(iii) Behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible);

(iv) Direction of vessel's travel (compass direction) and direction of animal's travel relative to the vessel; and

(v) Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other).

7. <u>Actions to minimize additional harm to live-stranded (or milling) marine mammals</u> – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic

sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(a) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise L-DEO that the shutdown around the animals' location is no longer needed.

(b) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

(c) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with L-DEO will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(d) Additional information requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

(i) Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

(ii) If available, description of the behavior of any marine mammal(s) observed preceding (*i.e.*, within 48 hours and 50 km) and immediately after the discovery of the stranding.

In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

8. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

9. Renewals - On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when

(1) up to another year of identical, or nearly identical, activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (recognizing that the Renewal IHA expiration date cannot extend beyond one year from expiration of the initial IHA).

(b) The request for renewal must include the following:

  (i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (*e.g.*, reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

  (ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

____________________________ ____________

Catherine Marzin, Date
Acting Director, Office of Protected Resources,
National Marine Fisheries Service.

Table 1. Numbers of Incidental Take of Marine Mammals Authorized.

Species	MMPA Stock	Authorized Take		Total Authorized Take
		Level B	Level A	
LF Cetaceans				
Humpback whale	Central North Pacific California/Oregon/Washington	112	29	141
Blue whale	Eastern North Pacific	40	11	51
Fin whale	California/Oregon/Washington Northeast Pacific	94	1	95
Sei whale	Eastern North Pacific	30	2	32
Minke whale	California/Oregon/Washington	96	7	103
Gray whale	Eastern North Pacific	43	1	44
MF Cetaceans				
Sperm whale	California/Oregon/Washington	72	0	72
Baird's beaked whale	California/Oregon/Washington	84	0	84
Small beaked whale	California/Oregon/Washington	242	0	242
Bottlenose dolphin	California/Oregon/Washington (offshore)	13	0	13
Striped dolphin	California/Oregon/Washington	46	0	46
Short-beaked common dolphin	California/Oregon/Washington	179	0	179
Pacific white-sided dolphin	California/Oregon/Washington	6084	0	6084

Northern right-whale dolphin	California/Oregon/Washington	4318	0	4318
Risso’s dolphin	California/Oregon/Washington	1664	0	1664
False killer whale	Hawai'i Pelagic	5	0	5
Killer whale	Southern Resident	10	0	10
	Northern Resident	73	0	73
	West Coast Transient			
	Offshore			
Short-finned pilot whale	California/Oregon/Washington	29	0	29
HF Cetaceans				
Pygmy/dwarf sperm whale	California/Oregon/Washington	125	5	130
Dall's porpoise	California/Oregon/Washington	9762	488	10250
Harbor porpoise	Northern Oregon/Washington Coast	7958	283	8241
	Northern California/Southern Oregon			
Otariid Seals				
Northern fur seal	Eastern Pacific	4592	0	4592
	California			
Guadalupe fur seal	Mexico to California	2048	0	2048
California sea lion	U.S.	889	0	889
Steller sea lion	Eastern U.S.	7504	0	7504
Phocid Seals				
Northern elephant seal	California Breeding	2754	0	2754
Harbor seal	Oregon/Washington Coast	3887	0	3887

Table 2. Level B Harassment Zones by Water Depth

Water depth (m)	Level B harassment zone (m)
> 1000	6,733
100 – 1000	9,468
< 100	12,650

Table 3. Level A Harassment Zones by Hearing Group

Source (volume)	Threshold	Level A harassment zone (m)				
		LF cetaceans	MF cetaceans	HF cetaceans	Phocids	Otariids
36-airgun array (6,600 in^3)	SEL$_{cum}$	426.9	0	1.3	13.9	0
	Peak	38.9	13.6	268.3	43.7	10.6

Appendix B: Biological Opinion

NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL AND CONFERENCE OPINION AND MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Title:	Biological and Conference Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation on the Lamont-Doherty Earth Observatory's Marine Geophysical Survey by the R/V *Marcus G. Langseth* of the Cascadia Subduction Zone in the Northeast Pacific Ocean and National Marine Fisheries Service Permits and Conservation Division's Issuance of an Incidental Harassment Authorization pursuant to Section 101(a)(5)(D) of the Marine Mammal Protection Act
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce
Action Agency:	National Oceanic Atmospheric Administration National Marine Fisheries Service-Office of Protected Resources-Permits and Conservation Division
Publisher:	Office of Protected Resources, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, U.S. Department of Commerce

Approved:

Catherine Marzin
Acting Director, Office of Protected Resources

Date: 5/19/21

Consultation Tracking number: OPR-2019-03434

Digital Object Identifier (DOI): *https://doi.org/10.25923/rv2p-vh59*

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 et seq.) establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat they depend on. Section 7(a)(2) of the ESA requires Federal agencies to insure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or adversely modify or destroy their designated critical habitat. Federal agencies must do so in consultation with National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that may be affected by the action that are under NMFS jurisdiction (50 C.F.R. §402.14(a)). If a Federal action agency determines that an action "may affect, but is not likely to adversely affect" endangered species, threatened species, or designated critical habitat and NMFS concurs with that determination for species under NMFS jurisdiction, consultation concludes informally (50 C.F.R. §402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of consultation, NMFS provides an opinion stating whether the Federal agency's action is likely to jeopardize ESA-listed species or destroy or adversely modify designated critical habitat. If NMFS determines that the action is likely to jeopardize listed species or destroy or adversely modify critical habitat, NMFS provides a reasonable and prudent alternative that allows the action to proceed in compliance with section 7(a)(2) of the ESA. If an incidental take is expected, section 7(b)(4) requires NMFS to provide an incidental take statement (ITS) that exempts take incidental to an otherwise lawful action, and specifies the impact of any incidental taking, including reasonable and prudent measures (RPMs) to minimize such impacts and terms and conditions to implement the RPMs.

The Federal action agencies for this consultation are the National Science Foundation (NSF) and the NMFS's Permits and Conservation Division. Two federal actions are considered in this biological and conference opinion (opinion). The first is the NSF's proposal to fund a seismic survey on the Cascadia Subduction Zone in the Northeast Pacific Ocean to take place in May 2021, in support of an NSF-funded collaborative research project led by Columbia University's Lamont-Doherty Observatory (L-DEO). The second is the NMFS Permits and Conservation Division's proposal to issue an incidental harassment authorization (IHA) authorizing non-lethal "takes" by Level A and Level B harassment (as defined by the Marine Mammal Protection Act [MMPA]) of marine mammals incidental to the planned seismic survey, pursuant to section 101 (a)(5)(D) of the MMPA, 16 U.S.C. § 1371(a)(5)(D).

This consultation, opinion, and incidental take statement, were completed in accordance with ESA section 7, associated implementing regulations (50 C.F.R. §§402.01-402.16), and agency policy and guidance. This consultation was conducted by the NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (hereafter referred to as "we" or "our"). We also completed an Essential Fish Habitat (EFH) consultation on the proposed action in accordance with section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and

Management Act (MSA; 16 U.S.C. § 1801 et seq.) and implementing regulations at 50 CFR Part 600. Consistent with Secretarial Order (#3206)*: American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act*, we conducted outreach with affected tribes in the action area to discuss how the proposed action may impact tribal trust resources.

This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of the proposed actions on endangered and threatened marine mammals, sea turtles, and fishes and designated and proposed critical habitat for those species. A complete record of this consultation is on file at the NMFS Office of Protected Resources in Silver Spring, Maryland.

1.1 Background

The NSF is proposing to fund and conduct a marine seismic survey for scientific research purposes and data collection in the Cascadia Subduction Zone in the Northeast Pacific Ocean off the coasts of Oregon, Washington, and Vancouver Island, Canada in the summer of 2021. The National Science Foundation, as the research funding and action agency, has a mission to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…" The proposed seismic survey will collect data in support of a research proposal that has been reviewed under the National Science Foundation merit review process and identified as a National Science Foundation program priority. In conjunction with this action, the NMFS Permits and Conservation Division proposes the issuance of an IHA pursuant to the MMPA requirements for incidental takes of marine mammals that could occur during the NSF seismic survey. This document represents the NMFS ESA Interagency Cooperation Division's opinion on the effects of the two proposed federal actions on threatened and endangered species, and has been prepared in accordance with section 7 of the ESA. Both the NSF and the NMFS Permits and Conservation Division have conducted similar actions in the past that have been the subject of ESA section 7 consultations. The previous opinions for NSF's seismic surveys in the vicinity of the proposed action area, which include Northeast Pacific (2012), Oregon (2017; FPR-2017-9195), and the Western Gulf of Alaska (2019; OPR-2018-00010) and the issuance of an IHA for each survey, determined that the authorized activities were not likely to jeopardize the continued existence of ESA-listed species, or result in the destruction or adverse modification of designated critical habitat.

The principal investigators worked with the NSF and L-DEO to consider potential times to carry out the proposed seismic surveys. Key factors taken into consideration included environmental conditions (i.e., the seasonal presence of marine mammals, sea turtles, and sea birds), weather conditions, equipment, and optimal timing for other proposed seismic surveys using the R/V *Marcus G. Langseth*.

Due to operational delays related to the coronavirus pandemic, the NSF delayed the start of the proposed action from the summer of 2020 to May 20, 2021. Seismic activities would begin on June 1, and last for 37 days, ending on or about July 7. The change in timing for the proposed action does not change the ESA-listed species we expect to occur in the action area.

1.2 Consultation History

This opinion is based on information provided in the NSF draft environmental assessment/analysis (EA) prepared pursuant to the National Environmental Policy Act, L-DEO's MMPA IHA application, the NMFS Permits and Conservation Division's notice of a proposed IHA prepared pursuant to the MMPA, and information from previous NSF seismic surveys in the vicinity of the action area. Our communication with the NSF and NMFS Permits and Conservation Division regarding this consultation is summarized as follows:

- **October 2, 2019:** The NSF submitted a request for a species list.
- **November 8, 2019:** The NSF submitted the draft initiation package to the ESA Interagency Cooperation Division for review.
- **November 25, 2019:** The NSF submitted a revised draft EA which included additional activities left out of the original draft.
- **December 10, 2019:** The ESA Interagency Cooperation Division determined the initiation package was complete and initiated consultation with NSF.
- **January 28, 2020:** The ESA Interagency Cooperation Division, with cooperation from the NMFS West Coast Region's tribal liaison, sent notification letters to 18 tribes whose tribal trust resources may be affected by the proposed action. The purpose was to set up a webinar for the affected tribes to provide them with information on the proposed action and to request their input under Secretarial Order (#3206): *American Indian Tribal Rights, Federal-Tribal Trust Responsibilities, and the Endangered Species Act*.
- **February 4, 2020:** The ESA Interagency Cooperation Division met with representatives from the headquarters' and the NMFS West Coast Region's Office of Habitat Conservation to discuss the Essential Fish Habitat (EFH) consultation for the proposed action.
- **March 18, 2020:** The Permits Division submitted their initiation package to the ESA Interagency Cooperation Division for review. The ESA Interagency Cooperation Division reviewed the package, determined it was complete, and initiated consultation on the same date.
- **April 10, 2020:** The NSF informed the ESA Interagency Cooperation Division that, due to complications arising from the coronavirus pandemic, the proposed action would be delayed to July 1, 2020.
- **May 29, 2020:** The NSF informed the ESA Interagency Cooperation Division and the Permits Division that the proposed action would be further delayed to the summer of 2021 due to logistical concerns arising from the coronavirus pandemic. The NSF stated they would provide additional details about the timing and any changes to the proposed survey lines as those details became available. The consultation was placed on hold.
- **January 2021:** The NSF confirmed the rescheduled dates for the proposed action. The proposed action will take place starting on May 20, 2021, with seismic activities to begin

on June 1, 2021. The ESA Interagency Cooperation Division and the Permits Division resumed work on the ESA section 7 consultation and MMPA IHA, respectively, following the notification by the NSF.

- **February 5, 2021:** The ESA Interagency Cooperation Division sent notice to each of the 18 tribes to inform them of the proposed action's new start date, and to invite them to a rescheduled informational webinar on the proposed action.
- **February 17, 2021:** The ESA Interagency Cooperation Division held an informational webinar for representatives from concerned tribes about the proposed action. In attendance were:
    - Representatives from the Makah, Quinault, and Quileute Tribes
    - Amilee Wilson, NMFS West Coast Region Tribal Liaison
    - Jolie Harrison and Amy Fowler, NMFS Permits Division
    - Cathy Tortorici and Colette Cairns, NMFS ESA Interagency Cooperation Division
    - George Galasso and Katie Wrubel, NOAA Olympic Coast National Marine Sanctuary
    - Holly Smith, National Science Foundation.
- **March 3, 2021:** Makah Tribal Councilman Timothy Greene sent a letter to the ESA Interagency Cooperation Division recommending actions NMFS and NSF could take to mitigate the effects of the proposed action to tribal trust resources.
- **March 19, 2021:** The West Coast Region Tribal Liaison sent responses to several questions posed by attendees during the February 17 webinar. These responses were developed in cooperation with the NSF and the ESA Interagency Cooperation Division. Also on this date, the ESA Interagency Cooperation Division met with biologists from the West Coast Region Habitat Conservation Division to discuss the EFH consultation.
- **March 31, 2021:** The West Coast Region Habitat Conservation Division completed the EFH consultation and provided it to the ESA Interagency Cooperation Division for incorporation in the ESA consultation document.
- **April 6, 2021**: NOAA held a fisheries coordination meeting with representatives from the Makah, Quinault, and Quileute Tribes to discuss coordinating notification to the Tribes during the NSF's action.
- **April 21, 2021:** The NMFS Office of Protected Resources responded to Councilman Greene with a letter describing our response to his recommendations. Our response detailed how the recommendations were incorporated into the proposed IHA.

2 THE ASSESSMENT FRAMEWORK

Section 7(a)(2) of the ESA requires Federal agencies, in consultation with NMFS, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species; or adversely modify or destroy their designated critical habitat.

"Jeopardize the continued existence of" means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of an ESA-listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 C.F.R. §402.02).

"Destruction or adverse modification" means a direct or indirect alteration that appreciably diminishes the value of critical habitat as a whole for the conservation of a listed species (50 C.F.R. §402.02).

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action and those aspects (or stressors) of the proposed action that may have effects on the physical, chemical, and biotic environment. This section also includes the avoidance and minimization measures that have been incorporated into the project to reduce the effects to ESA-listed species.

Action Area (Section 4): We describe the action area with the spatial extent of the stressors from the action.

Endangered Species Act-Listed Species and Proposed or Designated Critical Habitat Present in the Action Area (Section *5*): We identify the ESA-listed species and designated critical habitat that are likely to co-occur with the stressors produced by the proposed action in space and time.

Potential Stressors (Section 6): We identify the stressors that could occur as a result of the proposed action and affect ESA-listed species and designated critical habitat. We include a section (Section 7.1) for stressors that are not likely to adversely affect the species that are analyzed further in this opinion.

We also identify those *Species and Critical Habitat Not Likely to be Adversely Affected* (Section 7) and detail our effects analysis for these species and critical habitats (Sections 7.2 and 7.2.5).

Status of Species and Critical Habitat Likely to be Adversely Affected (Section 8): We examine the status of each species and critical habitat that may be adversely affected by the proposed action.

*Environmental Baseline (*Section 9): We describe the environmental baseline in the action area as the condition of the listed species and designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process. The consequences to listed species from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline.

Effects of the Action (Section 10): Effects of the action are all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and is reasonably certain to occur. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action. These are broken into analyses of exposure, response, and risk, as described below for the species that are likely to be adversely affected by the action.

Exposure, Response, and Risk Analyses (Section 10.2, 10.2.2, and 10.3): We identify the number, age (or life stage), and sex of ESA-listed individuals that are likely to be exposed to the stressors and the populations or subpopulations to which those individuals belong. We also identify the unit(s) of designated critical habitat that are likely to be exposed. This is our exposure analysis. We evaluate the available evidence to determine how individuals of those ESA-listed species are likely to respond given their probable exposure. We also consider how designated critical habitat in terms of changes in function. This is our response analysis (Section 10.2.2). We assess the consequences of these responses of individuals that are likely to be exposed to the populations those individuals represent, and the species those populations comprise. We also assess the consequences of responses of critical habitat to the critical habitat unit(s) and how changes in function may affect the conservation value of designated critical habitat. This is our risk analysis (Section 10.3).

Cumulative Effects (Section 11): Cumulative effects are the effects to ESA-listed species and designated critical habitat of future state or private activities that are reasonably certain to occur within the action area (50 C.F.R. §402.02). Effects from future Federal actions that are unrelated to the proposed action are not considered because they require separate ESA section 7 compliance.

Integration and Synthesis (Section 12): With full consideration of the status of the species and the designated critical habitat, we consider the effects of the action within the action area on populations or subpopulations and on essential habitat features when added to the environmental baseline and the cumulative effects to determine whether the action could reasonably be expected to:

- Reduce appreciably the likelihood of survival and recovery of ESA-listed species in the wild by reducing its numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; and/or
- Appreciably diminish the value of designated critical habitat for the conservation of an ESA-listed species, and state our conclusion as to whether the action is likely to destroy or adversely modify designated critical habitat.

The results of our jeopardy and destruction and adverse modification analyses are summarized in the *Conclusion* (Section 13). If, in completing the last step in the analysis, we determine that the action under consultation is likely to jeopardize the continued existence of ESA-listed species or destroy or adversely modify designated critical habitat, then we must identify Reasonable and Prudent Alternative(s) to the action, if any, or indicate that to the best of our knowledge there are no reasonable and prudent alternatives (see 50 C.F.R. §402.14(h)(3)).

An *Incidental Take Statement* (Section 14) is included for those actions for which take of ESA-listed species is reasonably certain to occur in keeping with the revisions to the regulations specific to ITSs (80 FR 26832, May 11, 2015: ITS rule). The ITS specifies the impact of the take, reasonable and prudent measures to minimize the impact of the take, and terms and conditions to implement the reasonable and prudent measures (ESA section 7 (b)(4); 50 C.F.R. §402.14(i)).

We also provide discretionary *Conservation Recommendations* (Section 15) that may be implemented by action agency (50 C.F.R. §402.14(j)). Finally, we identify the circumstances in which *Reinitiation of Consultation* (Section 16) is required (50 C.F.R. §402.16). In Section 17, we present the Magnuson-Stevens Fishery Conservation and Management Act EFH consultation response.

2.1 Evidence Available for the Consultation

To comply with our obligation to use the best scientific and commercial data available, we collected information identified through searches of Google Scholar and literature cited sections of peer reviewed articles, species listing documentation, and reports published by government and private entities. This opinion is based on our review and analysis of various information sources, including:

- Information submitted by the NSF and the Permits Division;
- Government reports (including NMFS biological opinions and stock assessment reports);
- NOAA technical memos; and
- Peer-reviewed scientific literature.

These resources were used to identify information relevant to the potential stressors and responses of ESA-listed species and designated critical habitat under NMFS' jurisdiction that may be affected by the proposed action to draw conclusions on risks the action may pose to the continued existence of these species and the value of designated critical habitat for the conservation of ESA-listed species.

3 DESCRIPTION OF THE PROPOSED ACTION

"Action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by federal agencies (50 C.F.R. §402.02).

Two proposed Federal actions were evaluated in this consultation. The first is the National Science Foundation's (along with researchers from the L-DEO of Columbia University, the Woods Hole Oceanographic Institution, and the University of Texas at Austin's Institute for Geophysics) proposal to sponsor and conduct a high-energy marine seismic survey on the R/V

Marcus G. Langseth in the Northeast Pacific Ocean over the Cascadia Subduction Zone in the summer (June and July) of 2021, with preparation for the survey beginning on or about May 20, 2021. The R/V *Marcus G. Langseth* is operated by the L-DEO of Columbia University under an existing cooperative agreement. The principal investigators are Drs. S. Carbotte (L-DEO), P. Canales (Woods Hole Oceanographic Institution), and S. Han (University of Texas at Austin's Institute for Geophysics). Researchers from the U.S. Geological Survey, Dalhousie University, and Simon Fraser University will also be assisting the principal investigators. The second is NMFS Permits and Conservation Division's issuance of an IHA authorizing non-lethal MMPA "takes" by Level A and B harassment pursuant to section 101(a)(5)(D) of the MMPA for the National Science Foundation's high-energy marine seismic survey in the Northeast Pacific Ocean.

The proposed NSF action includes a two-dimensional high-energy seismic survey in the Exclusive Economic Zones of the U.S and Canada, including in U.S. state waters and the Territorial Waters of Canada. The proposed survey will focus on the Cascadia Subduction Zone. The acquired data will be used to characterize: 1) the deformation and topography of the incoming plate; 2) the depth, topography, and reflectivity of the megathrust; 3) sediment properties and amount of sediment subduction; and 4) the structure and evolution of the accretionary wedge, including geometry and reflectivity of fault networks, and how these properties vary along strike, spanning the full length of the margin and down dip across what may be the full width of the seismogenic zone at Cascadia. The data will be processed to pre-stack depth migration using state-of-the art seismic processing techniques and would be made openly available to the community, providing a high-quality data set illuminating the regional subsurface architecture all along the Cascadia Subduction Zone.

Thus, the survey will provide data necessary to examine the depth, geometry, and physical properties of the seismogenic portion and updip extent of the megathrust zone between the subducting Juan de Fuca plate and the overlying accretionary wedge/North American Plate. These data would provide essential constraints for earthquake and tsunami hazard assessment in the region. The portion of the megathrust targeted for this survey is the source region for great earthquakes that occurred at Cascadia in pre-historical times, comparable in size to the Tohoku M9 earthquake in 2011; an earthquake of similar size is possible at Cascadia within the next century.

The information presented here is based primarily on the draft EA, IHA application, and *Federal Register* notice of the proposed IHA provided by the NSF and NMFS Permits and Conservation Division as part of their initiation packages.

3.1 National Science Foundation's and Lamont-Doherty Earth Observatory of Columbia University's Proposed Activities

The National Science Foundation proposes to fund and conduct a seismic survey in the Northeast Pacific Ocean on the Research Vessel (R/V) *Marcus G. Langseth* (operated by the L-DEO). A 36-airgun array will be deployed as an energy source. A multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler will be operated during the survey, and ocean-bottom seismometers and ocean-bottom nodes will collect data. A remotely operated vehicle (ROV) will be used to retrieve the ocean-bottom nodes.

3.1.1 Seismic Survey Overview

The survey will take place in the U.S. Exclusive Economic Zone (370.4 kilometers [200 nautical miles]), and in state waters of Oregon and Washington, in waters depths of approximately 60 to 4,400 meters (197 to 14,436 feet). The survey will also take place in the Exclusive Economic Zone of Canada, and the territorial seas of Canada (off the coast of British Columbia).

All planned seismic data acquisition activities will be conducted by the National Science Foundation and researchers, with onboard assistance by technical staff and the marine operations group. The research vessel will be self-contained, and the scientific party and crew will live aboard the vessel for the entire seismic survey.

The R/V *Marcus G. Langseth* is tentatively planned to depart port on May 20, 2021, and return to port in July 2021. The first part of the action involves a support vessel deploying ocean bottom seismometers and nodes that will be used to record the seismic data. Ocean bottom seismometers are deployed using a boom over the side of the vessel, while ocean bottom nodes are deployed using a ROV. After that is completed, the seismic survey activities will begin on June 1st. The seismic survey will consist of a total of approximately 40 days, including approximately 37 days of airgun array operations, approximately two days of equipment deployment and retrieval, and approximately one day of transit. The R/V *Marcus G. Langseth* will depart and return to port in Astoria, Oregon. Some minor deviation from the dates is possible, depending on logistics and weather.

The National Science Foundation will use conventional seismic survey methodology and the procedures will be similar to those used during previous seismic surveys. Seismic survey protocols generally involve a predetermined set of tracklines. The seismic acquisition or sound source vessel travels down a linear trackline for some distance until a line of data is acquired, then turns and acquires data on a different trackline.

A maximum of approximately 6,540 kilometers (3,531 nautical miles) of tracklines will be surveyed in the Northeast Pacific Ocean (see Figure 1). The location of the tracklines may shift from what is depicted in Figure 1 depending on factors such as mechanical issues, poor data quality, weather, etc.

There will be additional airgun array operations in the seismic survey area associated with turns, airgun array testing, and repeat coverage of any areas where initial data quality is considered sub-standard by the project scientists. A section of a trackline may need to be repeated when data quality is poor or missing due to equipment failure (e.g., airgun array or towed hydrophone streamer problems, data acquisition system issues, research vessel issues) or shut-downs or ramp-ups for protected species.

3.1.2 Vessel Specifications

The seismic survey will involve one source vessel, the U.S.-flagged R/V *Marcus G. Langseth*. The R/V *Marcus G. Langseth* is owned by the National Science Foundation and operated by Columbia University's L-DEO under an existing Cooperative Agreement. The R/V *Marcus G. Langseth* has a length of 72 meters (235 feet), a beam of 17 meters (56 feet), and a maximum draft of 5.9 meters (19.4 feet). It is 2,842 gross tons. Its propulsion system consists of two diesel Bergen BRG-6 engines, each producing 3,550 horsepower, and an 800 horsepower bowthruster. The R/V *Marcus G. Langseth*'s design is that of a seismic research vessel, with a particularly quiet propulsion system to avoid interference with the seismic signals. The operating speed during seismic data acquisition is typically approximately 8 kilometers per hour (4.3 to 4.5 knots). During the two-dimensional seismic survey, the vessel speed will be approximately 7.8 kilometers per hour (4.2 knots) and approximately 8.3 kilometers per hour (4.5 knots) during the three-dimensional seismic survey. When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically cruises at 18.5 kilometers per hour (10 knots) and has a range of approximately 13,500 kilometers (7,289.4 nautical miles). No chase vessel will be used during seismic survey activities. The R/V *Marcus G. Langseth* will also serve as the platform from which vessel-based protected species observers (PSOs) (acoustic and visual) will listen and watch for animals (e.g., marine mammals and sea turtles).

The proposed seismic survey will also use a second vessel, the U.S.-flagged R/V *Oceanus*, to deploy the ocean-bottom seismometers and ocean-bottom nodes. The R/V *Oceanus* is owned by the National Science Foundation, and operated by the Oregon State University. R/V *Oceanus* has a length of 54 meters (177 feet), a beam of 10 meters (33 feet), and a draft of 5.3 meters (17.4 feet). Its gross tonnage is 261. The ship is powered by one electromotive diesel engine, producing 3,000 horsepower, which drives the single screw propeller. The vessel also has a 350 horsepower bowthruster. The cruising speed is 20 kilometers per hour, the endurance is 30 days, and the range is approximately 13,000 kilometers.

3.1.3 Airgun Array and Acoustic Receivers' Description

The energy source for the seismic survey was chosen by the National Science Foundation to be the lowest practical to meet the scientific objectives.

During the seismic survey, the R/V *Marcus G. Langseth* will deploy an airgun array (i.e., a certain number of airguns of varying sizes in a certain arrangement) as an energy source. An airgun is a device used to emit acoustic energy pulses downward through the water column and into the seafloor, and generally consists of a steel cylinder that is charged with high-pressure air. Release of the compressed air into the water column generates a signal that reflects (or refracts) off the seafloor and/or sub-surface layers having acoustic impedance contrast. When fired, a brief (approximately 0.1 second) pulse of sound is emitted by all airguns nearly simultaneously. The airguns are silent during the intervening periods with the array typically fired on a fixed distance (or shot point) interval. The return signal is recorded by a listening device (e.g., receiving system) and later analyzed with computer interpretation and mapping systems used to depict the sub-surface. In the proposed action, the receiving system will consist of the towed hydrophone array, and the ocean bottom seismometers and nodes.

The R/V *Marcus G. Langseth* will deploy a 15-kilometer towed hydrophone streamer and an airgun array to conduct the two-dimensional multi-channel seismic survey. Ocean bottom seismometers and ocean bottom nodes would be deployed by a second vessel, the R/V *Oceanus*, and retrieved by a ROV. The ocean bottom seismometers and ocean bottom nodes would receive and store the returning acoustic signals; data will be analyzed later after the devices are retrieved.

The airgun array for the two-dimensional seismic survey will consist of 36 Bolt airguns (plus four spares) with a total discharge volume of 108,154.6 cubic centimeters (6,600 cubic inches [in^3]) (Table 1). The airguns will be configured as four identical linear arrays or "strings". The four airgun strings will be towed behind the R/V *Marcus G. Langseth* and will be distributed across an area approximately 24 meters (78.7 feet) by 16 meters (52.5 feet). The shot interval will be approximately 16 to 17 seconds (approximately every 37.5 meters [123 feet]). The firing pressure of the airgun array will be approximately 1,900 pounds per square inch (psi) (plus or minus 100 psi). The four airgun strings will be towed approximately 30 meters (98 feet) behind the vessel at a tow depth of 12 meters (39.4 feet). Other source array specifications such as source output (underwater decibels referenced to one micropascal at one meter [root mean squared; dB re 1µPa-m]), pulse duration, and dominant frequency components in Table 1.

It is expected that the airgun array will be active 24 hours per day during the seismic survey (except for the area described in Section 3.1.5.6, Figure 2), where airgun operations will occur during daylight hours only). Airguns will operate continually during the seismic survey period except for unscheduled shut-downs.

Table 1. Source array and survey specifications for the proposed two-dimensional seismic survey over the Cascadia Subduction Zone in the Northeast Pacific Ocean.

Source array specifications	
Energy source	36 Bolt 40 to 360-in^3 air guns 4 strings
Source output (downward)-36 air gun array	Zero to peak = 258 dB re 1 µPa-m Peak to peak = 264 dB re 1 µPa-m
Air discharge volume	~ 6,600-in^3
Pulse duration	0.1 second
Shot interval	37.5 m
Dominant frequency components	2 to 188 hertz

Source array specifications	
Tow depth	12-meters
Sound source velocity (tow speed)	4.2 knots (7.8 kilometers per hour)

The receiving system will consist of a single 15-kilometer (8.1 nautical miles) long towed hydrophone streamer (for the two-dimensional seismic survey), and ocean bottom seismometers and ocean bottom nodes. Surveys in the 1980s and 1990s used much shorter streamers (2.6 to 4 kilometers long), which provided rather poor quality sources of data. The most recent NSF seismic survey of the Cascadia Subduction Zone, which took place in 2012, used an 8-kilometer hydrophone streamer. A longer hydrophone streamer, like the one proposed for this action, provides opportunities to suppress unwanted energy that interferes with imaging targets, allows for accurate measurements of seismic velocities, and provides a large amount of data redundancy for enhancing seismic images during data processing. As the airgun array is towed along the tracklines, the hydrophone streamer will receive the returning acoustic signals and transfer the data to the onboard processing system. The ocean bottom seismometers and nodes will receive and store the returning acoustic signals internally for later analysis.

During the seismic survey, the R/V *Oceanus* will deploy up to 115 ocean bottom seismometers, and up to 350 ocean bottom nodes (Figure 1). The ocean bottom seismometers and nodes would be placed along lines perpendicular to the multi-channel seismic margin survey lines (see Figure 1). The ocean bottom seismometers will be deployed in two phases: once by the R/V *Oceanus* off Oregon, prior to the start of the proposed survey, and the second deployment off Vancouver Island and Washington, so the R/V *Marcus G. Langseth* can survey the northern portion of the survey area. Sixty ocean bottom seismometers placed every 10 kilometers (6.2 miles) would be deployed off Oregon, and 55 ocean bottom seismometers placed every 500 meters (1,640.4 feet) off Washington and Vancouver Island. The ocean bottom seismometers would be recovered by the R/V *Oceanus*. Ocean bottom seismometers have a height and diameter of 1 meter, and an 80-kilogram (176.4 pound) steel anchor. Three ocean bottom seismometers deployed in the Olympic Coast National Marine Sanctuary would use 20-kilogram (44 pounds) concrete anchors.

To retrieve an ocean bottom seismometer placed on the sea floor, an acoustic release transponder (pinger) transmits a signal to the instrument at a frequency of 8 to 11 kilohertz and a response is received at a frequency of 11.5 to 13 kilohertz (operator selectable) to activate and release the instrument. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 decibels. The pulse duration is two milliseconds (±10 percent) and the pulse repetition rate is one per second (±50 microseconds). The transponder will trigger the burn-wire assembly that releases the instrument from the anchor on the sea floor and the device floats to the surface. The anchor for the ocean bottom seismometer is scuttled and left on the sea floor.

The ocean bottom nodes would be deployed in three locations off Oregon; 179 deployed off northern Oregon, 107 deployed off central Oregon, and another 64 deployed off southern

Oregon. ROVs will be involved in the deployment and retrieval of the ocean bottom nodes. Unlike ocean bottom seismometers, ocean bottom nodes are small, compact, not buoyant, and do not have an anchor-release mechanism. As such, the ocean bottom nodes would be deployed and retrieved by a ROV controlled from the R/V *Oceanus*.

The ROV would have a skid capable of holding 31 units. The skid would be lowered to 5 to 10 meters (16.4 to 32.8 feet) above the seafloor, and towed at a speed of 0.6 knots (1.1 kilometers per hour). The ROV would deploy the ocean bottom nodes from the skid one at a time.

Ocean bottom nodes would be deployed 17 days before the R/V *Marcus G. Langseth* begins the survey. The ROV would retrieve the ocean bottom nodes 3 days after the survey ends.

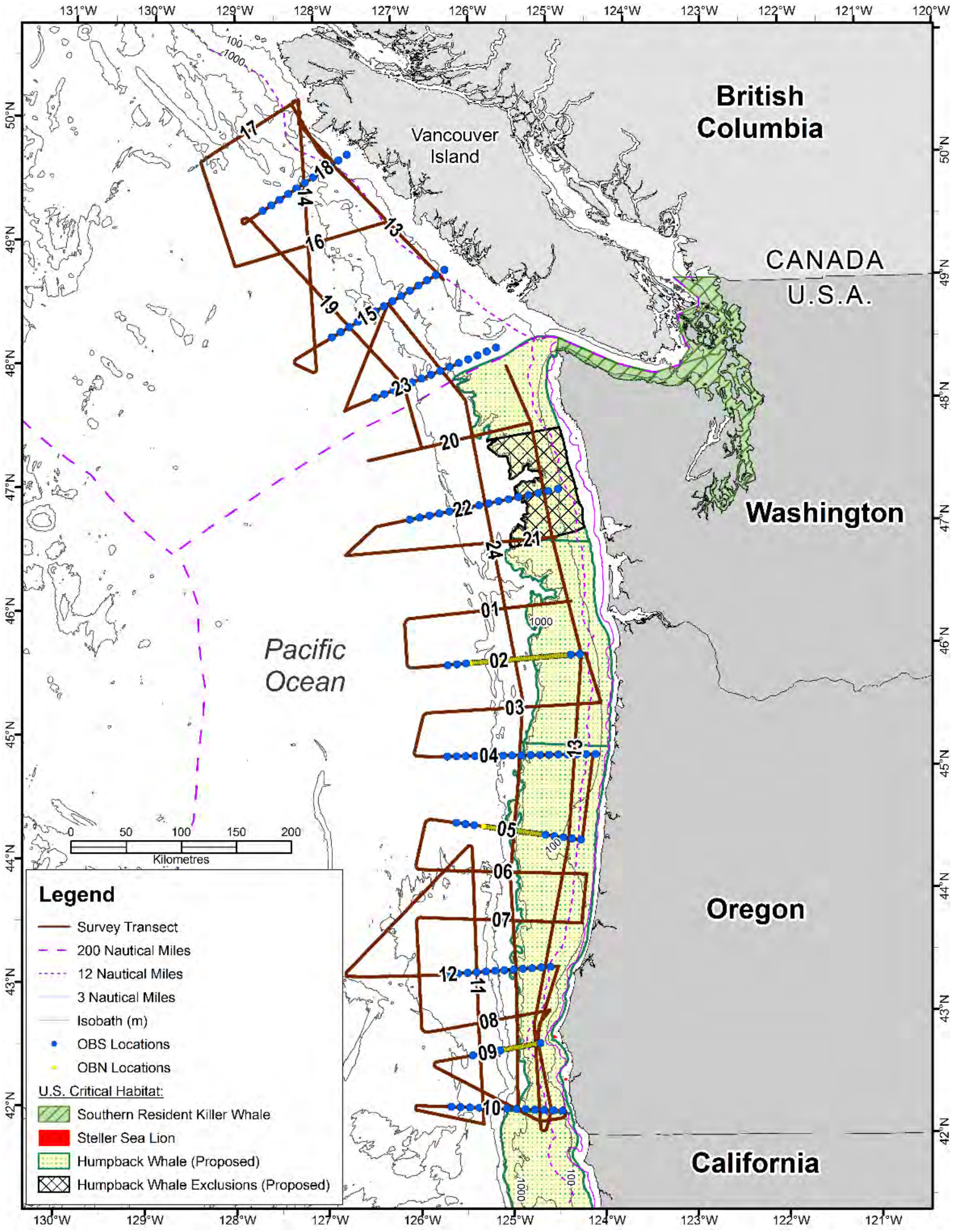

Figure 1. Action area map with locations of ocean bottom nodes and seismometers.

3.1.4 Multi-Beam Echosounder and Sub-Bottom Profiler

Along with operations of the airgun array, three additional acoustical data acquisition systems will operate during the seismic survey from the R/V *Marcus G. Langseth*. The Kongsberg EM 122 multi-beam echosounder and Knudsen Chirp 3260 sub-bottom profiler will map the ocean floor during the seismic survey. The multi-beam echosounder and sub-bottom profiler sound sources will operate continuously from the R/V *Marcus G. Langseth*, including simultaneously with the airgun array, but not during transit to and from the seismic survey area.

3.1.4.1 Multi-Beam Echosounder

The ocean floor will be mapped with the Kongsberg EM122 multi-beam echosounder. The multi-beam echosounder is a hull-mounted system operating at 10.5 to 13 (usually 12) kilohertz. The transmitting beamwidth is one or two degrees fore-aft and 150 degrees (maximum) athwartship (i.e., perpendicular to the ship's line of travel). The maximum sound source level is 242 dB re: 1 µPa-m. Each ping consists of eight (in water greater than 1,000 meters [3,281 feet]) or four (in water less than 1,000 meters [3,281 feet]) successive fan-shaped transmissions, each ensonifying a sector that extends one degree fore-aft. Continuous-wave signals increase from 2 to 15 milliseconds long in water depths up to 2,600 meters (8,530 feet) and frequency modulated chirp signals up to 100 milliseconds long are used in water greater than 2,600 meters (8,530 feet). The successive transmissions span an overall cross-track angular extent of about 150 degrees, with two millisecond gaps between the pings for successive sectors.

3.1.4.2 Sub-Bottom Profiler

The ocean floor will also be mapped with the Knudsen 3260 sub-bottom profiler. The sub-bottom profiler is normally operated to provide information about the near sea floor sedimentary features and the bottom topography that is mapped simultaneously by the multi-beam echosounder. The beam is transmitted as a 27-degree cone, which is directed downward by a 3.5-kilohertz transducer in the hull of the R/V *Marcus G. Langseth*. The nominal power output is 10 kilowatts, but the actual maximum radiated power is 3 kilowatts or 222 dB re: 1 µPa at 1 meter rms. The ping duration is up to 64 milliseconds, and the ping interval is one second. A common mode of operation is to broadcast five pulses at one-second intervals followed by a five-second pause. The sub-bottom profiler is capable of reaching depths of 10,000 meters (32,808.4 feet).

3.1.5 Proposed Conservation Measures

The National Science Foundation and L-DEO are obligated to enact mitigation measures to have their action result in the least practicable adverse impact on marine mammal species or stocks under the MMPA, which may also reduce the likelihood of adverse effects to ESA-listed marine species or adverse effects on their designated critical habitats. Monitoring is used to observe or check the progress of the mitigation over time and can also be used to ensure that any measures implemented to reduce or avoid adverse effects on ESA-listed species are successful.

The NMFS Permits and Conservation Division will require, and the National Science Foundation and L-DEO will implement, the mitigation and monitoring measures listed below. These mitigation and monitoring measures are required during the seismic survey to reduce the potential for injury to or harassment of marine mammals and sea turtles. For sea turtles, the National Science Foundation included conservation measures as part of its proposed action, namely an exclusion zone and shut down procedures. Additional details for each mitigation and monitoring measure are described in subsequent sections of this opinion, specifically:

- Proposed exclusion and buffer zones;
- Power-down procedures;

- Shut-down procedures;
- Ramp-up procedures;
- Visual monitoring by NMFS-approved PSOs;
- Passive acoustic monitoring;
- Vessel strike avoidance measures; and
- Additional mitigation measures.

Additional details on the other MMPA mitigation and monitoring measures (e.g., power-down, shut-down, and ramp-up procedures) can be found in NMFS Permits and Conservation Division *Federal Register* notice of proposed incidental harassment authorization and request for comments on proposed incidental authorization and possible renewal (85 FR 19580; April 7, 2020) and Appendix A.

3.1.5.1 Proposed Exclusion and Buffer Zones – Ensonified Area

The NMFS Permits and Conservation Division will require, and the National Science Foundation and L-DEO will implement, exclusion zones around the R/V *Marcus G. Langseth* to minimize any potential adverse effects of the sound from the airgun array on MMPA and ESA-listed sea turtles. The National Science Foundation included measures for sea turtles as part of its proposed action. The exclusion zones are areas within which occurrence of a marine mammal or sea turtle triggers a power-down or shutdown of the airgun array, to reduce exposure of marine mammals or sea turtles to sound levels expected to have adverse effects on the species. These exclusion zones are based upon modeled sound levels at various distances from the R/V *Marcus G. Langseth*, and correspond to the respective species' sound thresholds for potential injury and behavioral effects to MMPA and ESA-listed species.

Ensonified Area

The L-DEO model results are used to determine the 160 dB re: 1 µPa (rms) radius for single 40 cubic inch airgun array and 36 airgun array in shallow (less than 100 meters (328 feet) deep), intermediate (100 to 1,000 meters deep), and deep water (greater than 1,000 meters [3,280.8 feet]). This sound level was chosen because it corresponds to the distance at which Level B harassment under the MMPA occurs. Received sound levels were predicted by L-DEO's model (Diebold et al. 2010), which uses ray tracing for the direct wave traveling from the airgun array to the receiver and its associated source ghost (i.e., reflection at the air-water interface in the vicinity of the airgun array), in a constant-velocity half-space (infinite homogeneous ocean layer, unbounded by a seafloor).

Measurements have not been reported for the single 40 cubic inch airgun array. The L-DEO model results are used to determine the 160 dB re: 1 µPa (rms) radius for the single 40 cubic inch airgun array at a tow depth of 12 meters (39.4 feet) in shallow, intermediate, and deep water. The estimated distances to the 160 dB re: 1 µPa (rms) isopleths for the single 40 cubic inch airgun array and 36-airgun array are in Table 2.

Table 2. Predicted distances to which sound levels of 160 dB re: 1 μPa (rms) for Marine Mammal Protection Act Level B harassment for impulsive sources will be received from the single 40 cubic inch airgun and the 36-airgun array in shallow, intermediate, and deep water depths for marine mammals during the proposed seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (160 dB re: 1 μPa [rms]) (m)
1 Airgun	40	<100	1,041
		100 to 1,000	647
		>1,000	431
36 Airguns	6,600	<100	12,650
		100 to 1,000	9,648
		>1,000	6,733

in^3=cubic inches
m=meters

The National Science Foundation will implement an exclusion zone for sea turtles. An exclusion zone of 100 meters will be used as a shutdown distance for sea turtles (see Section 10.2.2.2 below). This distance is practicable for PSOs to implement shutdowns, and is sufficiently large to prevent sea turtles from being exposed to sound levels that could result in PTSThe buffer zone will correspond to the predicted 175 dB re: 1 μPa (rms) behavioral threshold distances to which sound source levels will be received from the single airgun array and 36 airgun array in shallow, intermediate, and deep water depths described in Table 3.

Table 3. Predicted distances to which sound levels of 175 dB re: 1 μPa (rms) will be received from the single 40 cubic inch airgun and the 36-airgun array in shallow, intermediate, and deep-water depths for sea turtles during the proposed seismic survey in the Northeast Pacific Ocean.

Source	Volume (in^3)	Water Depth (m)	Predicted Distance to Threshold (175 dB re: 1 μPa [rms]) (m)
1 Airgun	40	<100	170
		100 to 1,000	116

		>1,000	77
36 Airguns	6,600	<100	3,924
		100 to 1,000	2,542
		>1,000	1,864

in^3=cubic inches

m=meters

Note: The National Science Foundation and L-DEO will use a 100 meter exclusion zone in all water depths for the 36 airgun array as the shut-down distance for sea turtles.

Establishment of Proposed Exclusion and Buffer Zones

An exclusion zone is a defined area within which occurrence of an animal triggers mitigation action intended to reduce the potential for certain outcomes (e.g., auditory injury, disruption of critical behaviors). For marine mammals, PSOs will establish a default (minimum) exclusion zone with a 500 meter (1,640.4 feet) radius for visual monitoring for the 36-airgun array. The 500 meter (1,640.4 feet) exclusion zone will be based on the radial distance from any element of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). With certain exceptions (described below), if a marine mammal appears within, enters, or appears on course to enter this zone, the airgun array will be powered-down or shut-down, depending on the circumstance. As stated earlier, for sea turtles, NSF will established an exclusion zone of 100 meters (328 feet), with the buffer zone corresponding to the distance to the 175 dB threshold.

The buffer zone means an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone. The buffer zone encompasses the area at and below the sea surface from the edge of the zero to 100-meter (zero to 328 feet; for sea turtles), zero to 500-meter (zero to 1,640.4 feet; for marine mammals) exclusion zone, out to a radius of 1,000 meters (3,280.8 feet) from the edges of the airgun array (500 to 1,000 meters [1,640.4 to 3,280.8 feet]).

The 500 meter (1,640.4 feet) exclusion zone for marine mammals is intended to be precautionary in the sense that it will be expected to contain sound exceeding the injury criteria for all cetacean hearing groups (based on the dual criteria of the cumulative sound exposure level ($\mathrm{SEL_{cum}}$) and peak sound pressure level (SPL)), while also providing a consistent, reasonably observable zone within which PSOs will typically be able to conduct effective observations. Additionally, a 500 meter (1,640.4 feet) exclusion zone is expected to minimize the likelihood that marine mammals will be exposed to levels likely to result in more severe behavioral responses. Although significantly greater distances may be observed from an elevated platform under good conditions, the NMFS Permits and Conservation Division believes that 500 meters (1,640.4 feet) is likely regularly attainable for PSOs using the naked eye during typical conditions.

The National Science Foundation's draft environmental analysis and L-DEO's incidental harassment authorization application have a detailed description of the modeling for the R/V

Marcus G. Langseth's airgun arrays, as well as the resulting isopleths to thresholds for the various marine mammal hearing groups and sea turtles (Tables 2-3). Predicted distances to MMPA Level A harassment isopleths, which vary based on marine mammal hearing groups, were calculated based on modeling performed by L-DEO using the NUCLEUS software program and the NMFS User Spreadsheet (https://www.fisheries.noaa.gov/action/user-manual-optional-spreadsheet-tool-2018-acoustic-technical-guidance; Table 4).

Table 4. Predicted distances to permanent threshold shift thresholds for impulsive sources for various marine mammal hearing groups and sea turtles that could be received from the single airgun as well as the 36-airgun arrays during the proposed seismic survey in the Northeast Pacific Ocean.

Threshold	Low Frequency Cetaceans (m)	Mid Frequency Cetaceans (m)	High Frequency Cetaceans (m)	Phocid Pinnipeds (m)	Otariid Pinnipeds (m)	Sea Turtles (m)
Source – 1 Airgun						
SEL_{cum}	0.5	0	0	0	0	0
Peak SPL_{flat}	1.76	0.51	12.5	1.98	0.4	0
Source – 36 Airgun Array						
SEL_{cum}	426.9	0	1.3	13.9	0	20.5
Peak SPL_{flat}	38.9	13.6	268.3	43.7	10.6	10.6

m=meters

3.1.5.2 Shut-Down and Power-Down Procedures

The shutdown of the airgun array requires the immediate deactivation of all individual elements of the airgun array while a power-down of the airgun array requires the immediate deactivation of all individual elements of the airgun array except the single 40 cubic inch airgun. Any protected species observer on duty will have the authority to delay the start of seismic survey activities or to call for shutdown or power-down of the airgun array if a marine mammal or sea turtle is detected within the applicable exclusion zone. The operator must also establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the airgun array to ensure that shutdown and power-down commands are conveyed swiftly while allowing PSOs to maintain watch. When both visual and acoustic PSOs are on duty, all detections will be immediately communicated to the remainder of the on-duty protected species observer team for potential verification of visual observations by the acoustic protected species observer or of acoustic detections by visual PSOs. When the airgun array is active (i.e., anytime one or more airgun is active, including during ramp-up and power-down) and (1) a marine mammal appears within or enters the applicable exclusion zone and/or (2) a marine mammal (other than delphinds) is detected acoustically and localized within the applicable exclusion zone, the airgun array will be shut-down. When shutdown is called for by a protected species observer, the airgun array will be immediately deactivated and any dispute resolved only following deactivation. Additionally, shut-down will occur whenever passive acoustic monitoring alone (without visual sighting), confirms presence of marine mammal(s) or sea turtle(s) in the exclusion zone. If the acoustic protected species observer cannot confirm presence within the exclusion zone, visual PSOs will be notified but shutdown is not required.

Following a shutdown, the airgun array activity will not resume until the animal has cleared the exclusion zone – the 500 meter (1,640.4 feet) exclusion zone in the case of marine mammals or 100-meter exclusion zone in the case of sea turtles. For marine mammals, the animal will be considered to have cleared the 500 meter exclusion zone if it is visually observed to have departed the 500 meter exclusion zone, or it has not been seen within the 500 meter exclusion zone, or if has not been seen within the 500 meter exclusion zone for 15 minutes in the case of small odontocetes and pinnipeds, or 30 minutes in the case of mysticetes and large odontocetes, including sperm whales. For sea turtles, the animal is considered to have cleared the 100-meter exclusion zone if it is visually observed to have departed the 100-meter exclusion zone, or it has not been seen in the 100-meter exclusion zone for 15 minutes.

Power-down conditions will be maintained (except for delphinids for which shut-down is waived) until marine mammals are no longer observed within the 500 meter exclusion zone, or sea turtles are no longer observed within the 100 meter exclusion zone, following which full-power operations may be resumed without ramp-up.

A large body of anecdotal evidence indicates that small delphinoids commonly approach vessels and/or towed airgun arrays during active sound production for purposes of bow riding, with no apparent effect observed in those delphinoids (Barkaszi et al. 2012b). The potential for increased shut-downs resulting from such a measure will require the R/V *Marcus G. Langseth* to revisit the missed trackline to re-acquire data, resulting in an overall increase in the total sound energy input to the marine environment and an increase in the total duration over which the seismic survey activities is active in a given area. Although other mid-frequency hearing specialists (e.g., large delphinoids) are no more likely to incur auditory injury than are small delphinoids, they are much less likely to approach vessels. Therefore, retaining a power-down and/or shut-down requirement for large delphinoids will not have similar impacts in terms of either practicability for the applicant or corollary increase in sound energy output and time on the water. The NMFS Permits and Conservation Division anticipates some benefit for a power-down and/or shut-down requirement for large delphinoids in that it simplifies somewhat the total range of decision-making for PSOs and may preclude any potential for physiological effects other than to the auditory system, as well as some more severe behavioral reactions for any such animals in close proximity to the sound source vessel.

Visual PSOs will use best professional judgement in making the decision to call for a shut-down if there is uncertainty regarding identification (i.e., whether the observed marine mammal[s] belongs to one of the delphinid genera for which shut-down is waived or one of the species with a larger exclusion zone). If PSOs observe any behaviors in a small delphinid for which shutdown is waived that indicate an adverse reaction, then power-down will be initiated immediately.

In addition to the shutdown and power-down procedures described above, the NMFS Permits and Conservation Division's MMPA incidental harassment authorization will require shutdowns if:

- Any ecotype of killer whale is visually observed at any distance.
- A killer whale is acoustically detected during passive acoustic monitoring.
- Any large whale (defined as a sperm whale or any mysticete [baleen whale]) species with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult) is observed at any distance.
- An aggregation of six or more large whales is observed at any distance.
- A North Pacific right whale is observed at any distance.

3.1.5.3 Pre-Clearance and Ramp-Up Procedures

Ramp-up (sometimes referred to as "soft-start") means the gradual and systematic increase of emitted sound levels from an airgun array. Ramp-up begins by first activating a single airgun of the smallest volume, followed by doubling the number of active elements in stages until the full complement of an airgun array are active. Each stage will be approximately the same duration, and the total duration will not be less than approximately 20 minutes. The intent of pre-clearance observation (30 minutes) is to ensure no protected species are observed within the buffer zone prior to the beginning of ramp-up. During pre-clearance is the only time observations of protected species in the buffer zone will prevent operations (i.e., the beginning of ramp-up). The intent of ramp-up is to warn protected species of pending seismic survey activities and to allow sufficient time for those animals to leave the immediate vicinity. A ramp-up procedure, involving a step-wise increase in the number of airguns firing and total airgun array volume until all operational airguns are activated and the full volume is achieved, is required at all times as part of the activation of the airgun array. All operators must adhere to the following pre-clearance and ramp-up requirements:

- The operator must notify a designated protected species observer of the planned start of ramp-up as agreed upon with the lead protected species observer; the notification time will not be less than 60 minutes prior to the planned ramp-up in order to allow the protected species observer time to monitor the exclusion and buffer zones for 30 minutes prior to the initiation of ramp-up (pre-clearance);
- Ramp-ups will be scheduled so as to minimize the time spent with the airgun array activated prior to reaching the designated run-in;

- One of the PSOs conducting pre-clearance observations must be notified again immediately prior to initiating ramp-up procedures and the operator must receive confirmation from the protected species observer to proceed;
- Ramp-up may not be initiated if any marine mammals or sea turtle is within the applicable exclusion or buffer zone. If a marine mammal or sea turtle is observed within the applicable exclusion zone or the buffer zone during the 30 minute pre-clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zones or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and sea turtles) and 30 minutes for all other species (e.g. marine mammals).
- Ramp-up will begin by activating a single airgun array of the smallest volume in the airgun array and will continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration will not be less than 20 minutes. The operator must provide information to the protected species observer documenting that appropriate documenting that appropriate procedures were followed;
- PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the airgun array must be shutdown upon observation of a marine mammal or sea turtle within the applicable exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shut-down or power-down, but such observation will be communicated to the operator to prepare for the potential shut-down or power-down;
- Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up. Airgun array activation may only occur at times of poor visibility where operational planning cannot reasonably avoid such circumstances;
- If the airgun array is shut-down for brief periods (i.e., less than 30 minutes) for reasons other than that described for shut-down and power-down (e.g., mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or passive acoustic monitoring and no visual or acoustic detections of marine mammals or sea turtles have occurred within the applicable exclusion zone. For any longer shutdown, pre-clearance observation and ramp-ups are required. For any shut-down at night or in periods of poor visibility (e.g., Beaufort sea state 4 or greater), ramp-up is required, but if the shut-down period was brief and constant observation was maintained, pre-clearance watch of 30 minutes is not required; and
- Testing of the airgun array involving all elements requires ramp-up. Testing limited to individual elements or strings of the airgun array does not require ramp-up but does require pre-clearance of 30 minutes.

3.1.5.4 Vessel-Based Visual Mitigation Monitoring

Visual monitoring requires the use of trained PSOs to scan the ocean surface visually for the presence of marine mammals or sea turtles. The area to be scanned visually includes primarily the exclusion zone (0 to 500 meters), but also the buffer zone. As described above, the buffer zone is an area beyond the exclusion zone to be monitored for the presence of marine mammals and sea turtles that may enter the exclusion zone. During pre-clearance monitoring (i.e., before ramp-up begins), the buffer zone also acts as an extension of the exclusion zone in that observations of marine mammals and sea turtles within the buffer zone will also prevent airgun array operations from beginning (i.e., ramp-up). Visual monitoring of the exclusion zone and adjacent waters is intended to establish and, when visual conditions allow, maintain zones around the sound source that are clear of marine mammals and sea turtles, thereby reducing or eliminating the potential for injury and minimizing the potential for more severe behavioral reactions for animals occurring close to the vessel. Visual monitoring of the buffer zone is intended to (1) provide additional protection to naïve marine mammals that may be in the area during pre-clearance; and (2) during use of the airgun array, aid in establishing and maintaining the exclusion zone by alerting the visual protected species observer and crew of marine mammals and sea turtles that are outside of, but may approach and enter, the exclusion zone.

The National Science Foundation and L-DEO must use at least five dedicated, trained, NMFS-approved PSOs. The PSOs must have no tasks other than to conduct observational effort, record observational data, and communicate with and instruct relevant vessel crew with regard to the presence of marine mammals and sea turtles and mitigation requirements. The PSO resumes shall be provided to NMFS for approval.

At least one of the visual and two of the acoustic PSOs aboard the vessel must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration (i.e., high-energy) seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience. One visual protected species observer with such experience shall be designated as the lead for the entire protected species observer team. The lead protected species observer shall serve as the primary point of contact for the vessel operator and ensure all protected species observer requirements per the MMPA incidental harassment authorization are met. To the maximum extent practicable, the experienced PSOs will be scheduled to be on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

During seismic survey activities (e.g., any day on which use of the airgun array is planned to occur, and whenever the airgun array is in the water, whether activated or not), a minimum of two visual PSOs must be on duty and conducting visual observations at all times during daylight hours (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during nighttime ramp-ups of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the airgun array ceases or until 30 minutes past sunset. Visual PSOs shall coordinate to ensure 360-degree visual coverage around the vessel from the most appropriate observation posts, and shall conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner.

The PSOs will establish and monitor the buffer and exclusion zones. The buffer and exclusion zones will be based upon the radial distance from the edges of the airgun array (rather than being based on the center of the airgun array or around the vessel itself). During use of the airgun array (i.e., anytime the airgun array is active, including ramp-up), occurrences of marine mammals and sea turtles within the buffer zone (but outside the exclusion zone) will be communicated to the operator to prepare for the potential shutdown or power-down for the airgun array.

Visual PSOs will immediately communicate all observations to the on-duty acoustic protected species observer(s), including any determination by the protected species observer regarding species identification, distance, and bearing and the degree of confidence in the determination. Any observations of marine mammals and sea turtles by crewmembers will be relayed to the protected species observer team. During good conditions (e.g., daylight hours, Beaufort sea state three or less), visual PSOs will conduct observations when the airgun array is not operating for comparison of sighting rates and behavior with and without use of the airgun array and between acquisition periods, to the maximum extent practicable. Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties (visual and acoustic, but not at the same time) may not exceed 12 hours per 24-hour period for any individual protected species observer.

3.1.5.5 Passive Acoustic Monitoring

Passive acoustic monitoring means the use of trained personnel operators herein referred to as acoustic PSOs to operate passive acoustic monitoring equipment to acoustically detect the presence of marine mammals. Passive acoustic monitoring involves acoustically detecting marine mammals, regardless of distance from the airgun array, as localization of animals may not always be possible. Passive acoustic monitoring is intended to further support visual monitoring (during daylight hours) in maintaining an exclusion zone around the airgun array that is clear of marine mammals. In cases where visual monitoring is not effective (e.g., due to weather, nighttime), passive acoustic monitoring may be used to allow certain activities to occur, as further detailed below.

Passive acoustic monitoring will take place in addition to the visual monitoring program. Visual monitoring typically is not effective during periods of poor visibility or at night, and even with good visibility, is unable to detect marine mammals when they are below the surface or beyond visual range. Passive acoustic monitoring can be used in addition to visual observations to improve detection, identification, and localization of cetaceans. The passive acoustic monitoring will serve to alert visual PSOs (if on duty) when vocalizing cetaceans are detected. It is only useful when marine mammals call, but it can be effective either by day or night, and does not depend on good visibility. It will be monitored in real time so that the visual PSOs can be advised when cetaceans are detected.

The R/V *Marcus G. Langseth* will use a towed passive acoustic monitoring system, which must be monitored by a minimum one on-duty acoustic protected species observer beginning at least 30 minutes prior to ramp-up and at all times during use of the airgun array. Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period for any individual protected species observer.

Seismic survey activities may continue for 30 minutes when the passive acoustic monitoring system malfunctions or is damaged, while the passive acoustic monitoring operator diagnoses the issue. If the diagnosis indicates that the passive acoustic monitoring system must be repaired to solve the problem, operations may continue for an additional five hours without passive acoustic monitoring during daylight hours only under the following conditions:

- Beaufort sea state is less than or equal to four;
- No marine mammals (excluding delphinids) detected solely by passive acoustic monitoring in the applicable exclusion zone in the previous two hours;
- NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active passive acoustic monitoring system; and
- Operations with an active airgun array, but without an operating passive acoustic monitoring system, do not exceed a cumulative total of four hours in any 24-hour period.

The passive acoustic monitoring system will be used to implement shutdown requirements if killer whale vocalizations are detected, regardless of localization.

3.1.5.6 Operational Restrictions

While the R/V *Marcus G. Langseth* is surveying in waters 200 meters deep or less along the coast between Tillamook Head, Oregon and Barkley Sound, British Columbia (between latitudes 45.9460903° N and 48.780291° N), and within the boundaries of Olympic Coast National Marine Sanctuary, in the areas noted in Figure 2, survey operations will occur in daylight hours only (i.e., from 30 minutes prior to sunrise through 30 minutes following sunset). This is to ensure that PSOs are able to visually observe the entire 500-meter exclusion zone and beyond to implement shutdown procedures for species or situations with additional shutdown requirements outlined above (e.g., killer whale of any ecotype, aggregation of six or more large whales, and large whale with a calf). This particular area was selected because of the predicted density of Southern Resident killer whales in the coastal waters off Washington (see 9.3.1.1 for more details). In other locations throughout the survey area, airgun operations may occur 24 hours per day.

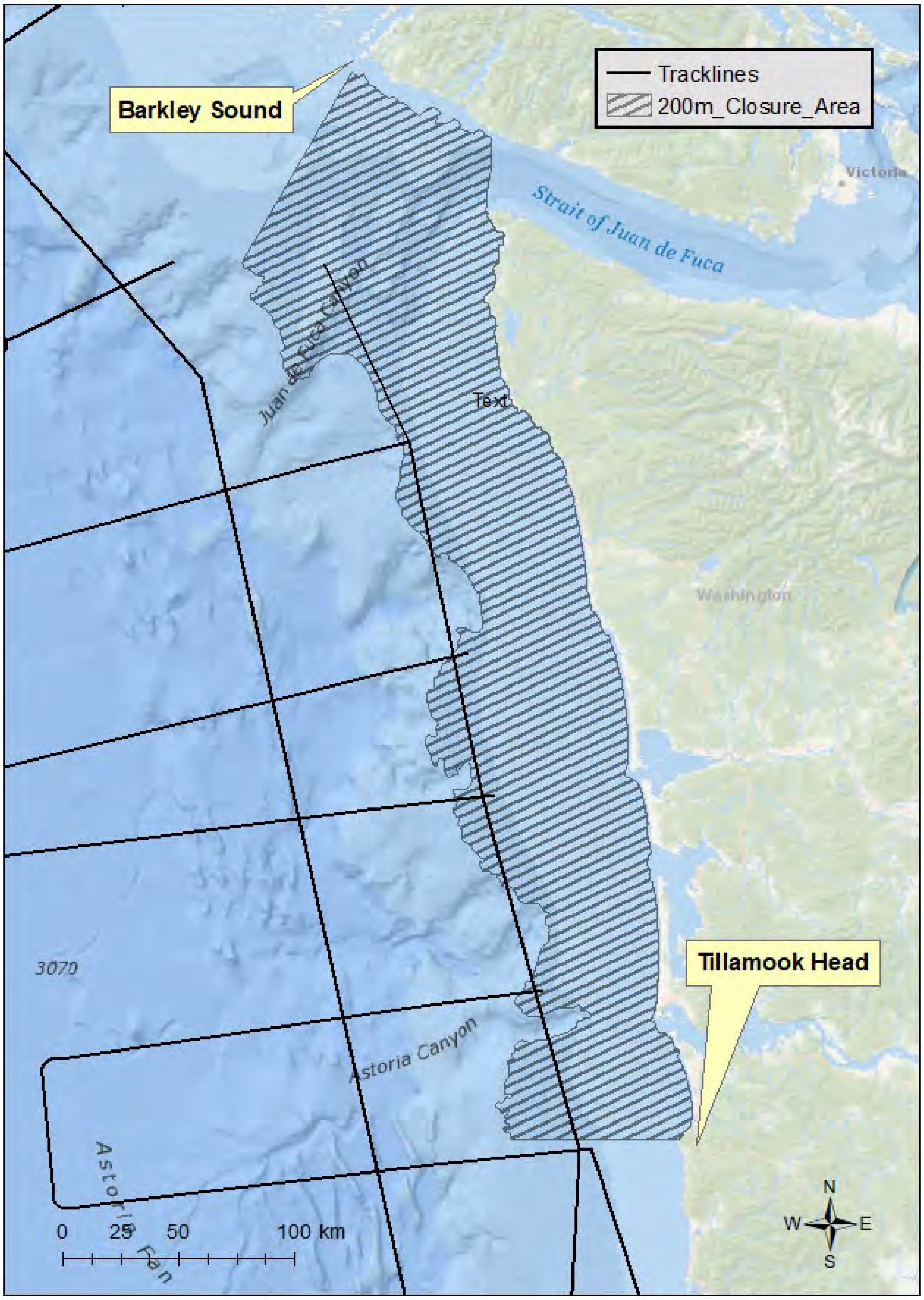

Figure 2. Map of the 200-meter depth exclusion area.

3.1.5.7 Communication

The L-DEO will communicate daily with NMFS Northwest Fisheries Science Center, NMFS West Coast Region, The Whale Museum, Orca Network, Canada's Division of Fisheries and Ocean and/or other sources for near real-time reporting for the whereabouts of Southern Resident killer whales.

3.1.5.8 Vessel Strike Avoidance

Vessel strike avoidance measures are intended to minimize the potential for collisions with marine mammals and sea turtles. The vessel strike avoidance measures apply to all vessels associated with the planned seismic survey activities. NMFS Permits and Conservation Division notes that these requirements do not apply in any case where compliance will create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply. These measures include the following:

- The vessel operator (R/V *Marcus G. Langseth*) and crew will maintain a vigilant watch during daylight hours for all marine mammals and sea turtles and slow down, stop, or alter the course of the vessel, as appropriate and regardless of vessel size, to avoid striking any marine mammal and sea turtle during seismic survey activities as well as transits. A single marine mammal at the surface may indicate the presence of submerged animals in the vicinity of the vessel; therefore, precautionary measures should be exercised when an animal is observed. A visual observer aboard the vessel will monitor a vessel strike avoidance zone around the vessel, to ensure the potential for vessel strike is minimized, according to the parameters stated below. Visual observers monitoring the vessel strike avoidance zone can be either third-party PSOs or crew members, but crew members responsible for these duties will be provided sufficient training to distinguish marine mammals and sea turtles from other phenomena and broadly to identify marine mammals and sea turtles to broad taxonomic group (i.e., as a large whale or other marine mammal).
- Vessel speeds must be reduced to 18.5 kilometers per hour (10 knots) or less when mother/calf pairs, pods, or large assemblages of marine mammals are observed near the vessel.
- The vessel (R/V *Marcus G. Langseth*) will maintain a minimum separation distance of 100 meter (328.1 feet) from large whales (i.e., all baleen whales and sperm whales).
- The vessel will maintain a minimum separation distance of 50 meter (164 feet) from all other marine mammals and sea turtles, with an exception made for animals that approach the vessel.
- When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance. If marine mammals or sea turtles are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This recommendation does not apply to any vessel towing gear.

3.1.5.9 Location and Timing

After discussion with the L-DEO, the NSF, the Permits Division, and NMFS regional experts, the NSF agreed to revise the location of the proposed survey lines off the coast of Washington. This was done out of concerns over impacts to Southern Resident killer whales. As a result of additional discussions the NSF had with the Canada Division of Fisheries and Oceans, the NSF made other alterations to the proposed survey lines over concerns to Southern Resident killer whales in Canadian territorial waters. See Section 10.2.1.2 for a more detailed discussion.

3.2 National Marine Fisheries Service's Proposed Activities

On November 25, 2019, NMFS Permits and Conservation Division received a request from the National Science Foundation and L-DEO for an incidental harassment authorization under the MMPA to take marine mammals incidental to conducting a high-energy marine seismic survey in the Northeast Pacific Ocean over the Cascadia Subduction zone. On March 6, 2020, NMFS Permits and Conservation Division deemed the National Science Foundation and L-DEO's application for an MMPA incidental harassment authorization to be adequate and complete. The National Science Foundation and L-DEO's request is for take of a small number of 31 species of marine mammals by MMPA Level A and Level B harassment. Neither the National Science Foundation, L-DEO, nor NMFS Permits and Conservation Division expects serious injury or mortality to result from the proposed activities; therefore, an MMPA incidental harassment authorization is appropriate. The planned seismic survey is not expected to exceed one year; hence, the NMFS Permits and Conservation Division does not expect subsequent MMPA incidental harassment authorizations will be issued for this proposed action. The incidental harassment authorization will be valid for a period of one year from the date of issuance. The NMFS Permits and Conservation Division proposes to issue the incidental harassment authorization after April 2021, so that the National Science Foundation and L-DEO's will have the incidental harassment authorization prior to the start of the proposed activities. Because the National Science Foundation and L-DEO have tentatively scheduled the proposed activities to begin on May 20, 2021 (seismic activities to begin on June 1, 2021), they have requested that the incidental harassment authorization be issued by early May 2021.

3.2.1 National Marine Fisheries Service's Proposed Incidental Harassment Authorization

The NMFS Permits and Conservation Division is proposing to issue an incidental harassment authorization authorizing non-lethal "takes" by MMPA Level A and Level B harassment of marine mammals incidental to the planned seismic survey. The incidental harassment authorization will be valid for a period of one year from the date of issuance. The incidental harassment authorization will authorize the incidental harassment of the following threatened and endangered marine mammal species: Southern Resident killer whale (*Orcinus orca*), blue whale (*Balaenoptera musculus*), fin whale (*Balaenoptera physalus*), Central America distinct population segment (DPS) of humpback whale (*Megaptera novaeangliae*), Mexico DPS of humpback whale, sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus*), and Guadalupe fur seal (*Arctocephalus townsendi*). The proposed incidental harassment authorization identifies requirements that the National Science Foundation must comply with as part of its authorization.

On April 7, 2020, NMFS Permits and Conservation published a notice of proposed incidental harassment authorization and request for comments on proposed incidental harassment authorization and possible renewal in the *Federal Register* (85 FR 19580). The public comment period closed on May 7, 2020. Appendix A contains the final incidental harassment authorization.

3.2.2 National Marine Fisheries Service's Revisions to Proposed Incidental Harassment Authorization

The NMFS Permits and Conservation Division made revisions to the proposed incidental harassment authorization since the notice was published in the *Federal Register* on April 7, 2020 (85 FR 19580). The revisions are based on public comments received from the Marine Mammal Commission and others. The revisions to the proposed incidental harassment authorization include modifications to the incidental take estimates of marine mammals, operational restrictions, mitigation measures, and survey lines. The proposed action was updated to reflect these changes.

4 ACTION AREA

Action area means all areas affected directly, or indirectly, by the Federal action, and not just the immediate area involved in the action (50 C.F.R. §402.02).

The proposed action will take place in the Northeast Pacific Ocean between approximately 42° to 51° North, and 124° to 130° West. The proposed action will take place within the exclusive economic zones of U.S. and Canada, and the Canadian Internal Waters of Vancouver Island, British Columbia.

The survey will occur in the U.S. Exclusive Economic Zone (370.4 kilometers [200 nautical miles]) off Oregon and Washington in waters depths of approximately 60 to 4,400 meters (197 to 14,436 feet). The survey will also take place in the Exclusive Economic Zone of Canada, and the territorial seas of Canada (off the coast of British Columbia). The nearest trackline to shore would be about 12 kilometers off the coast of Oregon; the furthest trackline would be about 200 kilometers from shore. The state of Washington's jurisdictional waters are 3 nautical miles from shore (5.6 kilometers), and the state of Oregon claims 3 geographical miles (5.6 kilometers) from shore as its jurisdictional waters. The survey tracklines themselves are outside the state jurisdictional waters, and are far enough offshore that the ensonified area created by the airgun blasts would not extend into the state waters of Oregon or Washington.

Under Canadian law, its maritime zones are categorized as Canadian Internal Waters, and the Exclusive Economic Zone. Like the U.S., the Exclusive Economic Zone in Canada is 200 nautical miles (370.4 kilometers; Oceans Act [S.C. 1996, c. 31, Part I, 13(1)]). Canadian Internal Waters are the waters "on the landward side of the baselines of the territorial sea of Canada", with territorial seas defined as 12 nautical miles (22 kilometers; Oceans Act [S.C. 1996, c. 31]). Portions of the proposed survey tracklines in Canada will take place in the territorial seas of Canada, as well as in the Canadian Exclusive Economic Zone. About 3.6 percent of the transect lines (234 kilometers) would take place in Canadian Internal Waters.

Representative tracklines for the proposed action are shown in Figure 3. The representative tracklines shown in Figure 3 have a total length of approximately 6,540 kilometers. Some minor deviation of the tracklines, including the order of operations, may occur for reasons such as poor data quality, inclement weather, or mechanical issues with the equipment and/or research vessel. The tracklines can occur anywhere within the coordinates noted in Figure 3.

The action area includes the survey tracklines, the transit for turns, and the area ensonified by the airgun array during the seismic survey. The total amount of ensonified area for the proposed seismic survey is approximately 79,582 square kilometers. Approximately 65.9 percent of the ensonified area will occur in waters greater than 1,000 meters deep (52,439 square kilometers), 23,562 square kilometers (29.6 percent) would occur in waters 1,000 to 100 meters deep, and the rest of the survey would take place in waters less than 100 meters deep (3,581 square kilometers, or 4.5 percent). The turns are the path the R/V *Marcus G. Langseth* will take as it finishes one survey trackline and transits to another; the airgun array will be active during turns. The action area will also include the area covered by the R/V *Marcus G. Langseth* while transiting from its port to the seismic survey area, and its return at the conclusion of the seismic survey. The R/V *Marcus G. Langseth* and *Oceanus* are expected to leave the port of Newport, Oregon, and return to the port of Seattle, Washington. The port locations may be subject to change.

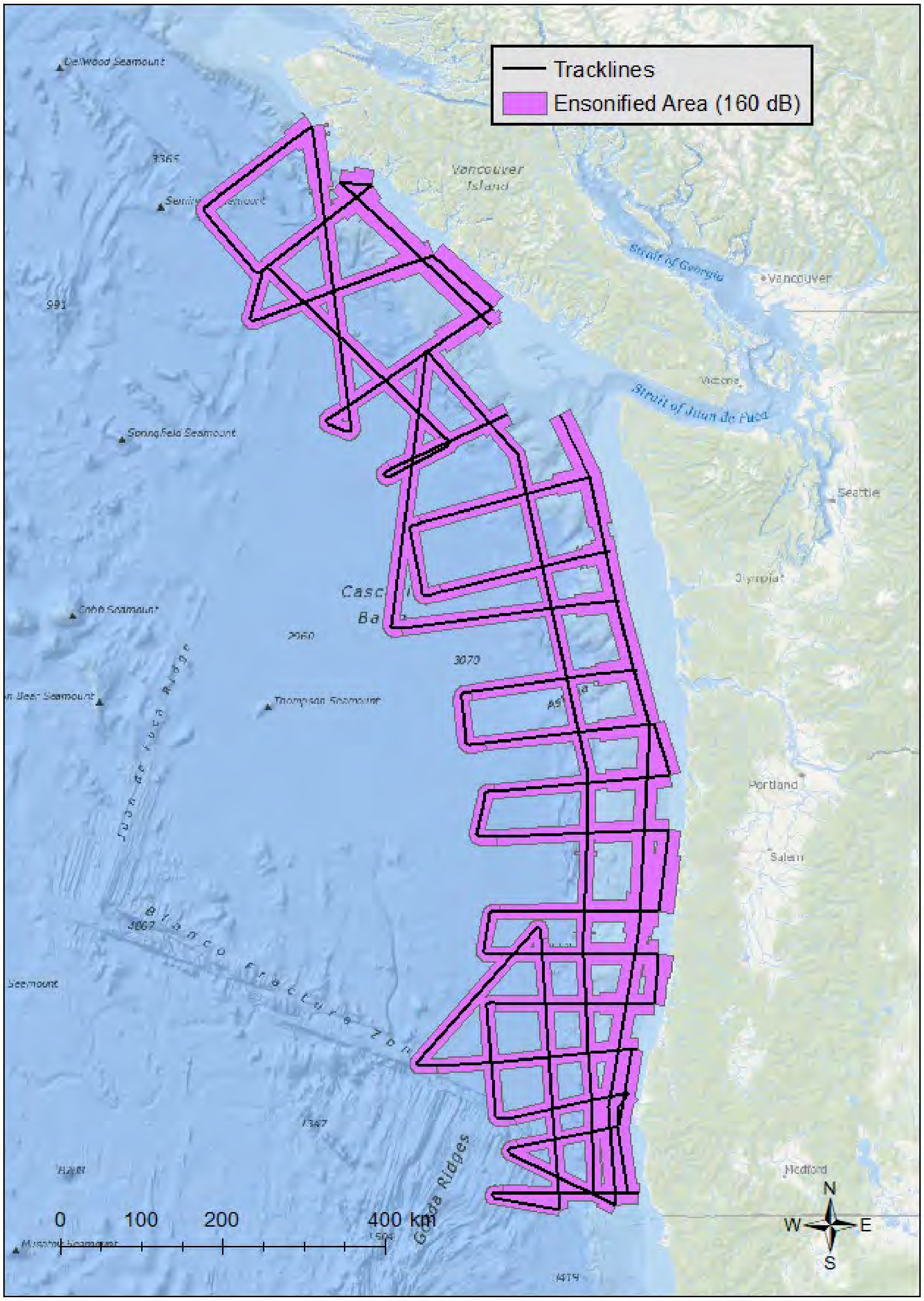

Figure 3. Map of the National Science Foundation and Lamont-Doherty Earth Observatory's high-energy marine seismic survey in the Northeast Pacific Ocean, Cascadia Subduction Zone.

4.1 Canadian Territorial Waters and the Action Area

Canada considers its territorial seas to extend out 12 nautical miles. A nation's territorial seas is the sovereign territory of that country. According to the draft Environmental Analysis that NSF prepared for this action, most of the survey lines will take place outside the 12 nautical mile line.

NMFS' jurisdiction under the ESA and MMPA only applies to the portions of the seismic survey that occur outside the 12 nautical mile boundary on the high seas.

The fact that portions of the proposed action fall both inside and outside of the 12 nautical mile boundary (the high seas under the ESA) presents us with a complexity. For ESA section 7 consultations, we are required to examine the effects of the action throughout the entire action area in making our jeopardy determination. However, we do not have authority under the ESA to authorize incidental take within the sovereign territory of Canada (i.e., within 12 nautical mile).

The ESA defines action area as "all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action." Although portions of the tracklines do not occur in the high seas (where the ESA has explicit jurisdiction), we are obligated to consider the effects of the action throughout the entire action area. Therefore, we must consider the 12 nautical mile boundary in relation to:

- The location of the tracklines, and
- The extent of the ensonified area.

By using GIS software, the L-DEO calculated the amount of survey tracklines and ensonified areas that were inside Canadian territorial waters. They then calculated MMPA take both inside Canadian territorial waters and for the entire action area (see Section 10.2).

This opinion considers two exposure scenarios to fulfill our requirements under the ESA:

1. Estimated exposure to determine the effects of the proposed action throughout the <u>entire action area</u> (inside and outside the 12 nautical mile boundary), including as part of our the jeopardy analysis, and
2. Estimated exposure in the portions of the action area where NMFS has jurisdiction under the ESA to exempt take from an otherwise lawful activity in an ITS.

5 ENDANGERED SPECIES ACT-LISTED SPECIES AND PROPOSED AND DESIGNATED CRITICAL HABITAT PRESENT IN THE ACTION AREA

This section identifies the ESA-listed species and designated and proposed critical habitat that potentially occur within the action area (Table 5) that may be affected by the proposed action. Marine mammal species are expected to occur in the seismic survey area in both offshore and inshore waters. Migratory baleen whales, sperm whales, leatherback sea turtles, and Guadalupe fur seals are likely more common in the offshore region during the summer, but other animals like Southern Resident killer whales and feeding humpback whales are expected to occur closer to shore.

Table 5. Threatened and endangered species and designated and proposed critical habitat that may be affected by the proposed action.

Species	ESA Status	Critical Habitat	Recovery Plan
Marine Mammals – Cetaceans			
Blue Whale (*Balaenoptera musculus)*	E – 35 FR 18319	-- --	07/1998 10/2018 - Draft
Fin Whale (*Balaenoptera physalus)*	E – 35 FR 18319	-- --	75 FR 47538 07/2010
Gray Whale (*Eschrichtius robustus*) Western North Pacific Population	E – 35 FR 18319	-- --	-- --
Humpback Whale (*Megaptera novaeangliae*) – Central America DPS	E – 81 FR 62259	86 FR 21082	11/1991
Humpback Whale (*Megaptera novaeangliae*) – Mexico DPS	T – 81 FR 62259	86 FR 21082	11/1991
Killer Whale (*Orcinus orca*) – Southern Resident DPS	E – 70 FR 69903 Amendment 80 FR 7380	71 FR 69054 84 FR 99214 (Proposed Revision)	73 FR 4176 01/2008
North Pacific Right Whale (*Eubalaena japonica*)	E – 73 FR 12024	73 FR 19000	78 FR 34347 06/2013
Sei Whale (*Balaenoptera borealis*)	E – 35 FR 18319	-- --	12/2011
Sperm Whale (*Physeter macrocephalus*)	E – 35 FR 18319	-- --	75 FR 81584 12/2010
Marine Mammals—Pinnipeds			
Guadalupe Fur Seal (*Artocephalus townsendi*)	T – 50 FR 51252	-- --	-- --
Steller Sea Lion (*Eumetopias jubatus*) – Western DPS*	E – 55 FR 49204	58 FR 45269	73 FR 11872 2008
*The range of Western DPS of Steller sea lions is outside the action area; however, the critical habitat designated for the Western DPS in Oregon falls within the action area.			
Marine Reptiles			
Green Turtle (*Chelonia mydas*) – East Pacific DPS	T – 81 FR 20057	-- --	63 FR 28359 01/1998
Leatherback Turtle (*Dermochelys coriacea*)	E – 35 FR 8491	44 FR 17710 and 77 FR 4170	10/1991 – U.S. Caribbean, Atlantic, and Gulf of Mexico 63 FR 28359 05/1998 – U.S. Pacific

Species	ESA Status	Critical Habitat	Recovery Plan
Loggerhead Turtle (*Caretta caretta*) – North Pacific Ocean DPS	E – 76 FR 58868	-- --	63 FR 28359
Fishes			
Chinook Salmon (*Oncorhynchus tshawytscha)* – California Coastal ESU	T – 70 FR 37160	70 FR 52488	81 FR 70666
Chinook Salmon (*Oncorhynchus tshawytscha)* – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chinook Salmon (*Oncorhynchus tshawytscha)* – Puget Sound ESU	T – 70 FR 37160	70 FR 52629	72 FR 2493
Chinook Salmon (*Oncorhynchus tshawytscha)* – Sacramento River Winter-Run ESU	E – 70 FR 37160	58 FR 33212	79 FR 42504
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Fall-Run ESU	T – 70 FR 37160	58 FR 68543	80 FR 67386 (Draft)
Chinook Salmon (*Oncorhynchus tshawytscha)* – Snake River Spring/Summer Run ESU	T – 70 FR 37160	64 FR 57399	81 FR 74770 (Draft) 11-2017-Final
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Columbia River Spring-Run ESU	E – 70 FR 37160	70 FR 52629	72 FR 57303
Chinook Salmon (*Oncorhynchus tshawytscha)* – Upper Willamette River ESU	T – 70 FR 37160	70 FR 52629	76 FR 52317
Chum Salmon (*Oncorhynchus keta*) – Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chum Salmon (*Oncorhynchus keta*) – Hood Canal Summer-Run ESU	T – 70 FR 37160	70 FR 52629	72 FR 29121
Coho Salmon (*Oncorhynchus kisutch*) – Central California Coast ESU	E – 70 FR 37160	64 FR 24049	77 FR 54565
Coho Salmon (*Oncorhynchus kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251	78 FR 41911
Coho Salmon (*Oncorhynchus kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816	81 FR 90780
Coho Salmon (*Oncorhynchus kisutch*) – Southern Oregon and Northern California Coasts ESU	T – 70 FR 37160	64 FR 24049	79 FR 58750
Eulachon (*Thaleichthys pacificus*) – Southern DPS	T – 75 FR 13012	76 FR 65323	9/2017

Species	ESA Status	Critical Habitat	Recovery Plan
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 71 FR 17757	74 FR 52300	2010 (Outline) 8/2018- Final
Sockeye Salmon (*Oncorhynchus nerka*) – Ozette Lake ESU	T – 70 FR 37160	70 FR 52630	74 FR 25706
Sockeye Salmon (*Oncorhynchus nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543	80 FR 32365
Steelhead Trout (*Oncorhynchus mykiss*) – California Central Valley DPS	T – 71 FR 834	70 FR 52487	79 FR 42504
Steelhead Trout (*Oncorhynchus mykiss*) – Central California Coast DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629	78 FR 41911
Steelhead Trout (*Oncorhynchus mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629	74 FR 50165
Steelhead Trout (*Oncorhynchus mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*Oncorhynchus mykiss*) – Puget Sound DPS	T – 72 FR 26722	81 FR 9251	-- --
Steelhead Trout (*Oncorhynchus mykiss*) – Snake River Basin DPS	T – 71 FR 834	70 FR 52629	81 FR 74770 (Draft) 11-2017-Final
Steelhead Trout (*Oncorhynchus mykiss*) – South-Central California Coast DPS	T – 71 FR 834	70 FR 52487	78 FR 77430
Steelhead Trout (*Oncorhynchus mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487	77 FR 1669
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629	72 FR 57303
Steelhead Trout (*Oncorhynchus mykiss*) – Upper Willamette River DPS	T – 71 FR 834	70 FR 52629	76 FR 52317
Boccaccio (*Sebastes paucispinis*) – Puget Sound/Georgia Basin DPS	E – 75 FR 22276 and 82 FR 7711	79 FR 68041	81 FR 54556 (Draft) 10/2017
Yelloweye Rockfish (*Sebastes rubberimus*) – Puget Sound/Georgia Basin DPS	T – 75 FR 22276 and 82 FR 7711	79 FR 68041	81 FR 54556 (Draft) 10/2017

6 POTENTIAL STRESSORS

The proposed action involves multiple activities, each of which can create stressors. Stressors are any physical, chemical, or biological entity that may directly or indirectly induce an adverse response either in an ESA-listed species or their designated critical habitat. During consultation, we deconstructed the proposed action to identify stressors that are reasonably certain to result from the proposed activities. These can be categorized as pollution (e.g., exhaust, fuel, oil, trash), vessel strikes, acoustic and visual disturbance (research vessel, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, ocean bottom seismometers, ocean bottom nodes, and seismic airgun array), and entanglement in towed seismic equipment (hydrophone streamers). Below we provide information on these potential stressors. Furthermore, the proposed action includes several conservation measures described in Section 3.1.5. that are designed to minimize effects that may result from these potential stressors. While we consider all of these measures important and expect them to be effective in minimizing the effects of potential stressors, they do not completely eliminate the identified stressors. Nevertheless, we treat them as part of the proposed action and fully consider them when evaluating the effects of the proposed action (Section 3).

6.1 Pollution

The operation of the R/V *Marcus G. Langseth* and R/V *Oceanus* as a result of the proposed action may result in pollution from exhaust, fuel, oil, trash, and other debris. Air and water quality are the basis of a healthy environment for all species. Emissions pollute the air, which could be harmful to air-breathing organisms and lead to ocean pollution (Duce et al. 1991; Chance et al. 2015). The release of marine debris such as paper, plastic, wood, glass, and metal associated with vessel operations can also have adverse effects on marine species most commonly through entanglement or ingestion (Gall and Thompson 2015), while the discharge of gray water and wastewater (containing pollutants) from the vessels can degrade habitat for marine life. While lethal and non-lethal effects to air-breathing marine animals such sea turtles, birds, and marine mammals from marine debris are well documented, marine debris also adversely affects marine fish (Gall and Thompson 2015). In addition, the ocean bottom seismometers and nodes have anchors that will remain after the recording devices (nodes, seismometers) are retrieved, constituting marine debris.

6.2 Vessel Strikes

Seismic surveys necessarily involve vessel traffic within the marine environment, and the transit of any research vessel in waters inhabited by ESA-listed species carries the risk of a vessel strike. Vessel strikes are known to adversely affect ESA-listed marine mammals, sea turtles, and fishes (Laist et al. 2001; NMFS and USFWS 2008; Brown and Murphy 2010; Work et al. 2010b). The probability of a vessel collision depends on the number, size, and speed of vessels, as well as the distribution, abundance, and behavior of the species (Laist et al. 2001; Jensen and Silber 2004; Hazel et al. 2007; Vanderlaan and Taggart 2007; Conn and Silber 2013a). If an animal is struck by a research vessel, it may experience minor, non-lethal injuries, serious injuries, or death.

6.3 Operational Noise and Visual Disturbance from Vessels and Equipment

The proposed action will produce a variety of different sounds associated with the operation of the vessels and the equipment, including: multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, ROVs, ocean bottom seismometers, ocean bottom nodes, and airgun arrays that may produce an acoustic disturbance or otherwise affect ESA-listed species. Operational noise from vessels and equipment may also make the area in and around the sound source undesirable for marine life (prey species like fishes and invertebrates, as well as ESA-listed species), causing them to vacate a particular area. This stressor involves the presence of vessels (and associated equipment) that produce a visual disturbance that may affect ESA-listed marine mammals, sea turtles, and fishes.

6.4 Gear Interaction

The towed seismic equipment (e.g., airgun array and hydrophones) and the ROV's cables that will be used in the proposed seismic survey activities may pose a risk of entanglement to ESA-listed species. The gear used in the proposed action may also strike ESA-listed species while in use, or during deployment or retrieval, resulting in injury. This is a possibility for the oceans bottom seismometers in particular, as they will be lowered into the water from the vessel by a boom, and then, weighted down with an 80-kilogram steel anchor, would drop to the ocean floor. Entanglement can result in death or injury of marine mammals, sea turtles, and fishes (Moore et al. 2009a; Moore et al. 2009b; Deakos and H. 2011; Van Der Hoop et al. 2013a; Van der Hoop et al. 2013b; Duncan et al. 2017). Marine mammal, sea turtle, and fish entanglement, or bycatch, is a global problem that every year results in the death of hundreds of thousands of animals worldwide. Entangled marine mammals and sea turtles may drown or starve due to being restricted by gear, suffer physical trauma and systemic infections, and/or be hit by vessels due to an inability to avoid them. For smaller animals like sea turtles, death is usually quick, due to drowning. However, large whales can typically pull gear, or parts of it, off the ocean floor, and are generally not in immediate risk of drowning. Nonetheless, depending on the entanglement, towing gear for long periods may prevent a whale from being able to feed, migrate, or reproduce (Van der Hoop et al. 2017; Lysiak et al. 2018).

7 SPECIES AND CRITICAL HABITAT NOT LIKELY TO BE ADVERSELY AFFECTED

NMFS uses two criteria to identify the ESA-listed species and critical habitats that are not likely to be adversely affected by the proposed action, as well as the effects of activities that are consequences of the Federal agency's proposed action. The first criterion is exposure, or some reasonable expectation of a co-occurrence, between one or more potential stressors associated with the proposed activities and ESA-listed species or designated critical habitat. If we conclude that an ESA-listed species or designated critical habitat is not likely to be exposed to the proposed activities, we must also conclude that the species or critical habitat is not likely to be adversely affected by those activities.

The second criterion is the probability of a response given exposure. ESA-listed species or designated critical habitat that co-occur with a stressor of the action but are not likely to respond to the stressor are also not likely to be adversely affected by the proposed action. We applied these criteria to the ESA-species and designated critical habitats in Table 5 and we summarize our results below.

The probability of an effect on a species or designated critical habitat is a function of exposure intensity and susceptibility of a species to a stressor's effects (i.e., probability of response). An action warrants a "may affect, not likely to be adversely affected" finding when its effects are wholly *beneficial, insignificant* or *discountable*. *Beneficial* effects have an immediate positive effect without any adverse effects to the species or habitat.

Insignificant effects relate to the size or severity of the impact and include those effects that are undetectable, not measurable, or so minor that they cannot be meaningfully evaluated. Insignificant is the appropriate effect conclusion when plausible effects are going to happen, but will not rise to the level of constituting an adverse effect.

Discountable effects are those that are extremely unlikely to occur. For an effect to be discountable, there must be a plausible adverse effect (i.e., a credible effect that could result from the action and that would be an adverse effect if it did impact a listed species), but it is very unlikely to occur.

In this section, we evaluate effects from the proposed action's stressors (Section 7.1) to numerous ESA-listed species and proposed or designated critical habitat that may be affected, but are not likely to be adversely affected by the proposed action. We also identify ESA-listed species and proposed or designated critical habitat that are not likely to be adversely affected by the proposed action (Section 7.2)

7.1 Stressors Not Likely to Adversely Affect Species

There are a number of stressors that could result from the proposed action as described in Section 6. We consider several of these stressors not likely to adversely affect species, and provide our rationale in the sections below. We also discuss the effects of these stressors on designated and proposed critical habitat in Section 7.2.5.

7.1.1 Pollution

Pollution in the form of vessel exhaust, fuel or oil spills or leaks, and trash or other debris resulting from the use of vessels as part of the proposed action could result in impacts to ESA-listed marine mammals, sea turtles, and fishes.

Vessel exhaust (i.e., air pollution) would occur during the entirety of the proposed action, during all vessel transit and operations, and could affect air-breathing ESA-listed species such as marine mammals and sea turtles. It is unlikely that vessel exhaust resulting from the operation of the R/V *Marcus G. Langseth* or R/V *Oceanus* would have a measurable impact on ESA-listed marine mammals or sea turtles given the relatively short duration of the proposed action (~37 days), the brief amount of time that whales and sea turtles spend at the surface, and the various regulations to minimize air pollution from vessel exhaust, such as NSF's compliance with the

Act to Prevent Pollution from Ships. For these reasons, the effects that may result from vessel exhaust on ESA-listed marine mammals and sea turtles are considered insignificant.

Discharges into the water from research vessels (the R/V *Marcus G. Langseth* and the R/V *Oceanus*, and the support vessel) in the form of wastewater or leakages of fuel or oil are possible, though effects of any spills to ESA-listed marine mammals, sea turtles, and fishes considered in this opinion will be minimal, if they occur at all. Wastewater from the vessels would be treated in accordance with U.S. Coast Guard standards. The potential for fuel or oil leakages is extremely unlikely. An oil or fuel leak could pose a significant risk to the vessel and its crew and actions to correct a leak should occur immediately to the extent possible. The research vessels used during the National Science Foundation-funded seismic survey have spill-prevention plans, which allow a rapid response to a spill in the event one occurs. In the event that a leak should occur, the response would prevent a widespread, high dose contamination (excluding the remote possibility of severe damage to the vessels) that will impact ESA-listed species directly or pose hazards to their food sources that may be part of proposed or designated critical habitat in the action area. Because the potential for oil or fuel leakage is extremely unlikely to occur, we find that the risk from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes is discountable.

Trash or other debris resulting from the proposed action may affect ESA-listed marine mammals, sea turtles, and fishes. Any marine debris (e.g., plastic, paper, wood, metal, glass) that might be released would be accidental. The National Science Foundation follows standard, established guidance on the handling and disposal of marine trash and debris during the seismic survey. The gear used in the proposed action may also result in marine debris. The ocean bottom nodes would be deployed and retrieved by the ROV, so there would be no components of those devices left behind. However, the ocean bottom seismometers would be released from the attached anchor and float to the surface for retrieval, leaving the anchor behind as debris on the ocean floor. There would be a total of 115 ocean bottom seismometer anchors left behind. Anchors that are placed within the boundaries of the Olympic Coast National Marine Sanctuary would be made of cement. Other ocean bottom seismometers would be made of steel. Although these anchors can be considered debris, we do not believe them to pose an entanglement risk or other hazards for ESA-listed marine mammals, sea turtles, or fishes. The small amount of debris created by the anchors as a result of the proposed action compared to the relative size of the available habitat used by ESA-listed species is insignificant. Because the potential for accidental release of trash is extremely unlikely to occur, we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are discountable. The marine debris created by the ocean bottom seismometers is minor, thus we find that the effects from this potential stressor on ESA-listed marine mammals, sea turtles, and fishes are insignificant.

Therefore, we conclude that pollution by vessel exhaust, wastewater, fuel or oil spills or leaks, and trash or other debris may affect, but is not likely to adversely affect ESA-listed species, and will not be analyzed further in this opinion.

7.1.2 Vessel Strikes

Vessel traffic associated with the proposed action carries the risk of vessel strikes of ESA-listed marine mammals, sea turtles, and fishes. In general, the probability of a vessel collision and the associated response depends, in part, on size and speed of the vessel. The R/V *Marcus G. Langseth* has a length of 235 feet (72 meters) and the operating speed during seismic data acquisition is typically approximately 9.3 kilometers per hour (5 knots). When not towing seismic survey gear, the R/V *Marcus G. Langseth* typically transits at 18.5 kilometers per hour (10 knots). The R/V *Oceanus* is 177 feet (54 meters) in length, and cruises up to 20.3 kilometers per hour (11 knots). During the deployment and retrieval of ocean bottom seismometers and ocean bottom nodes, the R/V *Oceanus* will be traveling at a much slower speed. The majority of vessel strikes of large whales occur when vessels are traveling at speeds greater than approximately 18.5 kilometers per hour (10 knots), with faster travel, especially of large vessels (80 meters [262.5 feet] or greater), being more likely to cause serious injury or death (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013a).

Much less is known about vessel strike risk for sea turtles, but it is considered an important injury and mortality risk within the action area (Lutcavage et al. 1997). Based on behavioral observations of sea turtle avoidance of small vessels, green turtles may be susceptible to vessel strikes at speeds as low as 3.7 kilometers per hour (2 knots;(Hazel et al. 2007). If an animal is struck by a vessel, responses can include death, serious injury, and/or minor, non-lethal injuries, with the associated response depending on the size and speed of the vessel, among other factors (Laist et al. 2001; Jensen and Silber 2004; Vanderlaan and Taggart 2007; Conn and Silber 2013b).

Each of the ESA-listed fish species considered in this opinion are thought to spend at least some time in the upper portions of the water column where they may be susceptible to vessel strike. Despite these species' use of the upper portion of the water column for at least some of their life history, in most cases, we would anticipate the ESA-listed fishes considered in this opinion would be able to detect vessels or other in-water devices and avoid them. Fish are able to use a combination of sensory cues to detect approaching vessels, such as sight, hearing, and their lateral line (for nearby changes in water motion). A study on fish behavioral responses to vessels showed that most adults exhibit avoidance responses to engine noise, sonar, depth finders, and fish finders (Jørgensen et al. 2004), reducing the potential for vessel strikes. Misund (1997) found that fish ahead of a ship showed avoidance reactions at ranges of 50 to 350 meters (160 to 490 feet). When the vessel passed over them, some fish responded with sudden escape responses that included movement away from the vessel laterally or through downward compression of the school. In an early study conducted by Chapman and Hawkins (1973), the authors observed avoidance responses of herring from the low-frequency sounds of large vessels or accelerating small vessels. Avoidance responses quickly ended within ten seconds after the vessel departed. Conversely, Rostad (2006) observed that some fish (likely schools of herring) are attracted to different types of drifting and stationary vessels (e.g., research vessels) of varying sizes, noise levels, and habitat locations, as well as moving commercial vessels. While we are not aware of studies specifically focusing on ESA-listed fishes' reactions to vessels, we cannot rule out either occurrence during the proposed action.

Several conservation measures proposed by the NMFS Permits and Conservation Division and/or National Science Foundation and L-DEO will minimize the risk of vessel strike to marine mammals and sea turtles, such as the use of PSOs, and ship crew keeping watch while in transit. In addition, the overall level of vessel activity associated with the proposed action is low relative to the large size of the action area, further reducing the likelihood of a vessel strike of an ESA-listed species.

While vessel strikes of marine mammals, sea turtles, and fishes during seismic survey activities are possible, we are not aware of any definitive case of a marine mammal, sea turtle, or fish being struck by a vessel associated with NSF seismic surveys. The R/V *Marcus G. Langseth* will be traveling at generally low speeds, reducing the probability of a vessel strike for marine mammals (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The R/V *Oceanus*, while capable of traveling faster while in transit (11 knots to the R/V *Marcus G. Langseth*'s 10 knots), is smaller than the R/V *Marcus G. Langseth*, making it more maneuverable and less likely to strike an ESA-listed species. Both vessels will maintain watches while in transit. Our expectation of vessel strike being extremely unlikely to occur is due to the hundreds of thousands of kilometers the R/V *Marcus G. Langseth* has traveled without a reported vessel strike, general expected movement of marine mammals and sea turtles away from or parallel to the R/V *Marcus G. Langseth*, as well as the generally slow movement of the R/V *Marcus G. Langseth* during most of its travels (Holst and Smultea 2008b; Hauser and Holst 2009; Holst 2010). In addition, adherence to observation and avoidance procedures is also expected to avoid vessel strikes of marine mammals and sea turtles. All factors considered, we have concluded vessel strike of ESA-listed species by the research vessels is extremely unlikely to occur. Therefore, we conclude that vessel strike may affect, but is not likely to adversely affect ESA-listed species and will not be analyzed further in this opinion.

7.1.3 Operational Noise and Visual Disturbance of Vessels and Equipment

The research vessels associated with the proposed action may cause visual or auditory disturbances to ESA-listed species that spend time near the surface or in the upper parts of the water column, such as marine mammals, sea turtles, and fishes, which may generally disrupt their behavior. Assessing whether these sounds may adversely affect ESA-listed species involves understanding the characteristics of the acoustic sources, the species that may be present in the vicinity of the sound, and the effects that sound may have on the physiology and behavior of those species. Although it is known that sound is important for marine mammal communication, navigation, and foraging (NRC 2003b; NRC 2005a), there are many unknowns in assessing impacts of sound, such as the potential interaction of different effects and the significance of responses by marine mammals to sound exposures (Nowacek et al. 2007; Southall et al. 2007b). Other ESA-listed species such as sea turtles and fishes are often considered less sensitive to anthropogenic sound, but given that much less is known about how they use sound, the impacts of anthropogenic sound are difficult to assess (Popper et al. 2014b; Nelms et al. 2016). Nonetheless, depending on the circumstances, exposure to anthropogenic sounds may result in auditory injury, changes in hearing ability, masking of important sounds, behavioral responses, as well as other physical and physiological responses (see Section 10.2.2).

Studies have shown that vessel operations can result in changes in the behavior of marine mammals, sea turtles, and fishes (Patenaude et al. 2002; Richter et al. 2003; Hazel et al. 2007; Smultea et al. 2008a; Holt et al. 2009; Luksenburg and Parsons 2009; Noren et al. 2009b). In many cases, particularly when responses are observed at great distances, it is thought that animals are likely responding to sound more than the visual presence of vessels (Evans et al. 1992; Blane and Jaakson 1994; Evans et al. 1994). At close distances animals may not even differentiate between visual and acoustic disturbances created by vessels and simply respond to the combined disturbance. Nonetheless, it is generally not possible to distinguish responses to the visual presences of vessels from those to the sounds associated with those vessels. We consider the effects to marine mammals, sea turtles, and fishes from the visual presence of vessels associated with the proposed action to be insignificant.

Sounds emitted by large vessels can be characterized as low-frequency, continuous, or tonal, and sound pressure levels at a source will vary according to speed, burden, capacity, and length (Richardson et al. 1995b; Kipple and Gabriele 2007; McKenna et al. 2012). Source levels for 593 container ships transits were estimated from long-term acoustic recording received levels in the Santa Barbara shipping channel, and a simple transmission loss model using Automatic Identification System data for source-receiver range (McKenna et al. 2013a). Vessel noise levels could vary 5 to 10 dB depending on transit conditions. Given the sound propagation of low frequency sounds, a large vessel in this sound range can be heard 139 to 463 kilometers (75.1 to 250 nautical miles) away (Polefka 2004). Hatch et al. (2008) measured commercial ship underwater noise levels and reported average source level estimates (71 to 141 hertz, re: 1 μPa [rms] ± standard error) for individual vessels ranged from 158 ± 2 dB (research vessel) to 186 ± 2 dB (oil tanker). McKenna et al (2012), in a study off Southern California, documented different acoustic levels and spectral shapes observed from different modern vessel-types, illustrating the variety of possible noise levels created by the diversity of vessels that may be present.

Very little research exists on sea turtle responses to vessel noise disturbance. Currently, there is nothing in the available literature specifically aimed at studying and quantifying sea turtle response to vessel noise. However, a study examining vessel strike risk to green sea turtles suggests that sea turtles may habituate to vessel sound and may be more likely to respond to the sight of a vessel rather than the sound of a vessel, although both may play a role in prompting reactions (Hazel et al. 2007). Regardless of the specific stressor associated with vessels to which turtles are responding, they only appear to show responses (i.e., avoidance behavior) at approximately 10 meters (32.8 feet) or closer (Hazel et al. 2007). Therefore, the noise from vessels is not likely to affect sea turtles from further distances, and disturbance may only occur if a sea turtle hears a vessel nearby or sees it as it approaches.

All fish species can detect vessel noise due to its low-frequency content and their hearing capabilities. Therefore, ESA-listed fishes could be exposed to a range of vessel noises, depending on the source and context of the exposure. In the near field, fish are able to detect water motion as well as visually locate an oncoming vessel. In these cases, most fishes located in close proximity that detect the vessel either visually, via sound and motion in the water would be capable of avoiding the vessel or move away from the area affected by vessel sound. Thus, fish are more likely to react to vessel noise at close range than to vessel noise emanating from a greater distance away.

The contribution of vessel noise by the R/V *Marcus G. Langseth* and the R/V *Oceanus* is likely small in the overall regional sound field. Brief interruptions in communication via masking are possible, but unlikely given the habits of marine mammals and fish to move away from vessels, either as a result of engine noise, the physical presence of the vessel, or both (Mitson and Knudsen 2003; Lusseau 2006). Also, as stated, sea turtles are most likely to habituate and are shown to be less effected by vessel noise at distances greater than 10 meters (32.8 feet) (Hazel et al. 2007). In addition, during research operations, the R/V *Marcus G. Langseth* and R/V *Oceanus* will be traveling at slow speeds, reducing the amount of noise produced by the propulsions system (Kite-Powell et al. 2007; Vanderlaan and Taggart 2007). The distance between the research vessel and observed marine mammals and sea turtles, per avoidance protocols, will also minimize the potential for acoustic disturbance from engine noise. Because the potential acoustic interference from engine noise will be undetectable or so minor that it cannot be meaningfully evaluated, we find that the risk from this potential stressor is insignificant. Therefore, we conclude that acoustic interference from engine noise may affect, but is not likely to adversely affect ESA-listed marine mammals, sea turtles, or fishes, and will not be analyzed further.

Unlike vessels, which produce sound as a byproduct of their operations, multi-beam echosounders, sub-bottom profilers, acoustic Doppler current profilers, acoustic release transponders, ocean bottom seismometers, ocean bottom nodes, ROVs, and airgun arrays are designed to actively produce sound, and as such, the characteristics of these sound sources are deliberate and under control. The ocean bottom seismometers have an acoustic release transponder that transmits a signal to the instrument at a frequency of 8 to 11 kilohertz and a response is received at a frequency of 11.5 to 13 kilohertz (operator selectable), to activate and release the instrument. The transmitting beam pattern is 55 degrees. The sound source level is approximately 93 dB. Other components of the ROV (e.g., side-looking sonars) have operating frequencies that are high frequencies.

The functional hearing ranges of ESA-listed sea turtles are not well understood and vary by species. In general, the available information on sea turtle hearing indicates that their hearing thresholds are less than 1 kilohertz (Moein et al. 1994). Loggerhead sea turtles are thought to have a functional hearing range of 250 to 750 hertz (Bartol et al. 1999), Kemp's ridley sea turtles a range of 100 to 500 hertz, and green sea turtles 100 to 800 hertz (Ketten and Bartol 2005),

The multibeam echosounder and the sub-bottom profiler will not be operated while the vessel is in transit. These devices will be used during the seismic survey, and we expect that, because the sound from the airguns is greater than that produced by the multibeam echosounder or the sub-bottom profiler, ESA-listed marine mammals, sea turtles, and fish will be affected by the airgun array to an extent that does not allow us to distinguish the effects from the operation of these devices. However, the sounds from operation of this equipment is discussed further in this opinion.

7.1.4 Gear Interaction

There is a variety of gear proposed for use during the proposed action that might entangle, strike, or otherwise interact with ESA-listed species in the action area.

Towed gear from the seismic survey activities pose a risk of entanglement to ESA-listed marine mammals and sea turtles. The towed hydrophone streamer could come in direct contact with ESA-listed species and sea turtle entanglements have occurred in towed gear from seismic survey vessels. We are not aware of any cases of leatherback sea turtles entanglement. However, a National Science Foundation-funded seismic survey off the coast of Costa Rica during 2011 recovered a dead olive ridley turtle (*Lepidochelys olivacea*) in the foil of towed seismic equipment; it is unclear whether the sea turtle became lodged in the foil pre- or post mortem (Spring 2011). However, entanglement is highly unlikely due to the towed hydrophone streamer design, as well as observations of sea turtles investigating the towed hydrophone streamer and not becoming entangled or operating in regions of high sea turtle density and entanglements not occurring (Holst et al. 2005b; Holst et al. 2005a; Hauser 2008; Holst and Smultea 2008a). The towed hydrophone streamer is rigid and as such will not encircle, wrap around, or in any other way entangle any of the marine mammals considered during this consultation. We expect the taut cables will prevent entanglement. Furthermore, marine mammals are expected to avoid areas where the airgun array is actively being used, meaning they will also avoid towed gear. We are not aware of any entanglement events with ESA-listed marine mammals or sea turtles with the towed gear proposed for use in this action.

The ocean bottom nodes will be placed on the seafloor by the ROV operated from the R/V *Oceanus*, and the ocean bottom seismometers will be dropped from the sea surface by the R/V *Oceanus*. We do not expect ESA-listed marine mammals or sea turtles to be at the ocean bottom, so the concerns about equipment strike would primarily be while the ROV is moving up and down the water column, deploying the ocean bottom nodes. Similarly, the ocean bottom seismometers pose a risk to ESA-listed marine mammals and sea turtles as they are being deployed, and dropping to the ocean floor. The ROV camera would allow the operator to avoid any sea turtles or marine mammals that may be present in the water column as the equipment for the ocean bottom nodes travels up and down the water column. We expect an ESA-listed marine mammal or sea turtles to perceive the disturbance and be able to detect the ROV or ocean bottom seismometers, exhibit avoidance behavior, and move out of the way.

ESA-listed fish species in the action area (e.g., green sturgeon, salmon, steelhead, and eulachon) could be entangled or struck by equipment used during the seismic survey. ESA-listed salmon, steelhead, and eulachon are distributed throughout the water column, while green sturgeon occur at the ocean bottom (typically in depths less than 110 meters). The ocean bottom seismometers, ocean bottom nodes, and the ROV will operate at or near the ocean floor. The towed hydrophone array, the PAM hydrophone (both towed near the surface), and the towed airgun array (towed at 12 meters below the surface) pose similar risks to ESA-listed fishes species. However, we consider the possibility of equipment entanglement or strike to be remote because of fishes' ability to detect the equipment moving through the water and move out of the way. In addition, the personnel operating the ROV will be able to use its camera to avoid ESA-listed fishes.

Although the towed hydrophone streamer or passive acoustic monitoring array could come in direct contact with an ESA-listed species, entanglements are highly unlikely and considered discountable. Based upon extensive deployment of this type of equipment with no reported entanglement and the nature of the gear that is likely to prevent it from occurring, we find the probability of adverse impacts to ESA-listed species to be discountable; therefore, gear interactions may affect, but are not likely to adversely affect any ESA-listed species, and will not be analyzed further in this opinion.

7.1.5 Stressors Considered Further

The only potential stressor that is likely to adversely affect some ESA-listed species within the action area is sound fields produced by the seismic airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, acoustic release transponder, ROV, ocean bottom seismometers, and ocean bottom nodes. This stressor and these sound sources associated with seismic survey activities may adversely affect the ESA-listed marine mammals, sea turtles, and fishes and are further analyzed and evaluated in detail in Section 10.

7.2 Species Not Likely to be Adversely Affected

There are a number of ESA-listed species, as well as designated and proposed critical habitat, that could potentially be in the action area and possibly be exposed to the stressors associated with the proposed action. As discussed previously, most of the stressors associated with the proposed action are not likely to adversely affect any of the listed species in the action area but acoustic sources (i.e., sound fields by the seismic airguns and the other equipment used in the survey) may result in adverse effects for some ESA-listed species. However, for the reasons discussed below, we consider green and loggerhead sea turtles, North Pacific right whale, Western North Pacific gray whale, Southern California DPS steelhead, and Puget Sound/Georgia Basin DPS boccaccio and yelloweye rockfish may be affected, but are not likely to be adversely affected by noise from these sound sources.

7.2.1 Green and Loggerhead Sea Turtles

Endangered Species Act-listed sea turtles may be present in the action area. Green turtle (*Chelonia mydas*) East Pacific distinct population segment (DPS) and loggerhead sea turtle (*Caretta caretta*) North Pacific DPS range along the West Coast of the United States. However, green and loggerhead turtles are only rarely found in Washington or Oregon waters (WDFW 2012). Because of their scarcity in the waters in and around the action area, we believe it is extremely unlikely that green or loggerhead sea turtles will be exposed to any of the stressors associated with the proposed action, and the effects are discountable. Therefore, we conclude that the proposed action may affect, but is not likely to adversely affect these species.

7.2.2 North Pacific Right Whale

North Pacific right whales occur in subpolar to temperate waters. They are generally migratory, with at least a portion of the population moving between summer feeding grounds in temperate or high latitudes and winter calving areas in warmer waters (Kraus et al. 1986; Clapham et al. 2004a). Historical whaling records provide virtually the only information on North Pacific right whale distribution (Gregr 2011). This species historically occurred across the Pacific Ocean north of 35 degrees North, with concentrations in the Gulf of Alaska, eastern Aleutian Islands, south-central Bering Sea, Okhotsk Sea, and the Sea of Japan (Omura et al. 1969; Scarff 1986a; Clapham et al. 2004a; Shelden et al. 2005; Gregr 2011; Ivashchenko et al. 2013). North Pacific right whales were probably never common along the west coast of North America (Scarff 1986a; Brownell Jr. et al. 2001), although historically, the North Pacific right whale was sighted in waters off the coast of British Columbia and Washington, Oregon, and California (Scarff 1986b; Clapham et al. 2004b). The rarity of reports for North Pacific right whales in more southern coastal areas in winter in either historical or recent times suggests that their breeding grounds may have been offshore (Clapham et al. 2004a). Presently, sightings are extremely rare, occurring primarily in the Okhotsk Sea and the eastern Bering Sea (Brownell Jr. et al. 2001; Shelden et al. 2005; Wade et al. 2006; Zerbini et al. 2010).

In October 2013, a North Pacific right whale sighting was made off the Strait of Juan de Fuca with a group of humpback whales moving south into the offshore area of the U.S. Navy's Northwest Training and Testing action area (Navy 2015). There have also been four sightings, each of a single North Pacific right whale, in California waters within approximately the last 30 years (in 1988, 1990, 1992, and 2017;(Carretta et al. 1994; Brownell et al. 2001; Price 2017). Various sightings of North Pacific right whales in the general vicinity of the action area have occurred on an irregular basis. Two North Pacific right whales were sighted in 1983 on Swiftsure Bank at the entrance to the Strait of Juan de Fuca (Osborne et al. 1988). There were no sightings of North Pacific right whales during six NMFS vessel surveys conducted in summer and fall off California, Oregon, and Washington from 1991 through 2008 (Barlow 2010).

In addition to the low population numbers (likely less than 1,000) in the North Pacific Ocean, because only a few individuals have been observed (Brownell Jr. et al. 2001; Wade et al. 2006), even given more recent sightings and detections, this species is considered extremely rare in the action area. The seismic activities of the proposed action will take place in June and July when we expect that North Pacific right whales to be on their summer feeding grounds outside of the action area in the Bering Sea, Gulf of Alaska, Okhotsk Sea, and the Northwestern Pacific Ocean (Muto et al. 2019). Based on this information, there is a very low probability of encountering this species anywhere in the coastal and offshore waters in the action area during the proposed seismic surveys. As a result, potential acoustic noise from the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder on North Pacific right whales is discountable. Therefore, we conclude that the National Science Foundation and L-DEO's seismic survey activities may affect, but are not likely to adversely affect ESA-listed North Pacific right whales.

7.2.3 Gray Whale Western North Pacific Population

The Western North Pacific population of gray whales exhibits extensive plasticity in the occurrence of animals, shifting use of areas within and between years, as well as over longer time frames, such as in response to oceanic climate cycles (e.g., El Niño-Southern Oscillation, Pacific Decadal Oscillation, and Arctic Oscillation; (Weller et al. 2012) (Gardner and Chávez-Rosales 2000). The population's typical distribution extends south along Japan, the Koreas, and China from the Kamchatka Peninsula (Omura 1988; Kato and Kasuya. 2002; IWC 2003; Weller et al. 2003; Reeves et al. 2008). Other possible range areas include Vietnam, the Philippines, and Taiwan, although only historical whaling records support occurrence in these areas (Henderson 1990; Ilyashenko 2009). The range has likely contracted from the Koreas and other southern portions of the range versus pre-whaling periods. Prey availability and, to a lesser extent, sea ice extent, are probably strong influences on the habitats used by the Western North Pacific population of gray whales (Moore 2000; Clarke and Moore 2002).

The Eastern and Western North Pacific populations of gray whales were once considered geographically separated along either side of the ocean basin, but recent photo-identification, genetic, and satellite tracking data refute this. Two individuals from the Western North Pacific population of gray whales have been satellite tracked from Russian foraging areas east along the Aleutian Islands, through the Gulf of Alaska, and south to the Washington and Oregon coasts in one case (Mate et al. 2011), and to the southern tips of Baja California and back to Sakhalin Island in another (IWC 2012). Comparisons of catalogues of Eastern and Western North Pacific populations of gray whales have thus far identified 24 individuals from the Western North Pacific population of gray whales occurring on the eastern side of the basin during winter and spring (Burdin et al. 2011; Weller et al. 2013); for reference, there are about 26,960 individuals in the Eastern North Pacific population (NMFS 2019a). During one field season off Vancouver Island, individuals from the Western North Pacific population of gray whales were found to constitute six of 74 (8.1 percent) of photo-identifications (Weller et al. 2012). In addition, two genetic matches with the Western North Pacific population of gray whales off Santa Barbara, California have been made (Lang et al. 2011). Individuals have also been observed migrating as far as Central Baja Mexico (Weller et al. 2012).

From this overview, it is apparent that individuals from the Western North Pacific population of gray whales could be found within the action area. It is possible that an individual or individuals from the Western North Pacific population of gray whale could be unintentionally impacted by the proposed seismic survey activities. However, given their low occurrence in the action area we find it highly unlikely that any individuals from the Western North Pacific population of gray whales will be affected by the proposed seismic survey activities. The few photo-identification matches from collaborating researchers have occurred primarily in the spring during the migration (Weller et al. 2012), which is not when the field work will occur (the seismic survey activities are planned for June and July 2021). Due to this, Western North Pacific population of gray whales will have a very low likelihood of being exposed to acoustic stressors produced by the seismic airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder used during the seismic survey activities. Therefore, we believe the potential impacts to the Western North Pacific population of gray whale as a result of the proposed seismic survey activities will be discountable. We conclude that the proposed seismic survey activities may affect, but are not likely to adversely affect ESA-listed Western North Pacific population of gray whales.

7.2.4 Steelhead Trout—Southern California DPS

As with other salmonids, Southern California DPS steelhead spend a portion of their life cycle in the marine environment, including the action area, and could potentially be exposed to the proposed action (e.g., sound fields created by the seismic airguns and other equipment used in the survey).

Limited information exists on Southern California steelhead runs. Based on combined estimates for the Santa Ynez, Ventura, and Santa Clara rivers, and Malibu Creek, an estimated 32,000 to 46,000 adult steelhead occupied this DPS historically. In contrast, less than 500 adults are estimated to occupy the same four waterways presently. The last estimated run size for steelhead in the Ventura River, which has its headwaters in Los Padres National Forest, is 200 adults (Busby et al. 1996a).

Given the extremely low abundance of ESA-listed Southern California steelhead in general and within the action area and the limited likelihood of co-occurrence with the proposed action's stressors, the likelihood of the proposed action adversely affecting Southern California steelhead is so low as to be discountable.

7.2.5 Puget Sound/Georgia Basin DPS Boccaccio and Yelloweye Rockfish

Puget Sound/Georgia Basin DPS boccaccio and yelloweye rockfish are those that reside in Puget Sound/Georgia Basin. They could be exposed to stressors associated with the proposed action while the research vessels are transiting back to port in Seattle, Washington.

ESA-listed rockfishes are largely benthic, with juveniles occupying shallow, nearshore environments, favoring rocky substrate and kelp habitats. Sub-adult and adult rockfishes occupy deeper waters, 30 to 425 meters.

The vessels associated with the proposed action will operate in the upper levels of the water column, where Puget Sound/Georgia Basin DPS boccaccio and yelloweye rockfish are not likely to be. The stressors that accompany vessel transit—pollution, noise, visual disturbance—were analyzed in Section 7.1 and found to be insignificant or discountable, respectively, to ESA-listed fishes. We concluded that the proposed action may affect, but is not likely to adversely affect Puget Sound/Georgie Basin DPS boccaccio or yelloweye rockfish, and will not be analyzed further in this opinion.

7.2.6 Critical Habitat Not Likely to be Adversely Affected

The action area includes the waters off Oregon, Washington, and Vancouver Island, where the seismic survey will occur, as well as the locations where the research vessels will transit to and from the survey area. The vessels will be departing the Port of Newport, Oregon, and returning to the Port of Seattle, Washington at the conclusion of the action. There are a number of critical habitat areas that overlap with the action area that are not likely to be adversely affected by the proposed action, and we present our rationale for this effects conclusion below.

7.2.6.1 Southern Resident Killer Whale Critical Habitat

There are two portions of critical habitat – one designated and one proposed – for Southern Resident killer whales in the action area (Figure 4). Different parts of the proposed action will occur in each portion of critical habitat (proposed and designated), and the effects are discussed below.

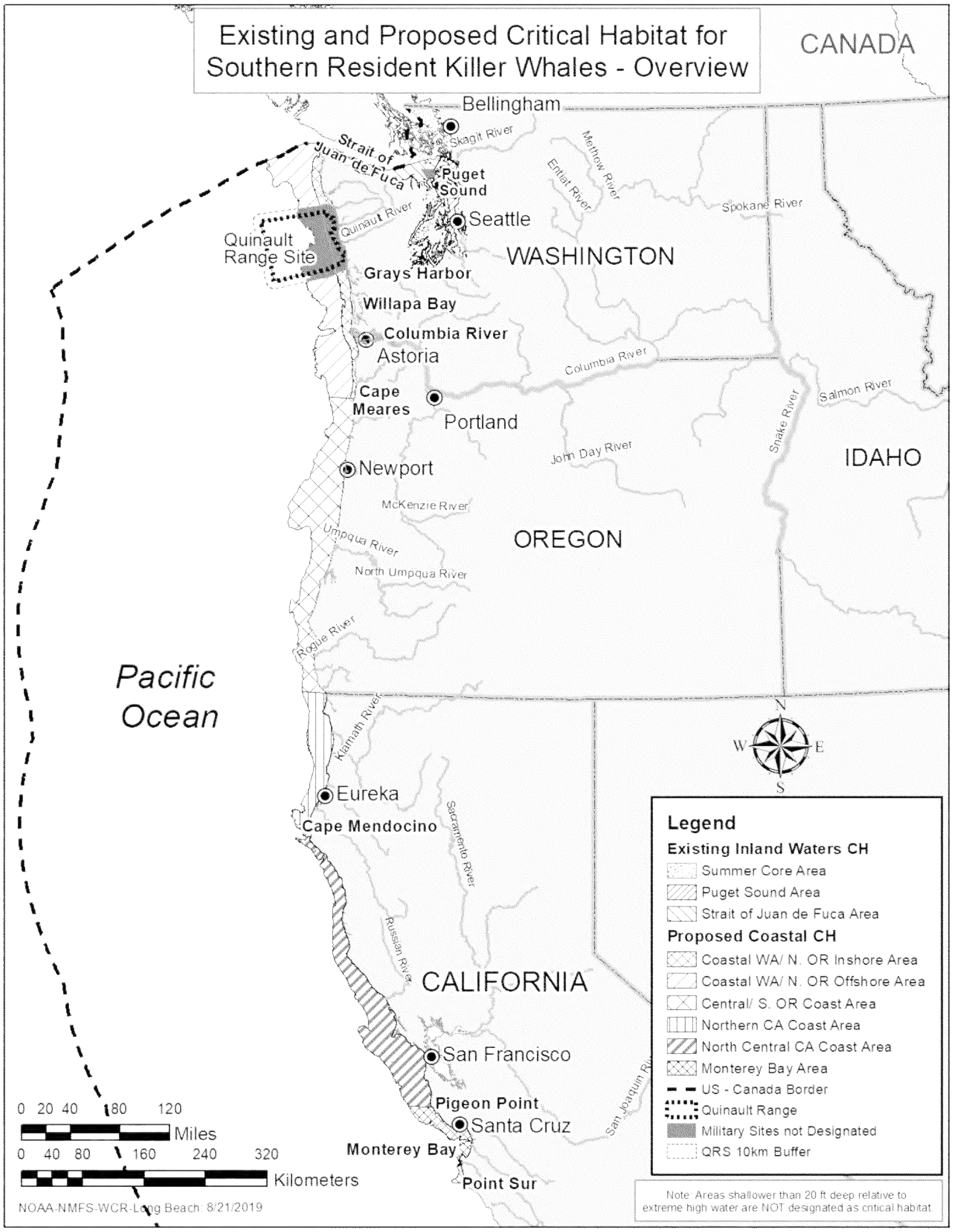

Figure 4. Southern Resident killer whale proposed and designated critical habitat.

Designated Critical Habitat

In 2006, NMFS designated critical habitat for the Southern Resident DPS of killer whale (71 FR 69054). The designated critical habitat, located in three specific areas in Washington: (1) the Summer Core Area in Haro Strait and waters around the San Juan Islands; (2) Puget Sound; and (3) the Strait of Juan de Fuca, overlaps with the action area because the R/V *Langseth* will transit back to port in Seattle. No other parts of the proposed action (e.g., seismic activities, placement of equipment) will occur in this portion of designated critical habitat.

The physical and biological features essential to the conservation of Southern Resident DPS of killer whales include: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) inter-area passage conditions to allow for migration, resting, and foraging.

The only stressors associated with the proposed action that would occur in the designated critical habitat would be those associated with vessel traffic while the research vessels transit back to port. These stressors would include noise associated with vessel operation, pollution from the vessel, and the visual disturbance created by the vessel.

The PBFs for the designated critical habitat are the same as for the proposed critical habitat; see the section below for our analysis of the effects of the proposed action on these PBFs.

Proposed Critical Habitat

On September 19, 2019, NMFS proposed to revise the critical habitat designation for Southern Resident killer whales by expanding it to include six new areas along the U.S. West Coast, while keeping the current designated critical habitat area in Washington. The proposed new areas along the U.S. West Coast include roughly 15,626 square miles of marine waters between the 6.1-meter depth contour and the 200-meter depth contour from the U.S. international border with Canada south to Point Sur, California.

The proposed critical habitat overlaps with the action area. Specifically, the planned seismic survey lines off the coasts of Oregon and Washington are within the proposed critical habitat and ocean bottom seismometers and nodes will be placed within the proposed critical habitat. The research vessels (the R/V *Langseth*, the R/V *Oceanus*, and the support vessel) will transit through the proposed critical habitat.

The identified PBFs that are essential to the conservation of the Southern Resident killer whale DPS proposed critical habitat are: (1) water quality to support growth and development; (2) prey species of sufficient quantity, quality, and availability to support individual growth, reproduction and development, as well as overall population growth; and (3) inter-area passage conditions to allow for migration, resting, and foraging.

NMFS previously considered identifying "sound levels that do not exceed thresholds that inhibit communication or foraging activities or result in temporary or permanent hearing loss" as a potential essential feature of the whales' inland critical habitat (69 FR 76673; December 22, 2004), but ultimately concluded that sufficient information was not available to do so (NMFS 2019a). An acoustic environment, or soundscape, in which Southern Resident killer whales can detect and interpret sounds is critical for carrying out basic life functions including communication, navigation, and foraging. We assess adverse habitat-related effects of anthropogenic sound by evaluating impacts to the prey and passage PBFs of critical habitat for Southern Resident killer whales. That is, we evaluate whether acoustic stressors resulting from the proposed action might alter the conservation value of habitat by reducing the quantity, quality, or availability of the whales' prey in a particular foraging area, by reducing the effective echolocation space for the whales to forage, or by creating a barrier that restricts movements through or within an area necessary for migration, resting, or foraging.

We do not expect there to be substantial effects to water quality as a result of the proposed action (see Section 7.1.1), and therefore do not expect the first PBF of the proposed critical habitat to be affected. The second PBF concerns the availability of sufficient prey species in the proposed critical habitat, to support Southern Resident killer whales. As described in Section 10.2.2, we do expect there to be impacts to Southern Resident killer whale prey species (i.e., ESA-listed Chinook, chum, and Coho). We expect those impacts to fish to be in the form of behavioral disturbance, TTS, and injury, but no mortality. In waters over the continental shelf, where we expect the most likely occurrence of fish prey species, the proposed action will take place over the course of about 10.5 days. After the survey has ended, we expect that fish will return to normal behavior in the action area. The overall short duration of the proposed action in an area where it would be most likely to impact prey species is not expected to rise to a level that would impact the prey PBF to such a degree as to cause significant alteration.

The third PBF concerns inter-area passage conditions for Southern Resident killer whales. The proposed action will take place throughout the proposed critical habitat. Based on density data provided by the Navy (2020), we expect that Southern Resident killer whales will be more likely to occur closer to shore, in areas that have been excluded from the action area. While the presence of the vessels and the proposed seismic activity may impact the Southern Resident killer whales, we are expecting an overall low amount of exposure for Southern Resident killer whales. Based on the size of the action area relative to the proposed critical habitat, Southern Resident killer whales should be able maneuver away from the vessel. Furthermore, the action is of an overall short duration in areas where we expect Southern Resident killer whales most likely to occur (e.g., off the coasts of Washington and Vancouver Island).

The effects of all other stressors analyzed, including vessel traffic and sound associated with the proposed seismic activities, on the essential PBFs were found to be insignificant and not likely to reduce the conservation value of proposed critical habitat. We conclude that the proposed action may affect, but is not likely to adversely affect Southern Resident killer whale proposed coastal critical habitat. We further evaluate the effects of seismic survey acoustic sources later; see Section 10.

7.2.6.2 Puget Sound/Georgia Basin DPS of Boccaccio, Canary Rockfish, and Yelloweye Rockfish Designated Critical Habitat

Critical habitat for the Puget Sound/Georgia Basin DPS of boccaccio, canary rockfish, and yelloweye rockfish was finalized in 2014 (79 FR 68041). Rockfish and boccaccio critical habitat is spread amongst five interconnected, biogeographic basins (San Juan/Strait of Juan de Fuca basin, Main basin, Whidbey basin, South Puget Sound, and Hood Canal) based upon presence and distribution of adult and juvenile rockfish and bocaccio, geographic conditions, and habitat features (Figure 5).

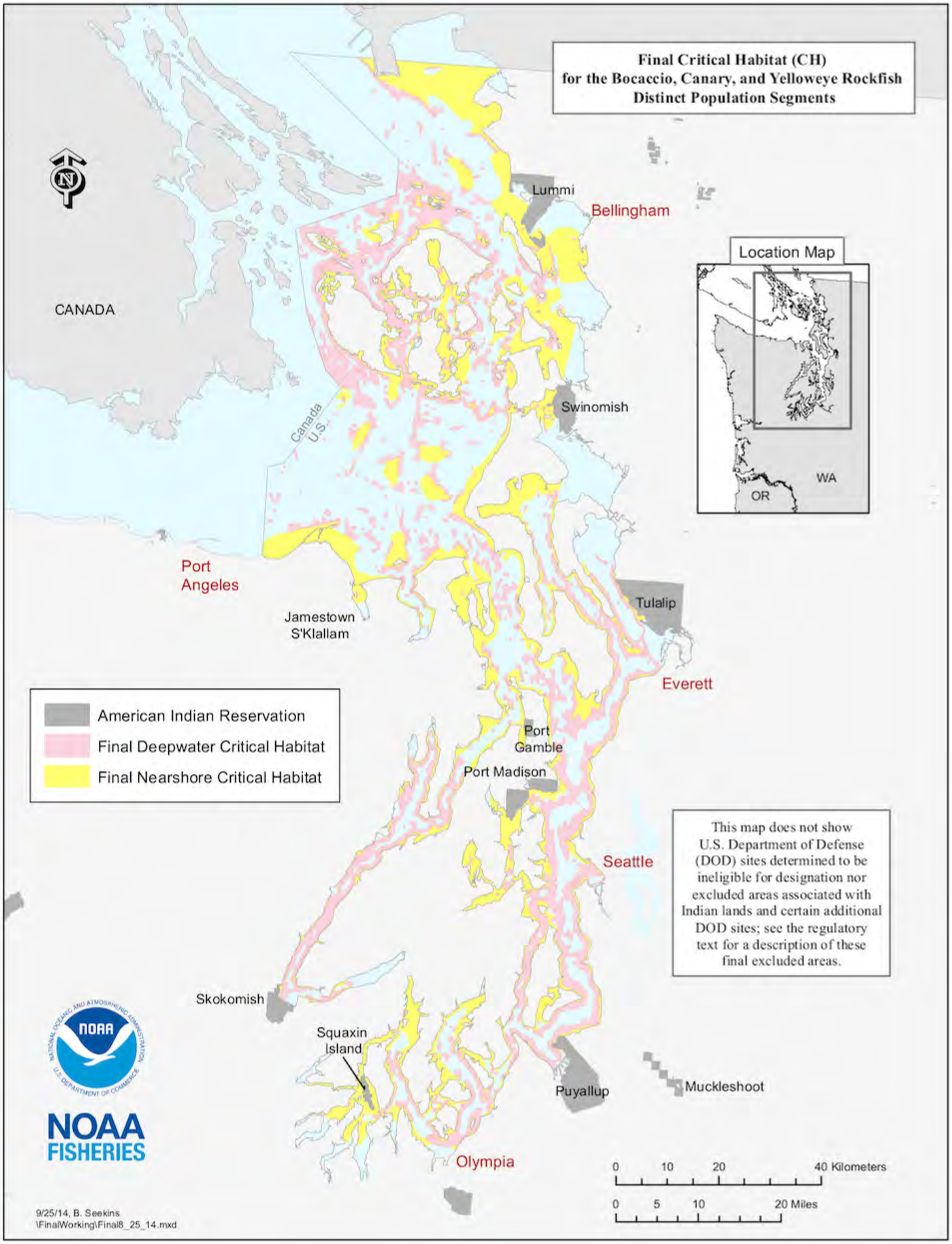

Figure 5. Designated Critical Habitat for ESA-listed Rockfishes.

Juvenile boccaccio settlement habitats located in the nearshore with substrates such as sand, rock and/or cobble compositions that also support kelp are essential for conservation because these features enable forage opportunities and refuge from predators and enable behavioral and physiological changes needed for juveniles to occupy deeper adult habitats (82 FR 7711). The PBFs for juvenile boccaccio in nearshore habitat are: (i) Quantity, quality, and availability of prey species to support individual growth, survival, and feeding opportunities; and (ii) Water quality and sufficient levels of dissolved oxygen to support growth, survival, reproduction, and feeding opportunities.

Benthic habitats and sites deeper than 30 meters that possess or are adjacent to areas of complex bathymetry consisting of rock and or highly rugose habitat are essential to conservation because these features support growth, survival, reproduction, and feeding opportunities by providing the structure for adult bocaccio to avoid predation, seek food and persist for decades (82 FR 7711). PBFs for adult bocaccio in deepwater habitat include the two above for juvenile bocaccio related to prey and water quality, as well as the following: (iii) the type and amount of structure and rugosity that supports feeding opportunities and predator avoidance.

Specific threats to boccaccio critical habitat include degradation of rocky habitat, loss of eelgrass and kelp, introduction of non-native species that modify habitat, and degradation of water quality.

The only stressors associated with the proposed action that would occur in the designated critical habitat would be those associated with vessel traffic while the research vessels transit back to port in Seattle. These would include noise associated with vessel operation, pollution from the vessel, and the visual disturbance created by the vessel.

The vessel transit associated with the proposed action will not alter prey quantity, quality, or availability or water quality. The noise, disturbance, and pollution potentially caused by the vessel during transit was evaluated in the previous sections, and found to be insignificant or discountable, respectively. The vessel transit will also not impact any benthic habitats, as the vessel will not anchor, and the likelihood of the vessel running aground is so remote as to be discountable. The effects of these stressors on the PBFs are not likely to reduce the conservation value of the critical habitat, and we conclude that the proposed action may affect, but is not likely to adversely affect designated critical habitat for Puget Sound/Georgia Basin DPS of boccaccio, canary rockfish, and yelloweye rockfish.

7.2.6.3 Humpback Whale Central America and Mexico Distinct Population Segment Proposed Critical Habitat

On October 9, 2019, NMFS proposed critical habitat for three distinct population segments of humpback whale on the U.S. West Coast: Central America, Mexico, and Western North Pacific DPSs. On April 21, 2021, the final rule (86 FR 21082) designating critical habitat for Central America, Mexico, and Western North Pacific DPS humpback whales was published. The designated critical habitat for the Western North Pacific DPS is exclusively in the waters of Alaska, outside of the action area for the proposed action. As such, it will not be discussed here.

The PBF for both the Mexico and Central America DPS critical habitat is prey species, primarily euphausiids and small pelagic schooling fishes of sufficient quality, abundance, and accessibility within humpback whale feeding areas to support feeding and population growth.

For the Central America DPS, the designated critical habitat includes marine waters in Washington, Oregon, and California (Figure 6). Designated critical habitat that falls within the action area are in Washington and Oregon. In Washington, the designated critical habitat nearshore boundary is defined by the 50-meter isobath, and the offshore boundary is defined by the 1,200-meter isobath relative to mean lower low water. Critical habitat also includes waters within the U.S. portion of the Strait of Juan de Fuca to an eastern boundary line at Angeles Point at 123°33′ W. In Oregon, the designated critical habitat nearshore boundary is defined by the 50-meter isobath. The offshore boundary is defined by the 1,200-meter isobath relative to mean lower low water; except, in areas off Oregon south of 42°10′, the offshore boundary is defined by the 2,000-meter isobath.

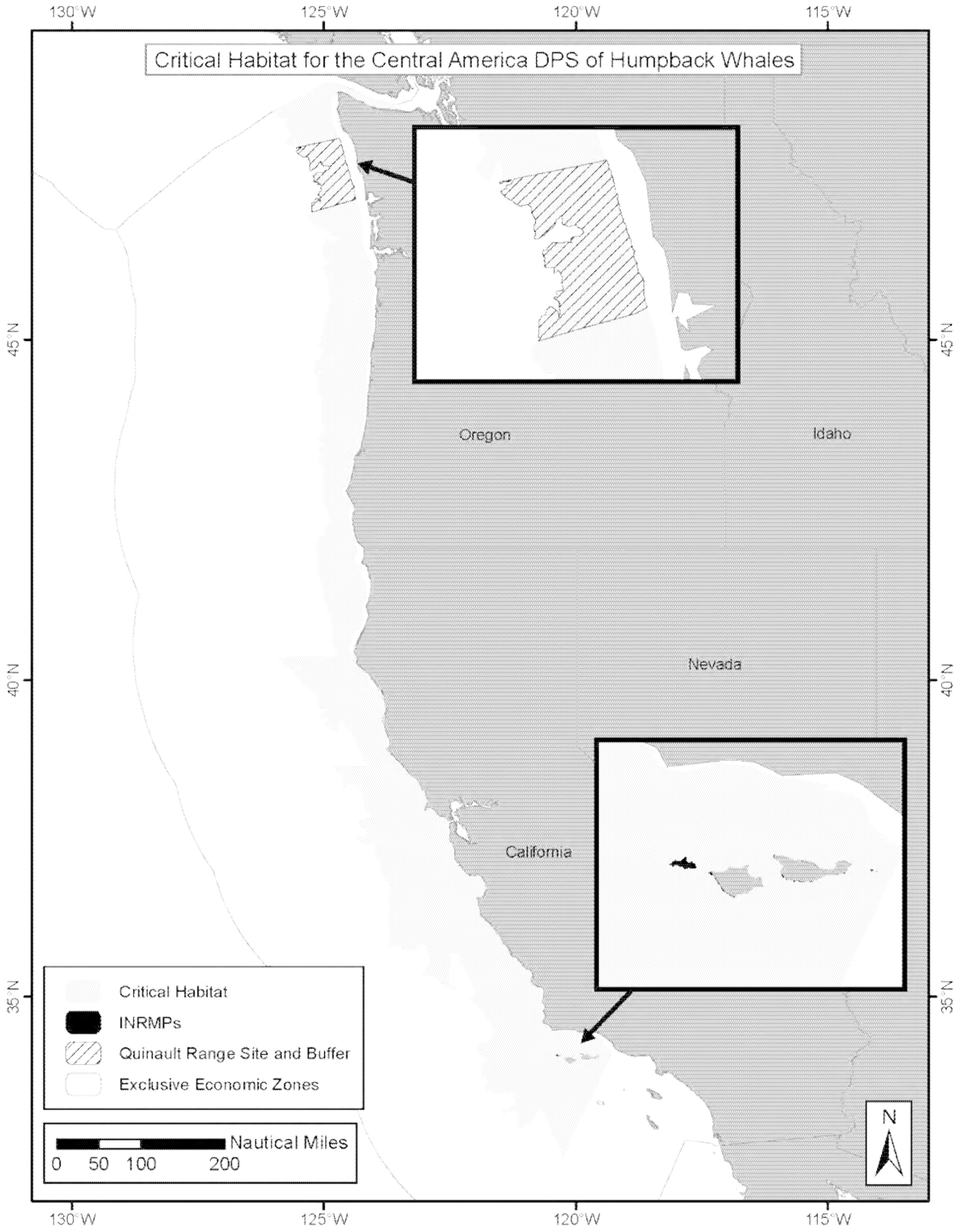

Figure 6. Designated critical habitat for the Central America distinct population segment of humpback whales. The Department of Defense areas subject to an Integrated Natural Resources Management Plan (INRMPs) and the Quinault Range Site are also depicted.

For the Mexico DPS, the designated critical habitat includes marine waters in Washington, Oregon, California, and Alaska (Figure 7). Only the areas proposed for designation in Washington and Oregon fall within the action area.

In Washington, the nearshore boundary is defined by the 50-meter isobath, and the offshore boundary is defined by the 1,200-meter isobath relative to mean lower low water. Critical habitat also includes waters within the U.S. portion of the Strait of Juan de Fuca to an eastern boundary line at Angeles Point at 123°33′ W.

In Oregon, the nearshore boundary is defined by the 50-meter isobath. The offshore boundary is defined by the 1,200-meter isobath relative to mean lower low water; except, in areas off Oregon south of 42°10′, the offshore boundary is defined by the 2,000-meter isobath.

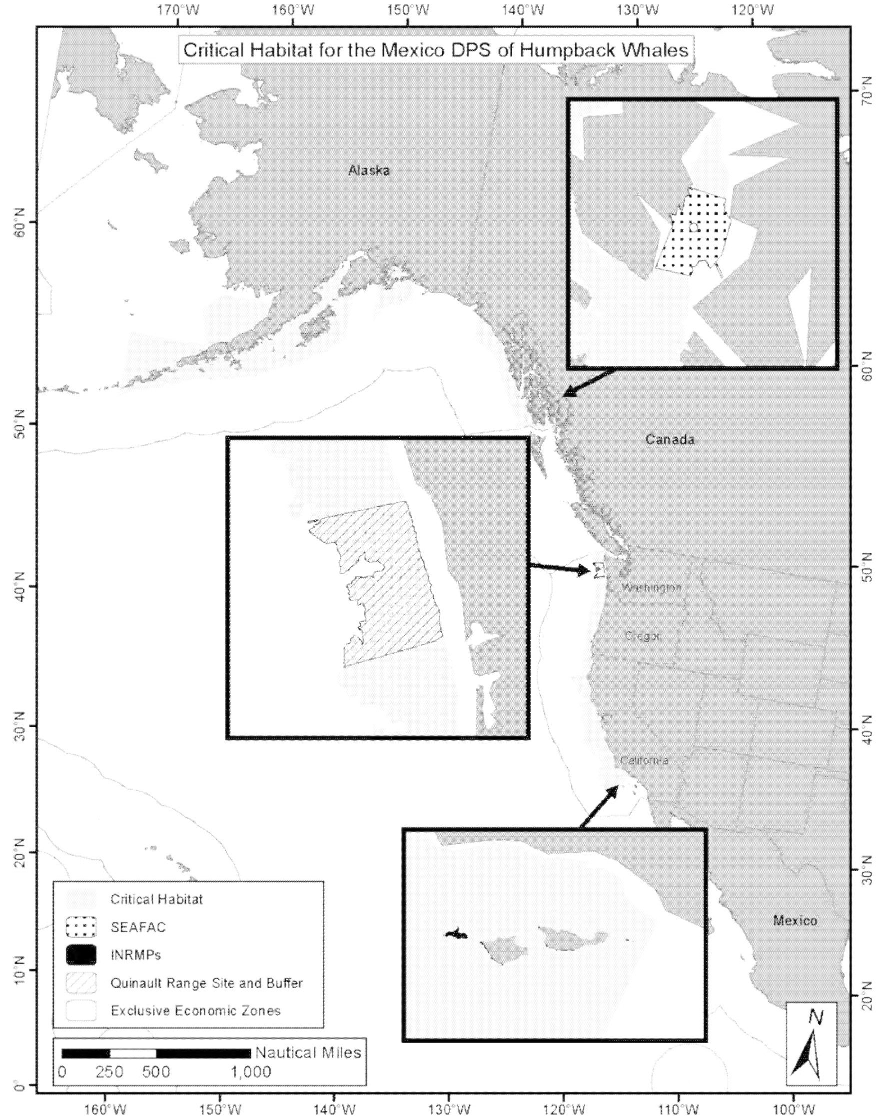

Figure 7. Designated critical habitat for Mexico distinct population segment of humpback whales. The Navy's Southeast Alaska Acoustic Measurement Facility (SEAFAC) and Department of Defense areas subject to an Integrated Natural Resources Management Plan (INRMPs), and the Quinault Range Site are also depicted.

The components of the proposed action that may impact the Mexico and Central America DPS humpback whale proposed critical habitat would be the sound from the airgun array affecting the occurrence of euphausiids and small pelagic schooling fishes. The disturbance caused by placement of ocean bottom seismometers (falling to the ocean floor) and nodes (placed by ROV) may also temporarily disperse fish. While the sound from airguns and the placement of the ocean bottom seismometers could disperse humpback whale prey, the impact is anticipated to be temporary and of short duration (only occurring during ensonification or activity duration, with a return to normal conditions a few days at most after the activity has ceased in an area) and of negligible magnitude (in terms of area size and proportion of available forage). The designated critical habitat is over 166,000 square kilometers along the entire U.S. West Coast (out to 1,200 meters deep, or 2,000 meters deep), compared to the 79,591 square kilometers for the entire ensonified area for the survey, in water depths over 6,000 meters deep. As a result, the effects of noise associated with the proposed seismic survey are anticipated to be insignificant. Therefore, the proposed action may affect, but is not likely to adversely affect Mexico and Central America DPS humpback whale critical habitat.

7.2.6.4 Steller Sea Lion Western Distinct Population Segment Critical Habitat

In 1997, NMFS designated critical habitat for the Steller sea lion. The Steller sea lion eastern DPS was delisted on November 4, 2013 (78 FR 66139); therefore, this DPS will not be considered in this opinion. However, this change in listing status does not affect the designated critical habitat for Steller sea lions (58 FR 45269), because "removing the eastern DPS from the List of Endangered and Threatened Wildlife does not remove or modify that designation" (78 FR 66162). Steller sea lion designated critical habitat remains in place until a separate rulemaking amends the designation.

The critical habitat includes specific rookeries, haulouts, and associated areas, as well as three foraging areas that are considered to be essential for the health, continued survival, and recovery of the species. The three areas of Steller sea lion critical habitat are located in Alaska, Oregon and California; only the critical habitat areas in Oregon fall within the action area. Within the action area, critical habitat is located on islands off the coast of Oregon (Long Brown and Seal Rocks, and Pyramid Rock).

In Oregon, major Steller sea lion rookeries and associated air and aquatic zones are designated as critical habitat. Critical habitat includes an air zone extending 3,000 feet (0.9 kilometers) above rookery areas historically occupied by sea lions. Critical habitat also includes an aquatic zone extending 3,000 feet (0.9 kilometers) seaward. These sites are located near Steller sea lion abundance centers and include important foraging areas, large concentrations of prey, and host large commercial fisheries that often interact with the species.

The PBFs identified for the aquatic areas of Steller sea lion designated critical habitat that occur within the action area are those that support foraging, such as adequate prey resources and available foraging habitat (58 FR 45269). While Steller sea lions do rest in aquatic habitat, there was insufficient information available at the time critical habitat was designated to include aquatic resting sites as part of the critical habitat designation (58 FR 45269).

The R/V *Oceanus* will not place ocean bottom seismometers or nodes in or near Steller sea lion critical habitat in Oregon, so that aspect of the proposed action will not affect critical habitat. The seismic survey tracklines will be about 9 and 13 kilometers away from the two Oregon units of Steller sea lion critical habitat. The extent of the ensonified area would reach the critical habitat. However, the R/V *Marcus G. Langseth* will travel at a speed of 4.2 knots (7.8 kilometers per hour during the survey, meaning the critical habitat units will only be exposed to sound from the seismic survey activity for a few hours.

Therefore, the short duration of the potential exposure, and the expected minor effects to prey species, lead us to conclude that the seismic survey activities would result in insignificant effects to designated Steller sea lion critical habitat. Therefore, the proposed action may affect, but is not likely to adversely affect Steller sea lion critical habitat.

7.2.6.5 Leatherback Turtle Critical Habitat

In 2012, NMFS revised designated critical habitat for the leatherback turtle by designating additional areas within the Pacific Ocean (Figure 6). This designation includes approximately 43,798 square kilometers (16,910 square miles) stretching along the California coast from Point Arena to Point Arguello east of the 3,000 meter (9,842.4 feet) depth contour; and 64,760 square kilometers (25,004 square miles) stretching from Cape Flattery, Washington to Cape Blanco, Oregon east of the 2,000 meter (6,561.7 feet) depth contour. The designated areas comprise approximately 108,558 square kilometers (41,914 square miles) of marine habitat and include waters from the ocean surface down to a maximum depth of 80 meters (262 feet). NMFS has identified one PBF for the conservation of leatherback turtles in marine waters off the U.S. West Coast that includes the occurrence of prey species, primarily scyphomedusae (i.e., jellyfish) of the order Semaeostomeae (e.g., *Chrysaora*, *Aurelia*, *Phacellophora*, and *Cyanea*), of sufficient condition, distribution, diversity, abundance, and density necessary to support individual as well as population growth, reproduction, and development of leatherback turtles (77 FR 4170).

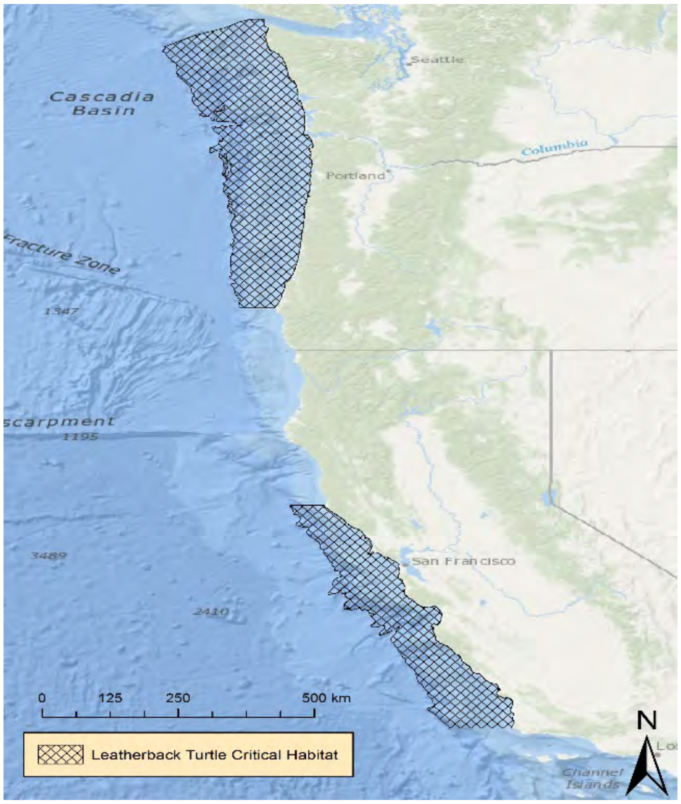

Figure 8. Map depicting leatherback turtle designated critical habitat along the United States Pacific Coast.

The components of the proposed action that may impact the leatherback sea turtle critical habitat would be the sound from the airgun array affecting the occurrence of jellyfish. While the sound could disperse leatherback prey, the impact is anticipated to be temporary and of short duration (only occurring during ensonification or activity duration, with a return to normal conditions a few days at most after the activity has ceased in an area) and of negligible magnitude (in terms of area size and proportion of available forage), and we consider those impacts to be insignificant. Therefore, proposed action may affect, but is not likely to adversely affect leatherback sea turtle critical habitat.

7.2.6.6 Green Sturgeon Southern Distinct Population Segment Critical Habitat

In 2009, NMFS designated critical habitat for the Southern DPS of green sturgeon. Specific areas include coastal U.S. marine waters within 109.7 meters (359.9 feet) depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its U.S. boundary; and certain coastal bays and estuaries in (Figure 9). NMFS designated approximately 2,323 square kilometers (11,421 square miles) of marine habitat as critical habitat for Southern DPS of green sturgeon. The PBFs essential for Southern DPS of green sturgeon include nearshore coastal marine areas that provide sufficient food resources, substrate type suitable for egg deposition, and development, water flow, water quality, migratory corridors, depth (greater than or equal to 5 meters [16.4 feet]), and sediment quality.

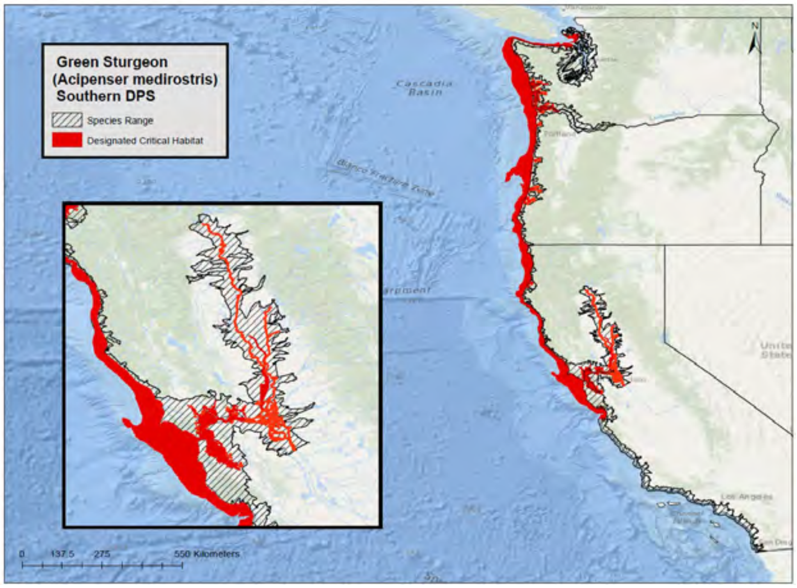

Figure 9. Map of geographic range (within the contiguous United States) and designated critical habitat for Southern distinct population segment of green sturgeon. Sacramento River basin inset.

The proposed activities do not occur in freshwater or estuarine habitats and will not affect critical habitat designated in these areas. Marine areas of critical habitat overlap with portions of the action area. The critical habitat's PBFs in marine habitat include migratory corridor, water quality, and food resources. No impediment of migration corridors would be expected to occur. The entire proposed action will take place over about 37 days, and the amount of time that the action will overlap with green sturgeon critical habitat is a few days. In the event acoustic stressors (or any other stressors) affect forage species, the impact is anticipated to be temporary and of short duration (only occurring during ensonification or activity duration) and of negligible magnitude (in terms of area size and proportion of available forage), and we consider those impacts to be insignificant. Therefore, we believe the proposed action may affect, but is not likely to adversely affect green sturgeon critical habitat.

7.2.6.7 Eulachon Southern Distinct Population Segment Critical Habitat

In 2011, NMFS designated critical habitat (76 FR 65324) for the Southern DPS of eulachon. Sixteen areas were designated in the states of Washington, Oregon, and California (Figure 10). The designated areas are a combination of freshwater creeks and rivers and their associated estuaries, comprising approximately 539 kilometers (335 miles) of habitat.

The PBFs essential to the conservation of the DPS include:

- Freshwater spawning and incubation sites with water flow, quality and temperature conditions and substrate supporting spawning and incubation, and with migratory access for adults and juveniles.
- Freshwater and estuarine migration corridors associated with spawning and incubation sites that are free of obstruction and with water flow, quality and temperature conditions

supporting larval and adult mobility, and with abundant prey items supporting larval feeding after the yok sac is depleted.

- Nearshore and offshore marine foraging habitat with water quality and available prey, supporting juveniles and adult survival. The components of the nearshore and offshore marine foraging essential feature include prey items in concentrations that support growth and reproductive development for juveniles and adults, and water quality with adequate dissolved oxygen, temperature, and lack of contaminants.

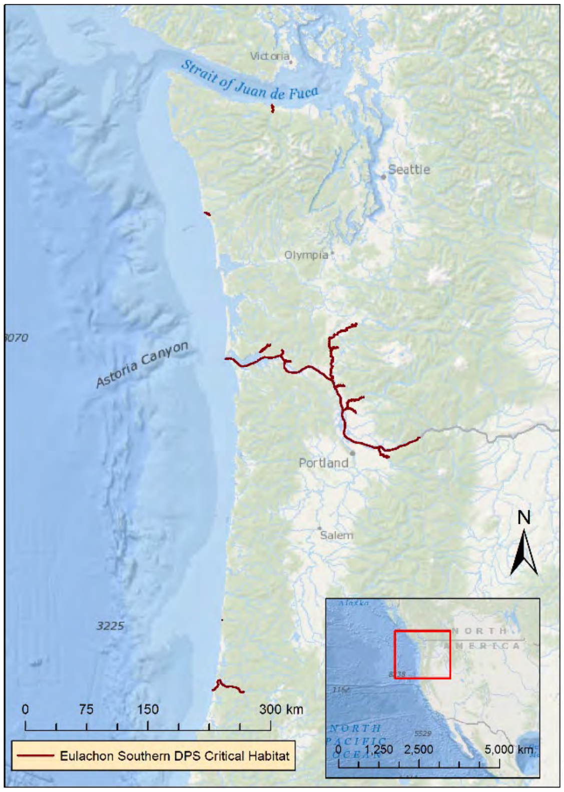

Figure 10. Map of designated critical habitat for the threatened Southern distinct population segment of eulachon; nearshore and marine areas of critical habitat not depicted.

The proposed action will take place off the coasts of Oregon and Washington. The ensonified area will not impact the nearshore and marine foraging areas off Washington, because the survey tracklines are far enough away from the coast, seaward of the 100-meter isobath. The ensonified area off Oregon may extend into the nearshore and marine foraging areas of critical habitat, because the survey lines, and resulting ensonified areas, extend closer to shore. The nearshore and marine foraging areas are within the proposed action area. The proposed action will involve vessel transit, placement of ocean bottom seismometers and ocean bottom nodes, seismic airgun activity, and operation of a multibeam echosounder and subbottom profiler, which will not alter water quality (other than the possibility of temporary and limited sediment resuspension as nodes or seismometers are dropped to the seaflood) or introduce contaminants into the marine environment; the marine debris (i.e., anchors from the oceanbottom seismometers) was analyzed and found to be insignificant (see 6.1 for further discussion). The sound produced by the airgun array may affect prey species like aquatic invertebrates and fishes. In the event acoustic stressors (or any other stressors) affect forage species, the impact is anticipated to be temporary and of short duration (only occurring during ensonification or activity duration, which would amount to a few days when the survey is off the coast of Oregon) and of negligible magnitude (in terms of area size and proportion of available forage). We consider these impacts to be insignificant, and conclude that the proposed action may affect, but is not likely to adversely affect Southern DPS eulachon critical habitat.

8 SPECIES AND CRITICAL HABITAT LIKELY TO BE ADVERSELY AFFECTED

This opinion examines the status of ESA-listed species and designated critical habitat that may be adversely affected by the proposed action.

The evaluation of adverse effects in this opinion begins by summarizing the biology and ecology of those species that are likely to be adversely affected and what is known about their life histories in the action area. The status is determined by the level of risk that the ESA-listed species face, based on parameters considered in documents such as recovery plans, status reviews, and listing decisions. This helps to inform the description of the species' current "reproduction, numbers, or distribution," which is part of the jeopardy determination as described in 50 C.F.R. §402.02. More detailed information on the status and trends of these ESA-listed species, and their biology and ecology can be found in the listing regulations and critical habitat designations published in the Federal Register, status reviews, recovery plans, and on this NMFS Web site: https://www.fisheries.noaa.gov/find-species.

One factor affecting the rangewide status of marine mammals, sea turtles, and aquatic habitat at large is climate change. Climate change will be discussed in the *Environmental Baseline* section (Section 9).

8.1 Blue Whale

The blue whale is a widely distributed baleen whale found in all major oceans. Blue whales are the largest animal on earth and distinguishable from other whales by a long body and comparatively slender shape, a broad, flat "rostrum" when viewed from above, proportionally smaller dorsal fin, and a mottled gray color that appears light blue when seen through the water. Most experts recognize at least three subspecies of blue whale, *B. m. musculus*, which occurs in the Northern Hemisphere, *B. m. intermedia*, which occurs in the Southern Ocean, and *B. m. brevicauda*, a pygmy species found in the Indian Ocean and South Pacific Ocean. The blue whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 1998), recent stock assessment reports (Carretta 2019a; Carretta 2019b), and recent scientific publications were used to summarize the life history, population dynamics, and status of the species as follows.

8.1.1 Life History

The average life span of blue whales is 80 to 90 years. They have a gestation period of ten to 12 months, and calves nurse for six to seven months. Blue whales reach sexual maturity between 5 and 15 years of age with an average calving interval of two to three years. They winter at low latitudes, where they mate, calve and nurse, and summer at high latitudes, where they feed. In the northeast Pacific, blue whales overwinter along the Pacific Coast of Baja California, and the upwelling area known as the Costa Rica Thermal Dome, but they may use other areas as well (Nichol 2011). Blue whales forage almost exclusively on krill and can eat approximately 3,600 kilograms (7,936.6 pounds) daily. Feeding aggregations are often found at the continental shelf edge, where upwelling produces concentrations of krill at depths of 90 to 120 meters (295.3 to 393.7 feet).

8.1.2 Population Dynamics

The global, pre-exploitation estimate for blue whales is approximately 181,200 (IWC 2007b). Current estimates indicate approximately 5,000 to 12,000 blue whales globally (IWC 2007b). Blue whales are separated into populations by ocean basin in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. There are three stocks of blue whales designated in United States waters: the Eastern North Pacific Ocean, Central North Pacific Ocean, and Western North Atlantic Ocean. Due to the location of the action, the Eastern North Pacific stock of blue whales is most likely to be in the action area. The minimum population size for eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta 2019a).

Current estimates indicate a growth rate of just under three percent per year for the eastern North Pacific stock (Calambokidis 2009).

Little genetic data exist on blue whales globally. Data on genetic diversity of blue whales in the Northern Hemisphere are currently unavailable. However, genetic diversity information for similar cetacean population sizes can be applied. Stocks that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Stocks that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Stock population at low densities (less than 100) are more likely to suffer from the 'Allee' effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density.

In general, distribution is driven largely by food requirements; blue whales are more likely to occur in waters with dense concentrations of their primary food source, krill. While they can be found in coastal waters, they are thought to prefer waters further offshore. In Canadian Pacific waters, blue whale habitat includes the continental shelf break, continental slope, and offshore waters beyond the shelf break (Canada 2017). Off California, they are associated with areas of upwelling off the continental slope, likely due to high concentrations of zooplankton there

(Nichol 2011). Data from satellite telemetry research indicate that blue whales in U.S. West Coast waters spend about five months outside the U.S. EEZ, from November to March (Hazen et al. 2017). In the North Pacific Ocean, blue whales range from Kamchatka to southern Japan in the west and from the Gulf of Alaska and California to Costa Rica in the east. They primarily occur off the Aleutian Islands and the Bering Sea.

8.1.3 Vocalization and Hearing

Blue whale vocalizations tend to be long (greater than 20 seconds), low frequency (less than 100 hertz) signals (Thomson and Richardson 1995a), with a range of 12 to 400 hertz and dominant energy in the infrasonic range of 12 to 25 hertz (McDonald et al. 1995; Mcdonald et al. 2001; Mellinger and Clark 2003). Vocalizations are predominantly songs and calls.

Calls are short-duration sounds (two to five seconds) that are transient and frequency-modulated, having a higher frequency range and shorter duration than song units and often sweeping down in frequency (20 to 80 hertz), with seasonally variable occurrence. Blue whale calls have high acoustic energy, with reports of source levels ranging from 180 to 195 dB re: 1 μPa at 1 meter (Cummings and Thompson 1971; Aburto et al. 1997; Mcdonald et al. 2001; Clark and Gagnon 2004; Berchok et al. 2006; Samaran et al. 2010). Calling rates of blue whales tend to vary based on feeding behavior. For example, blue whales make seasonal migrations to areas of high productivity to feed, and vocalize less at the feeding grounds then during migration (Burtenshaw et al. 2004a). Stafford et al. (2005) recorded the highest calling rates when blue whale prey was closest to the surface during its vertical migration. Wiggins et al. (2005) reported the same trend of reduced vocalization during daytime foraging followed by an increase at dusk as prey moved up into the water column and dispersed. Oleson et al. (2007c) reported higher calling rates in shallow diving (less than 30 meters [98.4 feet] whales), while deeper diving whales (greater than 50 meters [154 feet]) were likely feeding and calling less.

Although general characteristics of blue whale calls are shared in distinct regions (Thompson et al. 1996; Mcdonald et al. 2001; Mellinger and Clark 2003; Rankin et al. 2005), some variability appears to exist among different geographic areas (Rivers 1997). Sounds in the North Atlantic Ocean have been confirmed to have different characteristics (i.e., frequency, duration, and repetition) than those recorded in other parts of the world (Mellinger and Clark 2003; Berchok et al. 2006; Samaran et al. 2010). Clear differences in call structure suggestive of separate populations for the western and eastern regions of the North Pacific Ocean have also been reported (Stafford et al. 2001); however, some overlap in calls from the geographically distinct regions have been observed, indicating that the whales may have the ability to mimic calls (Stafford and Moore 2005). In Southern California, blue whales produce three known call types: Type A, B, and D. B calls are stereotypic of blue whale population found in the eastern North Pacific (McDonald et al. 2006) and are produced exclusively by males and associated with mating behavior (Oleson et al. 2007a). These calls have long durations (20 seconds) and low frequencies (10 to 100 hertz); they are produced either as repetitive sequences (song) or as singular calls. The B call has a set of harmonic tonals, and may be paired with a pulsed Type A call. D calls are produced in highest numbers during the late spring and early summer and in diminished numbers during the fall, when A-B song dominates blue whale calling (Oleson et al. 2007c; Hildebrand et al. 2011; Hildebrand et al. 2012).

Blue whale songs consist of repetitively patterned vocalizations produced over time spans of minutes to hours or even days (Cummings and Thompson 1971; Mcdonald et al. 2001). The songs are divided into pulsed/tonal units, which are continuous segments of sound, and phrases, repeated in combinations of one to five units (Payne and Mcvay 1971; Mellinger and Clark 2003). Songs can be detected for hundreds, and even thousands of kilometers (Stafford et al. 1998), and have only been attributed to males (Mcdonald et al. 2001; Oleson et al. 2007a). Worldwide, songs are showing a downward shift in frequency (McDonald et al. 2009). For example, a comparison of recording from November 2003 and November 1964 and 1965 reveals a long-term shift in the frequency of blue whale calling near San Nicolas Island. In 2003, the spectral energy peak was 16 hertz compared to approximately 22.5 hertz in 1964 and 1965, illustrating a more than 30 percent shift in call frequency over four decades (McDonald et al. 2006). McDonald et al. (2009) observed a 31 percent downward frequency shift in blue whale calls off the coast of California, and also noted lower frequencies in seven of the world's ten known blue whale songs originating in the Atlantic, Pacific, Southern, and Indian Oceans. Many possible explanations for the shifts exist but none have emerged as the probable cause.

As with other baleen whale vocalizations, blue whale vocalization function is unknown, although numerous hypotheses exist (maintaining spacing between individuals, recognition, socialization, navigation, contextual information transmission, and location of prey resources; (Payne and Webb. 1971; Thompson et al. 1992; Edds-Walton 1997; Oleson et al. 2007b). Intense bouts of long, patterned sounds are common from fall through spring in low latitudes, but these also occur less frequently while in summer high-latitude feeding areas. Short, rapid sequences of 30 to 90 hertz calls are associated with socialization and may be displays by males based upon call seasonality and structure. The low frequency sounds produced by blue whales can, in theory, travel long distances, and it is possible that such long distance communication occurs (Payne and Webb. 1971; Edds-Walton 1997). The long-range sounds may also be used for echolocation in orientation or navigation (Tyack 1999).

Direct studies of blue whale hearing have not been conducted, but it is assumed that blue whales can hear the same frequencies that they produce (low frequency) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). Based on vocalizations and anatomy, blue whales are assumed to predominantly hear low-frequency sounds below 400 hertz (Croll et al. 2001; Stafford and Moore 2005; Oleson et al. 2007c). In terms of functional hearing capability, blue whales belong to the low frequency group, which have a hearing range of 7 hertz to 35 kilohertz (NOAA 2018).

8.1.4 Status

The blue whale is endangered as a result of past commercial whaling. In the eastern North Pacific Ocean, about 3,411 blue whales were killed between 1905 and 1971 (Monnahan et al.

2014). According to historical whaling records from five whaling stations in British Columbia, 1,398 blue whales were killed between 1908 and 1967 (Gregr et al. 2000). Commercial whaling no longer occurs, but blue whales are affected by anthropogenic noise, threatened by ship strikes, entanglement in fishing gear, pollution, harassment due to whale watching, and reduced prey abundance and habitat degradation due to climate change. Because populations appear to be increasing in size, the species appears to be somewhat resilient to current threats; however, the species has not recovered to pre-exploitation levels.

8.1.5 Critical Habitat

No critical habitat has been designated for the blue whale.

8.1.6 Recovery Goals

See the 1998 Final Recovery Plan for the Blue Whale for complete downlisting/delisting criteria for each of the following recovery goals:

1. Determine stock structure of blue whale populations occurring in U.S. waters and elsewhere.
2. Estimate the size and monitor trends in abundance of blue whale populations.
3. Identify and protect habitat essential to the survival and recovery of blue whale populations.
4. Reduce or eliminate human-caused injury and mortality of blue whales.
5. Minimize detrimental effects of directed vessel interactions with blue whales.
6. Maximize efforts to acquire scientific information from dead, stranded, and entangled blue whales.
7. Coordinate state, federal, and international efforts to implement recovery actions for blue whales.
8. Establish criteria for deciding whether to delist or downlist blue whales.

8.2 Fin Whale

The fin whale is a large, widely distributed baleen whale found in all major oceans and comprised of three subspecies: *B. p. physalus* in the Northern Hemisphere, and *B. p. quoyi* and *B. p. patachaonica* (a pygmy form) in the Southern Hemisphere. Within the action area, fin whales occur year round off the coasts of Oregon and Washington (Carretta 2019b), as well as in the waters of British Columbia throughout the year (DFO 2017).

Fin whales are distinguishable from other whales by a sleek, streamlined body, with a V-shaped head, a tall falcate dorsal fin, and a distinctive color pattern of a black or dark brownish-gray body and sides with a white ventral surface. The lower jaw is gray or black on the left side and creamy white on the right side. The fin whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010b), recent stock assessment reports (Carretta 2019a; Carretta 2019b), and status review (NMFS 2011e) were used to summarize the life history, population dynamics and status of the species as follows.

8.2.1 Life History

Fin whales can live, on average, 80 to 90 years. They have a gestation period of less than one year, and calves nurse for six to seven months. Data from historical whaling records in Hecate Strait and Queen Charlotte Sound indicate that most births in the region occurred between mid-November and mid-March, with a peak in January (DFO 2017). Sexual maturity is reached between six and ten years of age with an average calving interval of two to three years. They mostly inhabit deep, offshore waters of all major oceans. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed, although some fin whales appear to be residential to certain areas. Acoustic recording data in British Columbia indicate that fin whales are present year-round (Koot 2015). Due to the detection of calling males from November through January, researchers assume that breeding occurs in Canadian Pacific waters in Hecate Strait and Queen Charlotte Sound during that time of year (DFO 2017). Fin whales eat pelagic crustaceans (mainly euphausiids or krill) and schooling fish such as capelin, herring, and sand lice. There is a presumed feeding area along the Juan de Fuca Ridge off northern Washington, based on rates of fin whale calls in the area from fall through February (Soule and Wilcock 2013; Muto et al. 2019).

8.2.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the fin whale.

The pre-exploitation estimate for the fin whale population in the North Pacific Ocean was 42,000 to 45,000. The North Pacific population of fin whales was reduced to 13,620 to 18,680 by 1973 (Ohsumi and Wada 1974). There are three stocks in United States Pacific Ocean waters: Northeast Pacific [minimum 1,368 individuals], Hawaii (approximately 58 individuals [N_{min}=27]) and California/Oregon/Washington (approximately 9,029 [N_{min}=8,127] individuals) (Nadeem et al. 2016). According to whaling records from Canadian Pacific waters, at least 7,605 fin whales were killed between 1908 to 1967 (Gregr et al. 2000).

The best current abundance estimate for fin whales in California, Oregon, and Washington waters out to 300 nautical miles is 9,029 (CV=0.12) (Nadeem et al. 2016); the minimum population estimate is 8,127 individuals (Carretta 2019b). Based on a photo-identification mark-recapture model using data from the Hecate Strait and Queen Charlotte Sound in British Columbia, fin whale abundance for that area was estimated at 405 individuals (CV=0.6, 95% CI=363-469) (Nichol 2018). An overall fin whale population trend in the U.S. Pacific has not been established, but there is evidence that there has been increasing rates in the recent past in different parts of the region. From 1991 to 2014, the estimated average rate of increase for

California, Oregon, and Washington waters was 7.5 percent, with the caveat that is unknown how much of that rate could be attributed to immigration rather than birth and death processes (Carretta 2019b).

Archer et al. (2013) examined the genetic structure and diversity of fin whales globally. Full sequencing of the mitochondrial DNA genome for 154 fin whales sampled in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere, resulted in 136 haplotypes, none of which were shared among ocean basins suggesting differentiation at least at this geographic scale. However, North Atlantic Ocean fin whales appear to be more closely related to the Southern Hemisphere population, as compared to fin whales in the North Pacific Ocean, which may indicate a revision of the subspecies delineations is warranted. Results of a later single-nucleotide polymorphism analysis indicate that distinct mitogenome matrilines in the North Pacific are interbreeding (Archer et al. 2019). Generally speaking, haplotype diversity was found to be high both within oceans basins, and across, with the greatest diversity found in North Pacific fin whales (Archer et al. 2019). Such high genetic diversity and lack of differentiation within ocean basins may indicate that despite some populations having small abundance estimates, the species may persist long-term and be somewhat protected from substantial environmental variance and catastrophes.

Within the action area, fin whales are present year-round off the coasts of Oregon, Washington, and Vancouver Island. The availability of prey, sand lice in particular, is thought to have had a strong influence on the distribution and movements of fin whales.

8.2.3 Vocalization and Hearing

Fin whales produce a variety of low frequency sounds in the 10 to 200 hertz range (Watkins 1981; Watkins et al. 1987; Edds 1988; Thompson et al. 1992). Typical vocalizations are long, patterned pulses of short duration (0.5 to two seconds) in the 18 to 35 hertz range, but only males are known to produce these (Patterson and Hamilton 1964; Clark et al. 2002). The most typically recorded call is a 20 hertz pulse lasting about one second, and reaching source levels of 189 ±4 dB re: 1 µPa at 1 meter (Watkins 1981; Watkins et al. 1987; Edds 1988; Richardson et al. 1995c; Charif et al. 2002; Clark et al. 2002; Sirovic et al. 2007). These pulses frequently occur in long sequenced patterns, are down swept (e.g., 23 to 18 hertz), and can be repeated over the course of many hours (Watkins et al. 1987). In temperate waters, intense bouts of these patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Richardson et al. (1995c) reported this call occurring in short series during spring, summer, and fall, and in repeated stereotyped patterns in winter. The seasonality and stereotype nature of these vocal sequences suggest that they are male reproductive displays (Watkins 1981; Watkins et al. 1987); a notion further supported by data linking these vocalizations to male fin whales only (Croll et al. 2002). In Southern California, the 20 hertz pulses are the dominant fin whale call type associated both with call-counter-call between multiple animals and with singing (Navy 2010; U.S. Navy 2012). An additional fin whale sound, the 40 hertz call described by Watkins (1981), was also frequently recorded, although these calls are not as common as the 20 hertz fin whale pulses. Seasonality of the 40 hertz calls differed from the 20 hertz calls, since 40 hertz calls were more prominent in the spring, as observed at other sites across the northeast Pacific Ocean (Sirovic et al. 2012). Source levels of Eastern Pacific Ocean fin whale 20 hertz calls has been reported as 189 ± 5.8 dB re: 1 µPa at 1 meter (Weirathmueller et al. 2013). Some researchers have also recorded moans of 14 to 118 hertz, with a dominant frequency of 20 hertz, tonal vocalizations of 34 to 150 hertz, and songs of 17 to 25 hertz (Watkins 1981; Edds 1988; Cummings and Thompson 1994). In general, source levels for fin whale vocalizations are 140 to 200 dB re: 1 µPa at 1 meter (as compiled by Erbe 2002c; see also Clark and Gagnon 2004). The source depth of calling fin whales has been reported to be about 50 meters (164 feet) (Watkins et al. 1987). Although acoustic recordings of fin whales from many diverse regions show close adherence to the typical 20-hertz bandwidth and sequencing when performing these vocalizations, there have been slight differences in the pulse patterns, indicative of some geographic variation (Watkins et al. 1987; Thompson et al. 1992).

Although their function is still in doubt, low frequency fin whale vocalizations travel over long distances and may aid in long distance communication (Payne and Webb. 1971; Edds-Walton 1997). During the breeding season, fin whales produce pulses in a regular repeating pattern, which have been proposed to be mating displays similar to those of humpback whales (Croll et al. 2002). These vocal bouts last for a day or longer (Tyack 1999). Also, it has been suggested that some fin whale sounds may function for long range echolocation of large-scale geographic targets such as seamounts, which might be used for orientation and navigation (Tyack 1999).

Direct studies of fin whale hearing have not been conducted, but it is assumed that fin whales can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). This suggests fin whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In a study using computer tomography scans of a calf fin whale skull, Cranford and Krysl (2015) found sensitivity to a broad range of frequencies between 10 hertz and 12 kilohertz and a maximum sensitivity to sounds in the 1 to 2 kilohertz range. In terms of functional hearing capability, fin whales belong to the low-frequency group, which have a hearing range of 7 hertz to 35 kilohertz (NOAA 2018).

8.2.4 Status

The fin whale is endangered as a result of past commercial whaling. Prior to commercial whaling, hundreds of thousands of fin whales existed. Fin whales may be killed under "aboriginal subsistence whaling" in Greenland, under Japan's scientific whaling program, and Iceland's formal objection to the International Whaling Commission's ban on commercial whaling. Additional threats include ship strikes, reduced prey availability due to overfishing or climate change, and noise. The species' overall large population size may provide some resilience to current threats, but trends are largely unknown.

8.2.5 Critical Habitat

No critical habitat has been designated for the fin whale.

8.2.6 Recovery Goals

See the 2010 Final Recovery Plan for the fin whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable population in all ocean basins.
2. Ensure significant threats are addressed.

8.3 Humpback Whale—Central America and Mexico Distinct Population Segments

The humpback whale is a widely distributed baleen whale found in all major oceans. Humpback whales are distinguishable from other whales by long pectoral fins and are typically dark grey with some areas of white. The humpback whale was originally listed as endangered on December 2, 1970 (35 FR 18319). Since then, NMFS has designated 14 DPSs with four identified as endangered (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, and Arabian Sea) and one as threatened (Mexico).

Information available from the recovery plan (NMFS 1991), the recent stock assessment report (Carretta 2019b), the status review (Bettridge et al. 2015), and the final listing were used to summarize the life history, population dynamics and status of the species as follows.

8.3.1 Life History

Humpback whales can live, on average, 50 years. They have a gestation period of 11 to 12 months, and calves nurse for one year. Sexual maturity is reached between five to 11 years of age. Every one to five years, females give birth to a single calf, with an average calving interval of two to three years. Humpback whales mostly inhabit coastal and continental shelf waters. They winter at lower latitudes, where they calve and nurse, and summer at high latitudes, where they feed. In British Columbia, the highest numbers of humpback whales are found between May and October, however, individuals are observed throughout the year (Ford 2009). Humpback whales exhibit a wide range of foraging behaviors and feed on a range of prey types, including: small schooling fishes, euphausiids, and other large zooplankton (Bettridge et al. 2015).

8.3.2 Population Dynamics

The following is a discussion of the species' population and its variance over time. This section includes abundance, population growth rate, genetic diversity, and spatial distribution as it relates to the Central America DPS and Mexico DPS of humpback whales.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). Prior to 1905, whaling records indicate that the humpback whale population in the North Pacific was 15,000 whales. By 1966, whaling had reduced the North Pacific population to about 1,200. In the 2015 status review for humpback whales, the abundance of the Central America DPS was 431 (CV=0.3) and 783 (CV=0.17) individuals (Bettridge et al. 2015); however, this estimate is based on data from 2004 through 2006, and is not considered a reliable estimate of current abundance (Carretta 2019a). A population growth rate is currently unavailable for the Central America DPS and the Mexico DPS of humpback whales. The current abundance of the Mexico DPS is unavailable, but it is thought to be more than 2,000 individuals (Bettridge et al. 2015).

The Canadian Department of Fisheries and Oceans describes the humpback whales in their jurisdictional waters as the Canadian North Pacific population, which ranges from along the west coast of Vancouver, between the borders from Washington to Alaska. The best estimate of this population is 2,145 individuals (Canada 2013).

For humpback whales, DPSs that have a total population size of 2,000 to 2,500 individuals or greater provide for maintenance of genetic diversity resulting in long-term persistence and protection from substantial environmental variance and catastrophes. Distinct population segments that have a total population of 500 individuals or less may be at a greater risk of extinction due to genetic risks resulting from inbreeding. Populations at low densities (less than one hundred) are more likely to suffer from the 'Allee" effect, where inbreeding and the heightened difficulty of finding mates reduces the population growth rate in proportion with reducing density. The Central America DPS has just below 500 individuals and so may be subject to genetic risks due to inbreeding and moderate environmental variance. The Mexico DPS is estimated to have more than 2,000 individuals and thus, should have enough genetic diversity for long-term persistence and protection from substantial environmental variance and catastrophes (Bettridge et al. 2015).

The Central America DPS is composed of humpback whales that breed along the Pacific coast of Costa Rica, Panama, Guatemala, El Salvador, Honduras, and Nicaragua. This DPS feeds almost exclusively offshore of California and Oregon in the eastern Pacific Ocean, with only a few individuals identified at the northern Washington – southern British Columbia feeding grounds.

The Mexico DPS is composed of humpback whales that breed along the Pacific coast of mainland Mexico, and the Revillagigedos Islands, and transit through the Baja California Peninsula coast. This DPS feeds across a broad geographic range from California to the Aleutian Islands, with concentrations in California-Oregon, northern Washington-southern British Columbia, northern and western Gulf of Alaska, and Bering Sea feeding grounds (81 FR 62259).

8.3.3 Vocalization and Hearing

Humpback whale vocalization is much better understood than is hearing. Different sounds are produced that correspond to different functions: feeding, breeding, and other social calls (Dunlop et al. 2008). Males sing complex sounds while in low-latitude breeding areas in a frequency range of 20 hertz to 4 kilohertz with estimated source levels from 144 to 174 dB (Winn et al. 1970b; Richardson et al. 1995f; Au et al. 2000; Frazer and Mercado Iii 2000; Au et al. 2006b). Males also produce sounds associated with aggression, which are generally characterized by frequencies between 50 hertz to 10 kilohertz with most energy below 3 kilohertz (Tyack 1983b;

Silber 1986b). Such sounds can be heard up to 9 kilometers (4.9 nautical miles) away (Tyack 1983b). Other social sounds from 50 hertz to 10 kilohertz (most energy below 3 kilohertz) are also produced in breeding areas (Tyack 1983b; Richardson et al. 1995f). While in northern feeding areas, both sexes vocalize in grunts (25 hertz to 1.9 kilohertz), pulses (25 to 89 hertz) and songs (ranging from 30 hertz to 8 kilohertz but dominant frequencies of 120 hertz to 4 kilohertz), which can be very loud (175 to 192 dB re: 1 μPa at 1 meter) (Payne 1985; Thompson et al. 1986b; Richardson et al. 1995f; Au et al. 2000; Erbe 2002b). However, humpback whales tend to be less vocal in northern feeding areas than in southern breeding areas (Richardson et al. 1995f). NMFS classified humpback whales in the low-frequency cetacean (i.e., baleen whale) functional hearing group. As a group, it is estimated that baleen whales can hear frequencies between 0.007 and 30 hertz (NOAA 2013a). Houser et al. (2001) produced a mathematical model of humpback whale hearing sensitivity based on the anatomy of the humpback whale ear. Based on the model, they concluded that humpback whales will be sensitive to sound in frequencies ranging from 0.7 to 10 kilohertz, with a maximum sensitivity between 2 to 6 kilohertz.

Humpback whales are known to produce three classes of vocalizations: (1) "songs" in the late fall, winter, and spring by solitary males; (2) social sounds made by calves (Zoidis et al. 2008) or within groups on the wintering (calving) grounds; and (3) social sounds made on the feeding grounds (Thomson and Richardson 1995b). The best-known types of sounds produced by humpback whales are songs, which are thought to be reproductive displays used on breeding grounds and sung only by adult males (Schevill et al. 1964; Helweg et al. 1992; Gabriele and Frankel. 2002; Clark and Clapham 2004; Smith et al. 2008). Singing is most common on breeding grounds during the winter and spring months, but is occasionally heard in other regions and seasons (McSweeney et al. 1989; Gabriele and Frankel. 2002; Clark and Clapham 2004). (Au et al. 2006a) noted that humpback whales off Hawaii tended to sing louder at night compared to the day. There is a geographical variation in humpback whale song, with different populations singing a basic form of a song that is unique to their own group. However, the song evolves over the course of a breeding season but remains nearly unchanged from the end of one season to the start of the next (Payne et al. 1983). The song is an elaborate series of patterned vocalizations that are hierarchical in nature, with a series of songs ('song sessions') sometimes lasting for hours (Payne and Mcvay 1971). Components of the song range from below 20 hertz up to 4 kilohertz, with source levels measured between 151 and 189 dB re: 1 μPa-m and high frequency harmonics extending beyond 24 kilohertz (Winn et al. 1970b; Au et al. 2006a). Social calls range from 20 hertz to 10 kilohertz, with dominant frequencies below 3 kilohertz (D'Vincent et al. 1985; Silber 1986b; Simao and Moreira 2005; Dunlop et al. 2008). Female vocalizations appear to be simple; Simao and Moreira (2005) noted little complexity.

"Feeding" calls, unlike song and social sounds are a highly stereotyped series of narrow-band trumpeting calls. These calls are 20 hertz to 2 kilohertz, less than one second in duration, and have source levels of 162 to 192 dB re: 1 μPa-m (D'Vincent et al. 1985; Thompson et al. 1986b). The fundamental frequency of feeding calls is approximately 500 Hertz (D'Vincent et al. 1985; Thompson et al. 1986b). The acoustics and dive profiles associated with humpback whale feeding behavior in the northwest Atlantic Ocean has been documented with digital acoustic recording tags (Stimpert et al. 2007). Underwater lunge behavior was associated with nocturnal feeding at depth and with multiple boats of broadband click trains that were acoustically different from toothed whale echolocation: (Stimpert et al. 2007) termed these sounds "mega-clicks" which showed relatively low received levels at the DTAGs (143 to 154 dB re: 1 µPa), with the majority of acoustic energy below 2 kilohertz.

In terms of functional hearing capability, humpback whales belong to low frequency cetaceans which have a hearing range of 7 hertz to 22 kilohertz (Southall et al. 2007b). Humpback whale audiograms using a mathematical model based on the internal structure of the ear estimate sensitivity is from 700 hertz to 10 kilohertz, with maximum relative sensitivity between 2 kilohertz and 6 kilohertz (Ketten and Mountain 2014). Research by Au et al. (2001) and Au et al. (2006a) off Hawaii indicated the presence of high frequency harmonics in vocalizations up to and beyond 24 kilohertz. While recognizing this was the upper limit of the recording equipment, it does not demonstrate that humpback whales can actually hear those harmonics, which may simply be correlated harmonics of the frequency fundamental in the humpback whale song. The ability of humpback whales to hear frequencies around 3 kilohertz may have been demonstrated in a playback study. Maybaum (1990b) reported that humpback whales showed a mild response to a handheld sonar marine mammal detection and location device with frequency of 3.3 kilohertz at 219 dB re: 1 µPa-m or frequency sweep of 3.1 to 3.6 kilohertz. In addition, the system had some low frequency components (below 1 kilohertz), which may have been an artifact of the acoustic equipment. This possible artifact may have affected the response of the whales to both the control and sonar playback conditions.

8.3.4 Status

Humpback whales were originally listed as endangered because of past commercial whaling, and the five DPSs that remain listed (Cape Verde Islands/Northwest Africa, Western North Pacific, Central America, Arabian Sea, and Mexico) have likely not yet recovered from this. According to historical whaling records from five whaling stations in British Columbia, 5,638 humpback whales were killed between 1908 and 1967 (Gregr et al. 2000). We have no way of knowing the degree to which a specific DPS of humpback whale was affected by historical whaling. However, it is likely that individuals from both the Mexico and Central America DPSs were taken, based on where the whalers were hunting off British Columbia (i.e., the purported feeding grounds for these population segments). Prior to commercial whaling, hundreds of thousands of humpback whales existed. Global abundance declined to the low thousands by 1968, the last year of substantial catches (IUCN 2012). Humpback whales may be killed under "aboriginal subsistence whaling" and "scientific permit whaling" provisions of the International Whaling Commission. Additional threats include ship strikes, fisheries interactions (including entanglement), energy development, and harassment from whaling watching noise, harmful algal blooms, disease, parasites, and climate change. Due to on-going threats, and the purported low population size, the Central America DPS still faces a risk of extinction. The Mexico DPS has a comparatively larger population than the Central America DPS, but still faces a risk of becoming endangered within the foreseeable future throughout all or a significant portion of its range.

8.3.5 Critical Habitat

Critical habitat has been designated for Central America and Mexico DPS humpback whales (86 FR 21082); see discussion in Section 7.2.5.1.

8.3.6 Recovery Goals

See the 1991 Final Recovery Plan for the humpback whale for the complete downlisting/delisting criteria for each of the four following recovery goals:

1. Maintain and enhance habitats used by humpback whales currently or historically.
2. Identify and reduce direct human-related injury and mortality.
3. Measure and monitor key population parameters.
4. Improve administration and coordination of recovery program for humpback whales.

8.4 Killer Whale—Southern Resident Distinct Population Segment

Killer whales are distributed worldwide, but populations are isolated by region and ecotype. Killer whales have been divided into distinct population segments on the basis of differences in genetics, ecology, morphology and behavior. The Southern Resident DPS of killer whale can be found along the Pacific Coast of the United States and Canada, and in the Salish Sea, Strait of Juan de Fuca, and Puget Sound (Figure 11).

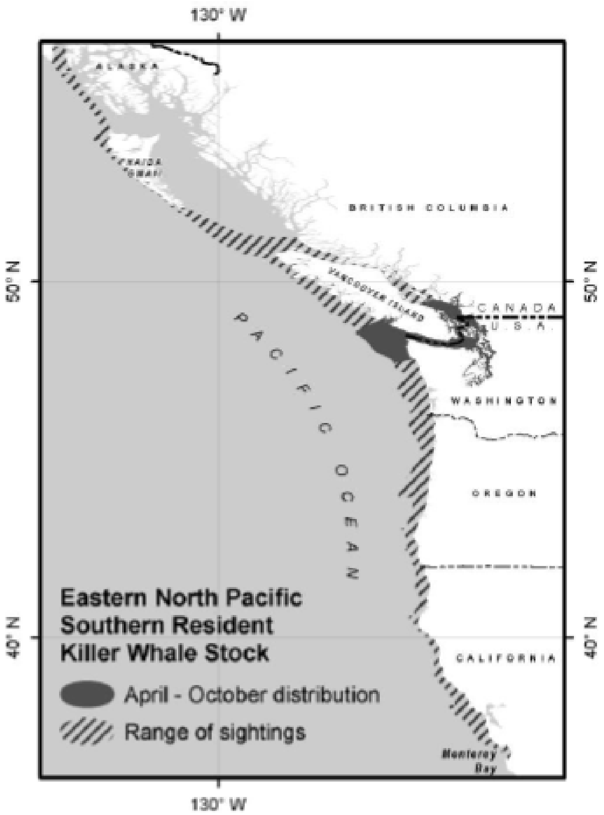

Figure 11. Map identifying the distribution and range of sightings of the endangered Southern Resident distinct population segment of killer whale. Approximate April through October distribution of the Southern Resident distinct population segment of killer whale (shaded area) and range of sightings (diagonal lines) (Carretta 2019b).

Killer whales are odontocetes and the largest delphinid species with black coloration on their dorsal side and white undersides and patches near the eyes. They also have a highly variable gray or white saddle behind the dorsal fin. The Southern Resident killer whales was listed as endangered under the ESA on November 18, 2005.

We used information available in the final rule, the Recovery Plan (NMFS 2008d), the 2016 Status Review (NMFS 2016h) and the recent stock assessment reports (Carretta 2019b; Carretta 2019a) to summarize the life history, population dynamics and status of this species, as follows.

8.4.1 Life History

Southern Resident DPS of killer whales are geographically, matrilineally, and behaviorally distinct from other killer whale populations. The Southern Resident DPS includes three large, stable pods (J, K, and L), which occasionally interact (Parsons et al. 2009a). Most mating occurs outside natal pods, during temporary associations of pods, or as a result of the temporary dispersal of males (Pilot et al. 2010). Males become sexually mature at 10 to 17 years of age. Females reach maturity at 12 to 16 years of age and produce an average of 5.4 surviving calves during a reproductive life span of approximately 25 years. Mating is believed to mostly occur in

May through October, and calves are born in all months, suggesting conception can happen year-round. Mothers and offspring maintain highly stable, life-long social bonds, and this natal relationship is the basis for a matrilineal social structure. Post-reproductive grandmothers (>45 years old) provide survival benefits to their grand offspring, possibly by using historical knowledge to lead the group in finding salmon, particularly during years of low to moderate salmon abundance (Nattrass et al. 2019).

Southern Resident killer whales communicate with one another while foraging, and share prey with others in the group (Ford and Ellis 2006; Wright et al. 2016). They prey upon fish, especially older and larger Chinook salmon (*Oncorhynchus tshawytscha*) in summer and fall, particularly those from the Fraser River (Hanson et al. 2010b). While on the outer coast, Southern Resident killer whales consume Chinook that originated in four river systems, mostly from the Columbia River (Hanson et al. 2021). Chinook remain an important prey item while the Southern Residents are in offshore coastal waters, where they also eat a greater diversity of fish species (NMFS 2019c). Southern Resident killer whales also eat chum (*O. keta*), Coho (*O. kitsutch*), and steelhead (*O. mykiss*), rockfish (*Sebastes spp.*), lingcod (*Ophiodon elongates*), Pacific halibut (*Hippoglossus stenolepis*), Pacific herring (*Clupea pallasi*), among others (Hanson et al. 2021).

A recent study of Southern Resident DPS of killer whale prey items at other times of the year (October through May) showed that Chinook remained an important prey item throughout the year in the Salish Sea and outer coast waters. Chinook comprised about 50 percent of Southern Resident DPS of killer whale diet in the fall, between 70 and 80 percent in the mid-winter and early spring, and nearly 100 percent in spring. Chum is consumed mainly in fall and winter (October through January; (Hanson et al. 2021).

8.4.2 Population Dynamics

The most recent abundance estimate for the Southern Resident DPS is 75 whales in 2019, and was previously 75 whales in 2018 (Carretta 2019a). The population is at 75 whales as of February 21, 2021[1]. This represents a decline from the recent past, when in 2012, there were 85 whales. Population abundance has fluctuated over time with a maximum of 99 whales in 1995 (Carretta 2019a; Carretta 2019b), with an increase between 1974 and the mid-90s, from 76 to 93 individuals. As compared to stable or growing populations, the DPS reflects lower fecundity and has demonstrated little to no growth in recent decades (NMFS 2016h). For the period between 1974 and the mid-1990s, when the population increased from 76 to 93 animals, the population growth rate was 1.8 percent (Ford et al. 1994). More recent data indicate the population is now in decline (Carretta 2019a; Carretta 2019b). Prior to 2019, there had been no Southern Resident killer whales born since 2015[2]. In 2019, two whales were born, one in L pod, and one in J pod. In 2020, two calves were born in J pod, and one calf born in 2021 to L pod.[2] Four whales died or were presumed dead following the 2018 census, as of July 1, 2019 (NMFS 2019c), L-41, a 42

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[1] http://www.orcanetwork.org/Main/index.php?categories_file=Births%20and%20Deaths; accessed 3/2/2021.

year old male, died in January 2020.[2] Nutritional stress in the forms of lack of prey, toxin loads, and vessel disturbance is thought to be a possible contributing factor to low offspring production for Southern Residents. Analysis of fecal hormones has indicated several miscarriages in recent years, particularly in late pregnancy (Wasser et al. 2017). The number of effective breeders in the population is about 26 (Ford et al. 2018a).

After thorough genetic study, the Biological Review Team concluded that Southern Resident DPS of killer whales were discrete from other killer whale groups (NMFS 2008). Despite the fact that their ranges overlap, Southern Resident DPS of killer whales do not intermix with Northern Resident killer whales. Low genetic diversity within a population is believed to be in part due to the matrilineal social structure (NMFS 2008d). Inbreeding is a concern for the Southern Residents; four cases of inbreeding have been recorded, two between parent and offspring, one between paternal half-siblings, and one between an uncle and a half-niece; the fitness consequences of inbreeding in this population are unknown (Ford et al. 2018a).

Southern Resident DPS of killer whales occur for part of the year in the inland waterways of Puget Sound, Strait of Juan de Fuca, and Southern Georgia Strait mostly during the spring, summer and fall. Their movement patterns appear related to the seasonal availability of prey, especially Chinook salmon. They also move to coastal waters primarily off Washington and British Columbia, and have been sighted as far as central California and southeast Alaska (Figure 11) (NMFS 2019c). There is evidence to show that the different pods spend time in different locations while in coastal waters; see section 10.2.1.1 for more details. Results from satellite tagging, acoustic recording data, and opportunistic sightings indicate that Southern Resident killer whales spend the majority of their time on the continental shelf, within 34 kilometers of shore (NMFS 2019c).

8.4.3 Vocalization and Hearing

Killer whales have advanced vocal communication and also use vocalizations to aid in navigation and foraging (NMFS 2008d). Their vocalizations typically have both a low frequency component (250 hertz to 1.5 kilohertz) and a high frequency component (5 to 12 kilohertz) (NMFS 2008d). Killer whale vocalizations consist of three main types, echolocation clicks, which are primarily used for navigation and foraging, and tonal whistles and pulse calls, which are thought to be used for communication (NMFS 2008d). The interval of clicks during foraging varies with depth, with slower repetition click trains mostly occurring at shallow depths (> 20 meters), and faster clicks occurring at deeper depths. These results indicate that Southern Residents spend the majority of the their foraging time (74 percent) near the surface searching for prey, and then diving to intercept prey (Holt et al. 2019). Resident killer whales off British Columbia produce whistles for long-range communication like during foraging and slow traveling, and social interactions with the clan and between different groups (Thomsen et al. 2002; Riesch et al. 2006). Individual Southern Resident killer whale pods have distinct call

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[2] http://www.orcanetwork.org/Main/index.php?categories_file=Births%20and%20Deaths (Accessed 3/4/2021).

repertoires, with each pod being recognizable by its acoustic dialect (NMFS 2008d). Killer whale hearing is one of the most sensitive of any odontocete, with a hearing range of 600 hertz to 114 kilohertz, with the most sensitive range being between 5 and 81 kilohertz (Branstetter et al. 2017).

8.4.4 Status

The Southern Resident DPS of killer whale was listed as endangered in 2005 in response to the population decline from 1996 through 2001, small population size, and reproductive limitations (i.e., few reproductive males and delayed calving). Current threats to its survival and recovery include contaminants, vessel traffic, and reduction in prey availability. Chinook salmon populations have declined due to degradation of habitat, hydrology issues, harvest, and hatchery introgression; such reductions may require an increase in foraging effort. In addition, these prey contain environmental pollutants. These contaminants become concentrated at higher trophic levels and may lead to immune suppression or reproductive impairment. The inland waters of Washington and British Columbia support a large whale watch industry, commercial shipping, and recreational boating; these activities generate underwater noise, which may mask whales' communication or interrupt foraging. The DPS's resilience to future perturbation is reduced as a result of its small population size. The recent decline, unstable population status, and population structure (e.g., few reproductive age males and non-calving adult females) continue to be causes for concern. The relatively low number of individuals in this population makes it difficult to resist or recover from natural spikes in mortality, including disease and fluctuations in prey availability.

8.4.5 Critical Habitat

Southern Resident killer whale proposed and designated critical habitat was described in Section 7.2.5.1.

8.4.6 Recovery Goals

See the 2008 Recovery Plan for the Southern Resident DPS of killer whale for complete downlisting/delisting criteria for each of the following recovery goals:

- Prey Availability: Support salmon restoration efforts in the region including habitat, harvest and hatchery management considerations and continued use of existing NMFS authorities under the ESA and Magnuson-Stevens Fishery Conservation and Management Act to ensure an adequate prey base
- Pollution/Contamination: Clean up existing contaminated sites, minimize continuing inputs of contaminants harmful to killer whales, and monitor emerging contaminants.
- Vessel Effects: Continue with evaluation and improvement of guidelines for vessel activity near Southern Resident DPS of killer whales and evaluate the need for regulations or protected areas.

- Oil Spills: Prevent oil spills and improve response preparation to minimize effects on Southern Resident DPS and their habitat in the event of a spill.
- Acoustic Effects: Continue agency coordination and use of existing ESA and MMPA mechanisms to minimize potential impacts from anthropogenic sound.
- Education and Outreach: Enhance public awareness, educate the public on actions they can participate in to conserve killer whales and improve reporting of Southern Resident DPS killer whale sightings and strandings.
- Response to Sick, Stranded, Injured Killer Whales: Improve responses to live and dead killer whales to implement rescues, conduct health assessments, and determine causes of death to learn more about threats and guide overall conservation efforts.
- Transboundary and Interagency Coordination: Coordinate monitoring, research, enforcement, and complementary recovery planning with Canadian agencies, and Federal and State partners.
- Research and Monitoring: Conduct research to facilitate and enhance conservation efforts. Continue the annual census to monitor trends in the population, identify individual animals, and track demographic parameters.

8.5 Sei Whale

The sei whale is a widely distributed baleen whale found in all major oceans. Sei whales are distinguishable from other whales by a long, sleek body that is dark bluish-gray to black in color and pale underneath, and a single ridge located on their rostrum. The sei whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2011f), recent stock assessment report (Carretta 2019b), and status review (NMFS 2012b) were used to summarize the life history, population dynamics, and status of the species as follows.

8.5.1 Life History

Sei whales can live, on average, between 50 and 70 years. They have a gestation period of ten to 12 months, and calves nurse for six to nine months. Sexual maturity is reached between 6 and 12 years of age with an average calving interval of two to three years. Sei whales mostly inhabit continental shelf and slope waters far from the coastline. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed on a range of prey types, including: plankton (copepods and krill) small schooling fishes, and cephalopods.

8.5.2 Population Dynamics

Two subspecies of sei whale are recognized, *B. b. borealis* in the Northern Hemisphere and *B. b. schlegellii* in the Southern Hemisphere. Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals

18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). The best abundance estimate for sei whales for the waters of the U.S. West Coast is 519 (CV=0.40) (Carretta 2019b).

Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

Based on genetic analyses, there appears to be some differentiation between sei whale populations in different ocean basins. An early study of allozyme variation at 45 loci found some genetic differences between Southern Ocean and the North Pacific sei whales (Wada and Numachi 1991). However, more recent analyses of mtDNA control region variation show no significant differentiation between Southern Ocean and the North Pacific sei whales, though both appear to be genetically distinct from sei whales in the North Atlantic (Baker and Clapham 2004; Huijser et al. 2018). Within ocean basin, there appears to be intermediate to high genetic diversity and little genetic differentiation despite there being different managed stocks (Danielsdottir et al. 1991; Kanda et al. 2006; Kanda et al. 2011; Kanda et al. 2013; Kanda et al. 2015; Huijser et al. 2018).

Sei whales are distributed worldwide, occurring in the North Atlantic Ocean, North Pacific Ocean, and Southern Hemisphere. Very little is known about the distribution of sei whales in the northeast Pacific. Generally, the species occupies pelagic habitats, and is very rarely seen inshore; over 3,700 sei whales were killed by whales offshore of the west coast of Vancouver Island. In the recent past, two sei whales have been sighted in Canadian Pacific waters, one in 2004 off southeastern Haida Gwaii, and the other in 2008 near Learmonth Bank in Dixon Entrance (Nichol 2011).

8.5.3 Vocalization and Hearing

Data on sei whale vocal behavior is limited, but includes records off the Antarctic Peninsula of broadband sounds in the 100 to 600 hertz range with 1.5 second duration and tonal and upsweep calls in the 200 to 600 hertz range of one to three second durations (McDonald et al. 2005). Vocalizations from the North Atlantic Ocean consisted of paired sequences (0.5 to 0.8 seconds, separated by 0.4 to 1.0 seconds) of 10 to 20 short (4 milliseconds) frequency modulated sweeps between 1.5 to 3.5 kilohertz (Thomson and Richardson 1995c). Source levels of 189 ±5.8 dB re: 1 µPa at 1 meter have been established for sei whales in the northeastern Pacific Ocean (Weirathmueller 2013).

Direct studies of sei whale hearing have not been conducted, but it is assumed that they can hear the same frequencies that they produce (low) and are likely most sensitive to this frequency range (Richardson et al. 1995c; Ketten 1997). This suggests sei whales, like other baleen whales, are more likely to have their best hearing capacities at low frequencies, including frequencies lower than those of normal human hearing, rather than mid- to high-frequencies (Ketten 1997). In terms of functional hearing capability, sei whales belong to the low-frequency group, which have a hearing range of 7 hertz to 35 kilohertz (NOAA 2018).

8.5.4 Status

The sei whale is endangered as a result of past commercial whaling, reduced to about 20 percent of their pre-whaling abundance in the North Pacific Ocean (Carretta 2019b). According to historical whaling records from five whaling stations in British Columbia, 4,002 sei whales were killed between 1908 and 1967 (Gregr et al. 2000). Current threats include ship strikes, fisheries interactions (including entanglement), climate change (habitat loss and reduced prey availability), and anthropogenic sound. Given the species' overall abundance, they may be somewhat resilient to current threats. However, trends are largely unknown, especially for individual stocks, many of which have relatively low abundance estimates.

8.5.5 Critical Habitat

No critical habitat has been designated for the sei whale.

8.5.6 Recovery Goals

See the 2011 Final Recovery Plan for the sei whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

8.6 Sperm Whale

The sperm whale is a widely distributed species found in all major oceans. Sperm whales are the largest toothed whale and distinguishable from other whales by its extremely large heard, which takes up to 25 to 35 percent of its total body length and a single blowhole asymmetrically situated on the left side of the head near the tip. The sperm whale was originally listed as endangered on December 2, 1970.

Information available from the recovery plan (NMFS 2010a), recent stock assessment reports (Carretta 2019b; Carretta 2019a), and status review (NMFS 2015g) were used to summarize the life history, population dynamics, and status of the species as follows.

8.6.1 Life History

The average lifespan of sperm whales is estimated to be at least 50 years (Whitehead 2009). They have a gestation period of one to one and a half years, and calves nurse for approximately two years. Sexual maturity for sperm whales in the North Pacific is reached between 7 and 13 years of age for females with an average calving interval for four to six years. Male sperm whales reach full sexual maturity between ages 18 and 21, after which they undergo a second growth spurt, reaching full physical maturity at around age 40 (Mizroch and Rice 2013). Data from historical whaling station records from 1908 to 1967 indicate that sperm whales mated in April through June, and calved in July to August in the offshore waters of British Columbia (Gregr et al. 2000). Sperm whales mostly occur far offshore, inhabiting areas with a water depth of 600 meters (1,968 feet) or more, and are uncommon in waters less than 300 meters (984 feet) deep. However, if there are shelf breaks or submarine canyons close to land, sperm whales can occur there. They winter at low latitudes, where they calve and nurse, and summer at high latitudes, where they feed primarily on squid; other prey includes octopus and demersal fish (including teleosts and elasmobranchs). An analysis of commercial whaling records from the Coal Harbor whaling station in northern Vancouver from 1963 to 1967 looked at sperm whale stomach contents. The samples came late spring through summer (April through September). North Pacific giant squid (*Moroteuhis robusta*) was the most abundant prey item for both males and females, but the secondary prey item differed between sexes. After giant squid, males consumed rockfish (*Sebastes spp*.), while females ate ragfish (*Icosteus spp*.) and other fish (Flinn et al. 2002).

8.6.2 Population Dynamics

The sperm whale is the most abundant of the large whale species, with a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997 (NMFS 2015b). There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

Ocean-wide genetic studies indicate sperm whales have low genetic diversity, suggesting a recent bottleneck, but strong differentiation between matrilineally related groups (Lyrholm and Gyllensten 1998). Consistent with this, two studies of sperm whales in the Pacific Ocean indicate low genetic diversity (Mesnick et al. 2011; Rendell et al. 2012). As none of the stocks for which data are available have high levels of genetic diversity, the species may be at some risk to inbreeding and 'Allee' effects, although the extent to which is currently unknown.

Sperm whales have a global distribution and can be found in relatively deep waters in all ocean basins. While both males and females can be found in latitudes less than 40°, only adult males venture into the higher latitudes near the poles. Sperm whale distribute widely throughout the North Pacific Ocean, with movements over 5,000 kilometers, likely driven by changes in prey abundance. Males appear to range more broadly than females (Mizroch and Rice 2013).

8.6.3 Vocalization and Hearing

Sound production and reception by sperm whales are better understood than in most cetaceans. Recordings of sperm whale vocalizations reveal that they produce a variety of sounds, such as clicks, gunshots, chirps, creaks, short trumpets, pips, squeals, and clangs (Goold 1999). Sperm whales typically produce short duration repetitive broadband clicks with frequencies below 100 hertz to greater than 30 kilohertz (Watkins 1977) and dominant frequencies between 1 to 6 kilohertz and 10 to 16 kilohertz. Another class of sound, "squeals," are produced with frequencies of 100 hertz to 20 kilohertz (e.g., Weir et al. 2007). The source levels of clicks can reach 236 dB re: 1 µPa at 1 meter, although lower source level energy has been suggested at around 171 dB re: 1 µPa at 1 meter (Weilgart and Whitehead 1993; Goold and Jones 1995;

Weilgart and Whitehead 1997a; Mohl et al. 2003). Most of the energy in sperm whale clicks is concentrated at around 2 to 4 kilohertz and 10 to 16 kilohertz (Weilgart and Whitehead 1993; Goold and Jones 1995). The clicks of neonate sperm whales are very different from typical clicks of adults in that they are of low directionality, long duration, and low frequency (between 300 hertz and 1.7 kilohertz) with estimated source levels between 140 to 162 dB re: 1 µPa at 1 meter (Madsen et al. 2003). The highly asymmetric head anatomy of sperm whales is likely an adaptation to produce the unique clicks recorded from these animals (Norris and Harvey 1972).

Long, repeated clicks are associated with feeding and echolocation (Whitehead and Weilgart 1991; Weilgart and Whitehead 1993; Goold and Jones 1995; Weilgart and Whitehead 1997a; Miller et al. 2004). Creaks (rapid sets of clicks) are heard most frequently when sperm whales are foraging and engaged in the deepest portion of their dives, with inter-click intervals and source levels being altered during these behaviors (Miller et al. 2004; Laplanche et al. 2005). Clicks are also used during social behavior and intragroup interactions (Weilgart and Whitehead 1993). When sperm whales are socializing, they tend to repeat series of group-distinctive clicks (codas), which follow a precise rhythm and may last for hours (Watkins and Schevill 1977). Codas are shared between individuals in a social unit and are considered to be primarily for intragroup communication (Weilgart and Whitehead 1997a; Rendell and Whitehead 2004). Research in the South Pacific Ocean suggests that in breeding areas the majority of codas are produced by mature females (Marcoux et al. 2006). Coda repertoires have also been found to vary geographically and are categorized as dialects (Weilgart and Whitehead 1997a; Pavan et al. 2000). For example, significant differences in coda repertoire have been observed between sperm whales in the Caribbean Sea and those in the Pacific Ocean (Weilgart and Whitehead 1997a). Three coda types used by male sperm whales have recently been described from data collected over multiple years: these codas are associated with dive cycles, socializing, and alarm (Frantzis and Alexiadou 2008).

Our understanding of sperm whale hearing stems largely from the sounds they produce. The only direct measurement of hearing was from a young stranded individual from which auditory evoked potentials were recorded (Carder and Ridgway 1990). From this whale, responses support a hearing range of 2.5 to 60 kilohertz and highest sensitivity to frequencies between 5 to 20 kilohertz. Other hearing information consists of indirect data. For example, the anatomy of the sperm whale's inner and middle ear indicates an ability to best hear high-frequency to ultrasonic hearing (Ketten 1992). The sperm whale may also possess better low-frequency hearing than other odontocetes, although not as low as many baleen whales (Ketten 1992). Reactions to anthropogenic sounds can provide indirect evidence of hearing capability, and several studies have made note of changes seen in sperm whale behavior in conjunction with these sounds. For example, sperm whales have been observed to frequently stop echolocating in the presence of underwater pulses made by echosounders and submarine sonar (Watkins and Schevill 1975b; Watkins et al. 1985). In the Caribbean Sea, Watkins et al. (1985) observed that sperm whales exposed to 3.25 to 8.4 kilohertz pulses (presumed to be from submarine sonar) interrupted their activities and left the area. Similar reactions were observed from artificial sound generated by banging on a boat hull (Watkins et al. 1985). André et al. (1997) reported that foraging whales exposed to a 10 kilohertz pulsed signal did not ultimately exhibit any general avoidance reactions: when resting at the surface in a compact group, sperm whales initially reacted strongly, and then ignored the signal completely. Thode et al. (2007) observed that the acoustic signal from the cavitation of a fishing vessel's propeller (110 dB re: 1 μPa^2-s between 250 hertz and 1 kilohertz) interrupted sperm whale acoustic activity and resulted in the animals converging on the vessel. Sperm whales have also been observed to stop vocalizing for brief periods when codas are being produced by other individuals, perhaps because they can hear better when not vocalizing themselves (Goold and Jones 1995). Because they spend large amounts of time at depth and use low frequency sound, sperm whales are likely to be susceptible to low frequency sound in the ocean (Croll et al. 1999). Nonetheless, sperm whales are considered to be part of the mid-frequency marine mammal hearing group, with a hearing range between 150 hertz and 160 kilohertz (NOAA 2018).

8.6.4 Status

The sperm whale is endangered as a result of past commercial whaling. According to historical whaling records from five whaling stations in British Columbia, 6,158 sperm whales were killed between 1908 and 1967 (Gregr et al. 2000). Although the aggregate abundance worldwide is probably at least several hundred thousand individuals, the extent of depletion and degree of recovery of populations are uncertain. Commercial whaling is no longer allowed, however, illegal hunting may occur at biologically unsustainable levels. Continued threats to sperm whale populations include ship strikes, entanglement in fishing gear, competition for resources due to overfishing, population, loss of prey and habitat due to climate change, and noise. The species' large population size shows that it is somewhat resilient to current threats.

8.6.5 Critical Habitat

No critical habitat has been designated for the sperm whale.

8.6.6 Recovery Goals

See the 2010 Final Recovery Plan for the sperm whale for complete downlisting/delisting criteria for both of the following recovery goals:

1. Achieve sufficient and viable populations in all ocean basins.
2. Ensure significant threats are addressed.

8.7 Guadalupe Fur Seal

Guadalupe fur seals were once found throughout Baja California, Mexico and along the California coast. Currently, the species breeds mainly on Guadalupe Island, Mexico, off the coast of Baja California. A smaller breeding colony, discovered in 1997, appears to have been established at Isla Benito del Este in the San Benito Archipelago, Baja California, Mexico (Belcher and T.E. Lee 2002).

Guadalupe fur seals are medium sized, sexually dimorphic otariids (Belcher and T.E. Lee 2002; Reeves et al. 2002). Distinguishing characteristics of the Guadalupe fur seal include the digits on their hind flippers (all of similar length), large, long foreflippers, and unique vocalizations (Reeves et al. 2002). Guadalupe fur seals are dark brown to black, with the adult males having tan or yellow hairs at the back of their mane. Guadalupe fur seals were listed as threatened under the ESA on December 16, 1985 (50 FR 51252).

8.7.1 Life History

Guadalupe fur seals prefer rocky habitats and can be found in natural recesses and caves (Fleischer 1978), using sheltered beaches and rocky platforms for breeding (Arias-del-Razo et al. 2016). Breeding occurs in June through August. Adult males return to the colonies in early June. Female Guadalupe fur seals arrive on beaches in June, with births occurring between mid-June to July (Pierson 1978); the pupping season is generally over by late July (Fleischer 1978). Breeding adult males are polygamous, and may mate with up to 12 females during a single breeding season. Females stay with pups for seven to eight days after parturition, and then alternate between foraging trips at sea and lactation on shore; nursing lasts about eight months (Figureroa-Carranza 1994). Guadalupe fur seals feed mainly on squid species (Esperon-Rodriguez and Gallo-Reynoso 2013); the Gulf of Ulloa on the Pacific side of the Baja California peninsula is an important feeding area (Aurioles-Gamboa and Szteren 2019). Based on a stable isotope analysis of male Guadalupe fur seal carcasses, there appears to be some niche segregation between coastal and oceanic males, possibly based on individual age and size (Aurioles-Gamboa and Szteren 2019). Foraging trips can last between four to twenty-four days (average of fourteen days). Tracking data show that adult females spend seventy-five percent of their time sea, and twenty-five percent at rest (Gallo-Reynoso et al. 1995).

8.7.2 Population Dynamics

It is difficult to obtain an accurate abundance estimate of Guadalupe fur seals due in part to their tendency to stay in caves and remain at sea for extended lengths of time, making them unavailable for counting. At the time of listing in 1985, the population was estimated at 1,600 individuals, compared to approximately 30,000 before hunting occurred in the 18th and 19th centuries. A population was "rediscovered" in 1928 with the capture of two males on Guadalupe Island; from 1949 on, researchers reported sighting Guadalupe fur seals at Isla Cedros (near the San Benito Archipelago), and Guadalupe Island (Bartholomew Jr. 1950; Peterson et al. 1968). In 1994, the population at Guadalupe Island was estimated at 7,408 individuals (Gallo-Reynoso 1994). There have been other, more recent population abundance estimates for Guadalupe Island, with a considerable amount of variation between them: 20,000 in 2010 (García-Capitanachi et al. 2017), and between 34,000 and 44,000 in 2013 (García-Aguilar et al. 2018). Guadalupe fur seals are also found on San Benito Island, likely immigrants from Guadalupe Island, as there are relatively few pups born on San Benito Island (Aurioles-Gamboa et al. 2010). There were an estimated 2,504 seals on San Benito Island in 2010 (García-Capitanachi et al. 2017). Based on information presented by (García-Aguilar et al. 2018), and using a population size:pup count ratio of 3.5, the minimum population estimate is 31,019 (Carretta 2019a).

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. Gallo-Reynoso (1994) calculated that the population of Guadalupe fur seals in Mexico from thirty years of population and counts and concluded the population was increasing; with an average annual growth rate of 13.3 percent on Guadalupe Island. The 2000 NMFS stock assessment report for Guadalupe fur seals also indicated the breeding colonies in Mexico were increasing; and more recent evidence indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). From 1984 to 2013 at Guadalupe Island, the Guadalupe fur seal population increased at an average annual growth rate of 5.9 percent (range 4.1 to 7.7 percent) (García-Aguilar et al. 2018). Other estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997-2007) indicate that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). However, these estimates are considered too high, and likely result from immigration at Guadalupe Island (Carretta 2017; Carretta 2019a). Based on direct counts of animals from 1955 and 1993, the estimated annual population growth rate is 13.7 percent (Carretta 2019a).

The Guadalupe fur seal clearly experienced a precipitous decline due to commercial exploitation, and may have undergone a population bottleneck. Bernardi et al. (1998) compared the genetic divergence in the nuclear fingerprint of samples taken from 29 Guadalupe fur seals, and found an average similarity of 0.59 of the DNA profiles. This average is typical of outbreeding populations. When comparing the amount of unique character fragments found in Guadalupe fur seals to that of other pinnipeds that have experienced bottlenecks (e.g., Hawaiian monk seals), that amount is much higher (0.14 vs. 0.05) in Guadalupe fur seals than Hawaiian monk seals. By using mitochondrial DNA sequence analysis in comparing the genetic diversity of Guadalupe fur seals to northern elephant seals (which did experience a severe bottleneck), Guadalupe fur seals had more haplotypes and a higher number of variable sites. The authors hypothesized that the numbers of Guadalupe fur seals left after harvest may have been underestimated, and the population may not have actually experienced a bottleneck, or the bottleneck may have been of short duration and not severe enough to suppress genetic diversity. Although the relatively high levels of genetic variability are encouraging, it is important to note that commercial harvest still influenced the population. Later studies comparing mitochondrial DNA found in the bones of pre-exploitation Guadalupe fur seals against the extant population showed a loss of genotypes, with twenty-five genotypes in pre-harvest fur seals, and seven present today (Weber et al. 2004).

Guadalupe fur seals are known to travel great distances, with sightings occurring thousands of kilometers away from the main breeding colonies (Aurioles-Gamboa et al. 1999). Guadalupe fur seals are infrequently observed in U.S. waters. They can be found on California's Channel

Islands, with as many fifteen individuals being sighted since 1997 on San Miguel Island, including three females and reared pups.

8.7.3 Status

Commercial sealers in the 19th century decimated the Guadalupe fur seal population, taking as many 8,300 fur seals from San Benito Island (Townsend 1924). Numbers on the total number of fur seals harvested are difficult to ascertain because of the difficulty the hunters had in distinguishing species while hunting (Seagars 1984). These harvests were devastating for the Guadalupe fur seal population, so much so that in 1892, only seven individuals were observed on Guadalupe Island, the location of one of the larger known breeding colonies (Bartholomew Jr. 1950); two years later, a commercial sealer took all 15 remaining individuals that could be found (Townsend 1899).

The species was presumed extinct, until 1926, when a small herd was found on Guadalupe Island by commercial fishermen, who later returned and killed all the seals they could find. In 1928, the Mexican government declared Guadalupe Island as a pinniped sanctuary. In 1954, during a survey of the island, Hubbs (1956) discovered at least 14 individuals. The government of Mexico banned the hunting of Guadalupe fur seals in 1967. Although population surveys occurred on an irregular basis in subsequent years, evidence shows that the Guadalupe fur seal population has been increasing ever since (see Section 8.7.2).

How the Guadalupe fur seal population was able to persist despite intensive and repeated episodes of hunting is not precisely known, although several factors likely played a role. Hubbs (1956) postulated that since Guadalupe fur seals bred in caves, it made them difficult to find, and they were able to evade hunters. Furthermore, since the adult females spend up to 75 percent of their time at sea for two weeks or more at a time, enough females were away during hunting to survive these episodes.

Although a number of human activities may have contributed to the current status of this species, historic commercial hunting was likely the most devastating. Even with population surveys occurring on an irregular basis in subsequent years, these surveys provide evidence that the Guadalupe fur seal has been increasing after suffering such a significant decline. Although commercial hunting occurred in the past, and has since ceased, the effects of these types of exploitations persist today. Other human activities, such as entanglements from commercial fishing gear, are ongoing and continue to affect these species. While some incidental breeding takes place on the San Benito Islands and the Channel Islands, the Guadalupe Island breeding colony supports the population (García-Aguilar et al. 2018). The current abundance of the Guadalupe fur seal represents about one-fifth of the estimated historical population size, and although the population has continued to increase, the species has not expanded its breeding range, potentially affecting its recovery (García-Aguilar et al. 2018). Because, over the last fifty years, the population has been increasing since being severely depleted, we believe that the Guadalupe fur seal population is resilient to future perturbations.

8.7.4 Critical Habitat

No critical habitat has been designated for Guadalupe fur seals.

8.7.5 Recovery Goals

NMFS has not prepared a Recovery Plan for Guadalupe fur seals.

8.8 Leatherback Turtle

The leatherback sea turtle is unique among sea turtles for its large size, wide distribution (due to thermoregulatory systems and behavior), and lack of a hard, bony carapace. It ranges from tropical to subpolar latitudes, worldwide (Figure 12).

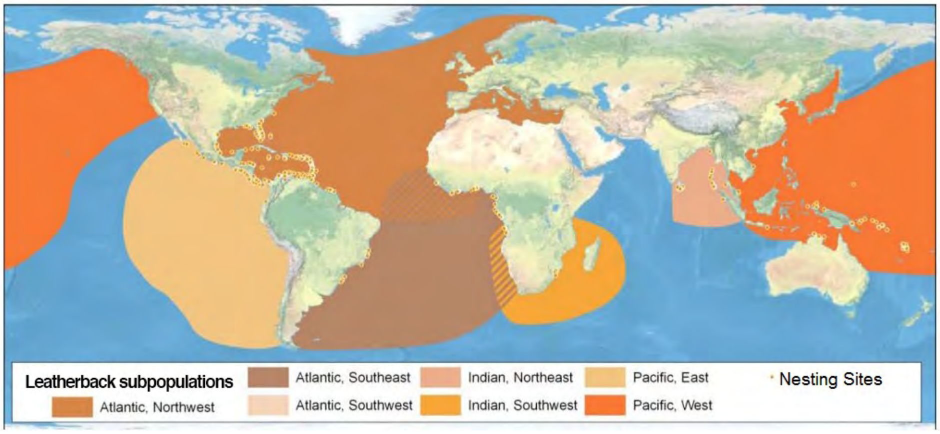

Figure 12. Map identifying the range of the endangered leatherback turtle. Adapted from (Wallace et al. 2013).

Leatherback turtles are the largest living turtle, reaching lengths of 2 meters (6.5 feet) long, and weighing up to 907.2 kilograms (2,000 pounds). Leatherback turtles have a distinct black leathery skin covering their carapace with pinkish white skin on their belly. The species was first listed under the Endangered Species Conservation Act (35 FR 8491) and listed as endangered under the ESA since 1973.

We used information available in the five year review (NMFS and USFWS 2013) and the critical habitat designation (77 FR 61573) to summarize the life history, population dynamics and status of the species, as follows.

8.8.1 Life History

Age at maturity has been difficult to ascertain, with estimates ranging from five to 29 years (Spotila et al. 1996; Avens et al. 2009). Females lay up to seven clutches per season, with more than sixty-five eggs per clutch and eggs weighing greater than 80 grams (0.17 pounds) (Reina et al. 2002; Wallace et al. 2007). The number of leatherback turtle hatchlings that make it out of the nest on to the beach (i.e., emergent success) is approximately 50 percent worldwide (Eckert et al. 2012). Females nest every one to seven years. Natal homing, at least within an ocean basin, results in reproductive isolation between five broad geographic regions: eastern and western

Pacific, eastern and western Atlantic, and Indian Ocean. Leatherback turtles migrate long, transoceanic distances between their tropical nesting beaches and the highly productive temperate waters where they forage, primarily on jellyfish and tunicates. These gelatinous prey are relatively nutrient-poor, such that leatherback turtles must consume large quantities to support their body weight. Leatherback turtles weigh about 33 percent more on their foraging grounds than at nesting, indicating that they probably catabolize fat reserves to fuel migration and subsequent reproduction (James et al. 2005; Wallace et al. 2006). Sea turtles must meet an energy threshold before returning to nesting beaches. Therefore, their remigration intervals (the time between nesting) are dependent upon foraging success and duration (Hays 2000; Price et al. 2004).

8.8.2 Population Dynamics

Leatherback turtles are globally distributed, with nesting beaches in the Atlantic, Indian, and Pacific Oceans. Detailed population structure is unknown, but is likely dependent upon nesting beach location. Based on estimates calculated from nest count data, there are between 34,000 and 94,000 adult leatherback turtles in the North Atlantic Ocean (TEWG 2007). In contrast, leatherback turtle populations in the Pacific Ocean are much lower. Overall, Pacific populations have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000).

Population growth rates for leatherback turtles vary by ocean basin. Counts of leatherback turtles at nesting beaches in the western Pacific Ocean indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013). Based on surveys over 28 years of feeding grounds off central California, leatherback abundance has declined at an annual rate of 5.6 percent, with no substantial changes noted in ocean conditions or prey availability (Benson et al. 2020).

Analyses of mitochondrial DNA from leatherback turtles indicates a low level of genetic diversity, pointing to possible difficulties in the future if current population declines continue (Dutton et al. 1999).

Leatherback turtles are distributed in oceans throughout the world (Figure 12). Leatherback turtles occur throughout marine waters, from nearshore habitats to oceanic environments (Shoop and Kenney 1992). During a seismic research survey in late summer 2009, about 250 kilometers offshore of Vancouver, a leatherback sea turtle was sighted (Holst 2017). Movements are largely dependent upon reproductive and feeding cycles and the oceanographic features that concentrate prey, such as frontal systems, eddy features, current boundaries, and coastal retention areas (Benson et al. 2011b).

8.8.3 Vocalization and Hearing

Sea turtles are low frequency hearing specialists, typically hearing frequencies from 30 hertz to 2 kilohertz, with a range of maximum sensitivity between 100 and 800 hertz (Ridgway et al. 1969; Lenhardt 1994; Bartol et al. 1999; Lenhardt 2002; Moein Bartol and Ketten 2006). Piniak (2012) measured hearing of leatherback turtle hatchlings in water an in air, and observed reactions to low frequency sounds, with responses to stimuli occurring between 50 hertz and 1.6 kilohertz in air between 50 hertz and 1.2 kilohertz in water (lowest sensitivity recorded was 93 dB re: 1 μPa at 300 hertz).

These hearing sensitivities are similar to those reported for two terrestrial species: pond and wood turtles. Pond turtles respond best to sounds between 200 and 700 hertz, with slow declines below 100 hertz and rapid declines above 700 hertz, and almost no sensitivity above 3 kilohertz (Wever and Vernon 1956). Wood turtles are sensitive up to about 500 hertz, followed by a rapid decline above 1 kilohertz and almost no responses beyond 3 to 4 kilohertz (Patterson 1966).

8.8.4 Status

The leatherback turtle is an endangered species whose once large nesting populations have experienced steep declines in recent decades. The primary threats to leatherback turtles include fisheries bycatch, harvest of nesting females, and egg harvesting. Because of these threats, once large rookeries are now functionally extinct, and there have been range-wide reductions in population abundance. Other threats include loss of nesting habitat due to development, tourism, and sand extraction. Lights on or adjacent to nesting beaches alter nesting adult behavior and are often fatal to emerging hatchlings as they are drawn to light sources and away from the sea. Plastic ingestion is common in leatherback turtles and can block gastrointestinal tracts leading to death. Climate change may alter sex ratios (as temperature determines hatchling sex), range (through expansion of foraging habitat), and habitat (through the loss of nesting beaches, because of sea-level rise). The species' resilience to additional perturbation is low.

8.8.5 Critical Habitat

Critical habitat within the action area has been designated for leatherback sea turtles on January 20, 2012 (50 C.F.R. §226). Leatherback turtle critical habitat was described in Section 7.5.3.

8.8.6 Recovery Goals

See the 1998 and 1991 Recovery Plans for the U.S. Pacific and U.S Caribbean, Gulf of Mexico and Atlantic leatherback turtles for complete down listing/delisting criteria for each of their respective recovery goals. The following items were the top five recovery actions identified in the Pacific Leatherback Five Year Action Plan:

1. Reduce fisheries interactions
2. Improve nesting beach protection and increase reproductive output
3. International cooperation
4. Monitoring and research
5. Public engagement

8.9 Green Sturgeon—Southern Distinct Population Segment

The North American green sturgeon, *Acipenser medirostris*, is an anadromous fish that occurs in the nearshore Eastern Pacific Ocean from Alaska to Mexico (Moyle 2002b). Green sturgeon are long-lived, late-maturing, iteroparous, anadromous species that spawn infrequently in natal streams, and spend substantial portions of their lives in marine waters. NMFS has identified two DPSs of green sturgeon; northern and southern (Israel et al. 2009). The northern DPS spawns primarily in the Klamath and Rogue Rivers, and occasionally in the Columbia River, while the southern DPS spawns exclusively in the Sacramento Basin (Schreier and Stevens 2020). The southern DPS green sturgeon includes individuals which spawn in the Sacramento, Feather, and Yuba rivers. In 2006, NMFS determined that the southern DPS green sturgeon warranted listing as a threatened species under the ESA (71 FR 17757).

Information available from the recovery plan (NMFS 2018b), status review (NMFS 2015f), and recent scientific publications were used to summarize the life history, population dynamics, and status of the species as follows.

8.9.1 Life History

Green sturgeon can live to be 70 years old. Green sturgeon reach sexual maturity at approximately 15 years of age (Van Eenennaam et al. 2006), and may spawn every one to four years throughout their long lives (Moser et al. 2016). Southern DPS green sturgeon spawn in cool (14 to 17 degrees Celsius), deep, turbulent areas with clean, hard substrates.

By far, the Sacramento River is the largest known spawning river for the southern DPS. Six discrete spawning sites have been identified in the upper Sacramento River between Gianella Bridge (river kilometer 320.6) and the Keswick dam (river kilometer 486) (Poytress et al. 2013). Spawning for the DPS occurs to a much lesser degree in the Yuba and Feather Rivers. Some minor spawning takes place in the Feather River, with between 21 to 28 sturgeon observed in 2011, and fertilized eggs on egg mats found (Seesholtz et al. 2015). Spawning pairs of green sturgeon were captured on video at the foot of a dam in the Yuba River in 2011 (Bergman et al. 2011).

In preparation for spawning, adult southern DPS green sturgeon enter San Francisco Bay between mid-February and early-May, then migrate rapidly (on the order of a few weeks) up the Sacramento River (Heublein et al. 2009). Spawning occurs from April through early July, with peaks of activity that depend on a variety of factors including water temperature and water flow rates (Poytress et al. 2009; Poytress et al. 2010). Post-spawn fish typically congregate and hold for several months in a few deep pools in the upper main stem Sacramento River near spawning sites and migrate back downstream when river flows increase in fall. They re-enter the ocean during the winter months (November through January) and begin their marine migration north along the coast (Erickson and Hightower 2007).

Green sturgeon larvae are different from all other sturgeon because of the absence of a distinct swim-up or post-hatching stage. Larvae grow fast; young fish grow to 74 millimeters 45 days after hatching (Deng 2000). Larvae and juveniles migrate downstream toward the Sacramento-San Joaquin Delta/Estuary, where they rear for one to four years before migrating out to the Pacific Ocean as subadults (Nakamoto et al. 1995). Acoustically tagged juveniles stayed mostly at or near the bottom while in the San Joaquin River Channel (Thomas et al. 2019). Once at sea, subadults and adults occupy coastal waters to a depth of 110 meters from Baja California, Mexico to the Bering Sea, Alaska (Erickson and Hightower 2007), and regularly aggregate in estuaries. Fish congregate in coastal bays and estuaries of Washington, Oregon, and California during summer and fall. In winter and spring, similar aggregations can be found from Vancouver Island to Hecate Strait, British Columbia, Canada (Lindley et al. 2008). Green sturgeon are found in Willapa Bay, Washington, from May through September, but acoustically-tagged individuals occur there over shorter time periods (34 days, ± 41 days SD) (Borin et al. 2017). Hansel et al. (2017) detected acoustically-tagged green sturgeon in the Columbia River Estuary from May to October.

Adults captured in the Sacramento-San Joaquin Delta are benthic feeders on invertebrates including shrimp, mollusks, amphipods, and even small fish (Houston 1988; Moyle et al. 1992a). Juveniles in the Sacramento River delta feed on opossum shrimp, *Neomysis mercedis*, and *Corophium* amphipods (Radtke 1966). Green sturgeon in Willapa Bay, Washington, eat burrowing shrimp (*Neotrypaea californiensis*) (Borin et al. 2017).

8.9.2 Population Dynamics

Mora et al. (2018) used dual-frequency identification sonar sampling in the Sacramento River for five years between 2010 and 2015 to estimate spawning run size and population size of the southern DPS green sturgeon. Southern DPS spawning run size varied across years, from a minimum of 336 to a maximum of 1,236 individuals. The total population size for the Sacramento River was estimated at 17,548 individuals (95 percent confidence interval [CI] = 12,614 to 22,482). The study also estimated the number of juveniles, sub-adults, and adults in the river. There are an estimated 4,387 juveniles (95 percent CI = 2,595 to 6,179), an estimated 11,055 subadults (95 percent CI = 6,540 to 15,571), and an estimated 2,106 adults (95 percent CI = 1,246 to 2,966) in the Sacramento River (Mora et al. 2018). Mora et al. (2015) did a similar study in the Rogue River and estimated the total abundance of green sturgeon to be 223 (95 percent CI = 150 to 424).

Attempts to evaluate the status of southern DPS green sturgeon have been met with limited success due to the lack of reliable long-term data. No estimate of intrinsic growth rate is available for southern DPS green sturgeon.

Green sturgeon stocks from the DPSs have been found to be genetically differentiated (Israel et al. 2004; Israel et al. 2009).

Green sturgeon from both the northern and southern DPSs range along the Pacific Coast (Moyle 2002b), with green sturgeon tagged and released in the Sacramento River later detected in Willapa Bay, Washington (Hansel et al. 2017). Green sturgeon have been observed in large concentrations in the summer and autumn within coastal bays and estuaries along the west coast of the US, including the Columbia River estuary, Willapa Bay, Grays Harbor, San Francisco Bay and Monterey Bay.

8.9.3 Hearing

Information available about the hearing abilities of green sturgeon come from studies of other species of sturgeon.

Meyer et al. (2003) investigated shortnose sturgeon (*Acipenser brevirostrum*) hearing abilities by using physiological methods to measure responses to pure tones. The authors presented shortnose sturgeon with pure tone stimuli from 50 to 1000 hertz with intensities ranging from of 120 to 160 dB re 1 µPa. Shortnose sturgeon were most sensitive to tones presented at 100 and 400 hertz although thresholds were not determined. Based on the limited data, sturgeon were able to detect sounds below 100 hertz to about 1,000 hertz and that sturgeon should be able to determine the direction of sounds (Popper 2005). Paillid sturgeon (*Scaphirhynchus albus*) and the shovelnose sturgeon (*S. platorynchus*) produce sounds like squeaks, chirps, knocks, and moans during the breeding season, and are thought to help individuals locate other sturgeon (Johnston and Phillips 2003).

Meyer (2010) recorded auditory evoked potentials to pure tone stimuli of varying frequency and intensity in lake sturgeon (*Acipenser fulvescens*) have best sensitivity from 50 to 400 hertz. Lovell (2005) also studied sound reception in and the hearing abilities of paddlefish (*Polyodon spathula*) and lake sturgeon in pressure dominated and particle motion dominated sound fields. They concluded that both species were responsive to sounds ranging in frequency from 100 to 500 hertz with lowest hearing thresholds from frequencies in bandwidths between 200 and 300 hertz and higher thresholds at 100 and 500 hertz. The results showed that both species were not sensitive to sound pressure, and would have a significantly higher hearing threshold in a pressure dominated sound field. Based on the above we assume that the hearing sensitivity of shortnose sturgeon is best between 100 to 500 hertz with sensitivity falling up to 1,000 hertz.

BOEM (2012) categorized sturgeon in general as fishes that detect sounds from below 50 hertz to perhaps 800 to 1,000 hertz (though several probably only detect sounds to 600 to 800 hertz). Green sturgeon have a swim bladder but no known structures in the auditory system that would enhance hearing, and sensitivity (lowest sound detectable at any frequency) is not very great. Sounds would have to be more intense to be detected compared to fishes with swim bladders that enhance hearing. Sturgeon can detect both particle motion and pressure.

8.9.4 Status

Attempts to evaluate the status of southern DPS green sturgeon have been met with limited success due to the lack of reliable long-term data. However, based on available scientific data (Adams et al. 2007) and ongoing conservation efforts, NMFS concluded in the final rule designating this species that southern DPS green sturgeon were likely to become endangered in the foreseeable future throughout all of its range. The final rule listing southern DPS green sturgeon indicates that the principle factor for the decline in the DPS is the reduction of spawning to a limited area in the Sacramento River caused primarily by impoundments. The species also faces threats from changes in water temperature, availability, and flow, and commercial and recreational bycatch (71 FR 17757). Climate change has the potential to impact southern DPS green sturgeon in the future, but it is unclear how changing oceanic, nearshore and river conditions will affect the southern DPS overall (NMFS 2015f).

8.9.5 Critical Habitat

Critical habitat was designated for southern DPS green sturgeon on October 9, 2009, and includes marine, coastal bay, estuarine, and freshwater areas (74 FR 52300). Southern DPS green sturgeon critical habitat was described in Section 7.2.5.6.

8.9.6 Recovery Goals

The final recovery plan for southern DPS green sturgeon indicates that the recovery potential for southern DPS green sturgeon is considered moderate to high (NMFS 2018b); however, certain life history characteristics (e.g., long-lived, delayed maturity) indicate recovery could take many decades, even under the best circumstances. According to the recovery plan key recovery needs and implementation measures include additional spawning and egg/larval habitat, as well as additional research and monitoring (NMFS 2018b).

8.10 Eulachon—Southern Distinct Population Segment

The eulachon is a small, cold-water species of anadromous fish, occupying the eastern Pacific Ocean in nearshore waters to depths of about 1,000 feet (300 meters) from California to the Bering Sea. Eulachon will return to their natal river spawn. Southern DPS eulachon are those that spawn in rivers south of the Nass River in British Columbia to the Mad River in California (Figure 15) (NMFS 2016e).

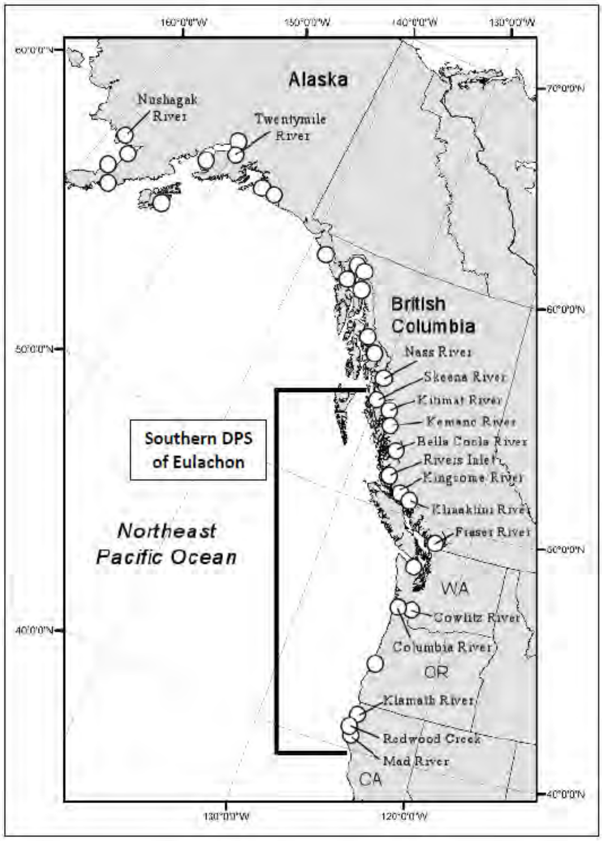

Figure 13. Map identifying the range of the eulachon Southern distinct population segment (NMFS 2016e).

Eulachon are a small (8.5 inches [21.5 centimeters]) anadromous fish, with brown or blue backs, silver on their sides, and white underneath. The Southern DPS was first listed as threatened by NMFS on March 18, 2010 (75 FR 13012).

We used information available in the status review (Gustafson et al. 2010), the updated status review (Gustafson 2016a), the 5-year review (NMFS 2016e), and recent scientific publications to summarize the life history, population dynamics and status of the species, as follows.

8.10.1 Life History

Although primarily marine, eulachon return to freshwater to spawn. For the Southern DPS eulachon, most spawning occurs in the Columbia River and its tributaries. Spawning usually occurs between ages two and five. Spawning is strongly influenced by water temperatures, and the timing of migration typically occurs between December and June, when water temperatures are between 0°C and 10°C (Gustafson 2016a). In the Columbia River and further south, spawning occurs from late January to March (Hay and McCarter 2000). Further north, the peak of eulachon runs in Washington State is from February through March (Hay and McCarter 2000). Females lay between 7,000 and 60,000 eggs over sand, course gravel or detrital substrate. Eggs attach to gravel or sand and incubate for 30 to 40 days after which larvae drift to estuaries and coastal marine waters. In their first year of life, juveniles are found along the continental shelf (Wydoski and Whitney 1979; Gustafson 2016a). Adult eulachon are found in coastal and offshore marine habitats. With the exception of some individuals in Alaska, eulachon generally die after spawning (Gustafson 2016a). The maximum known lifespan is nine years of age, but 20 to 30 percent of individuals live to four years and most individuals survive to three years of age, although spawning has been noted as early as two years of age. Larval and post larval eulachon prey upon phytoplankton, copepods, copepod eggs, mysids, barnacle larvae, worm larvae, and other eulachon larvae until they reach adult size (WDFW and ODFW 2001). The primary prey of adult eulachon are copepods and euphausiids, malacostracans and cumaceans.

8.10.2 Population Dynamics

For most Southern DPS eulachon spawning runs, abundance is unknown with the exception of the Columbia and Fraser River spawning runs. Beginning in 1995, the Canada's Department of Fisheries and Oceans (DFO) started annual surveys in the Fraser River. These surveys consisted of estimating larval density, measuring river discharge, and using estimates of relative fecundity to determine spawning biomass (NMFS 2020). Beginning in 2011, Oregon Department of Fish and Wildlife (ODFW) and Washington Department of Fish and Wildlife (WDFW) began instituting similar monitoring in the Columbia River. From 2014 through 2018, the eulachon spawner population estimate for the Fraser River is 2,608,909 adults and for the Columbia River 16,188,081 adults (Table 6). The combined spawner estimate from the Columbia and Fraser rivers is 18,796,090 eulachon (NMFS 2020).

Table 6. Southern DPS eulachon spawning estimates for the lower Fraser River (British Columbia, Canada) and Columbia River (Oregon/Washington states, USA) (NMFS 2020).

	Fraser River		**Columbia River**	
Year	**Biomass estimate (metric tons)**	**Estimated spawner population**	**Biomass estimate (metric tons)**	**Estimated spawner population**
2011	31	765,445	723	17,860,400
2012	120	2,963,013	810	20,008,600
2013	100	2,469,177	1,845	45,546,700
2014	66	1,629,657	3,412	84,243,100
2015	317	7,827,292	2,330	57,525,700
2016	44	1,086,438	877	21,654,800
2017	35	864,212	330	8,148,600
2018	408	10,074,243	53	1,300,000
2014-2018	**106**	**2,608,009**	**656**	**16,188,081**

Southern DPS eulachon are genetically distinct from eulachon in the northern parts of its range (i.e., Alaska). Recent genetic analysis indicates that the Southern DPS exhibits a regional population structure, with a three-population southern Columbia-Fraser group, coming from the Cowlitz, Columbia, and Fraser rivers (Candy et al. 2015; Gustafson 2016a).

Adult and juvenile Southern DPS eulachon can be found in the Pacific Ocean, along the continental shelf, in waters from 50 to 200 m deep (Gustafson 2016a). Adults are most frequently found in the Columbia River and its tributaries (e.g., Cowlitz River, Sandy River), and sometimes in the Klamath River, California.

8.10.3 Status

Eulachon formerly experienced widespread, abundant runs and have been a staple of Native American diets for centuries along the northwest coast. However, runs that were formerly present in several California rivers as late as the 1960s and 1970s (i.e., Klamath River, Mad River and Redwood Creek) no longer occur (Larson and Belchik 2000). This decline likely began in the 1970s and continued until, in 1988 and 1989, the last reported sizeable run occurred in the Klamath River. No fish were found in 1996, although a moderate run was noted in 1999 (Moyle 2002b). Eulachon have not been identified in the Mad River and Redwood Creek since the mid-1990s (Moyle 2002b). The species is considered to be at moderate risk of extinction throughout its range because of a variety of factors, including predation, commercial and recreational fishing pressure (directed and bycatch), and loss of habitat. Warmer water temperatures associated with climate change could alter the timing of spawning, and the availability of prey for larval and juvenile eulachon (NMFS 2016e). Further population decline is anticipated to continue as a result of climate change and bycatch in commercial fisheries. However, because of their fecundity, eulachon are assumed to have the ability to recover quickly if given the opportunity (Bailey and Houde 1989).

8.10.4 Critical Habitat

On October 20, 2011, NMFS designated critical habitat for Southern DPS eulachon (76 FR 65324). Southern DPS eulachon critical habitat was discussed in Section 7.2.5.7.

8.10.5 Recovery Goals

See the 2017 Recovery Plan for the Southern DPS eulachon, for complete down listing/delisting criteria for each of their respective recovery goals (NMFS 2017f). The following items were the top recovery actions identified in the Recovery Plan:

- Implement outreach and education strategies.
- Conduct strategic research on eulachon.
- Develop biological viability targets.
- Conduct strategic research on eulachon habitats.
- Conduct research on threats, including in marine and freshwater habitat, bycatch, predation, dams and water diversions, water quality, and others.
- Assess regulatory measures, inadequacy of existing regulatory mechanisms.

- Develop a research, monitoring, evaluation, and adaptive management plan.

8.11 Sockeye Salmon – Ozette Lake ESU

This evolutionarily significant unit, or ESU, includes naturally spawned sockeye salmon originating from the Ozette River and Ozette Lake and its tributaries (Figure 14). In addition, sockeye salmon are bred in two artificial propagation programs.

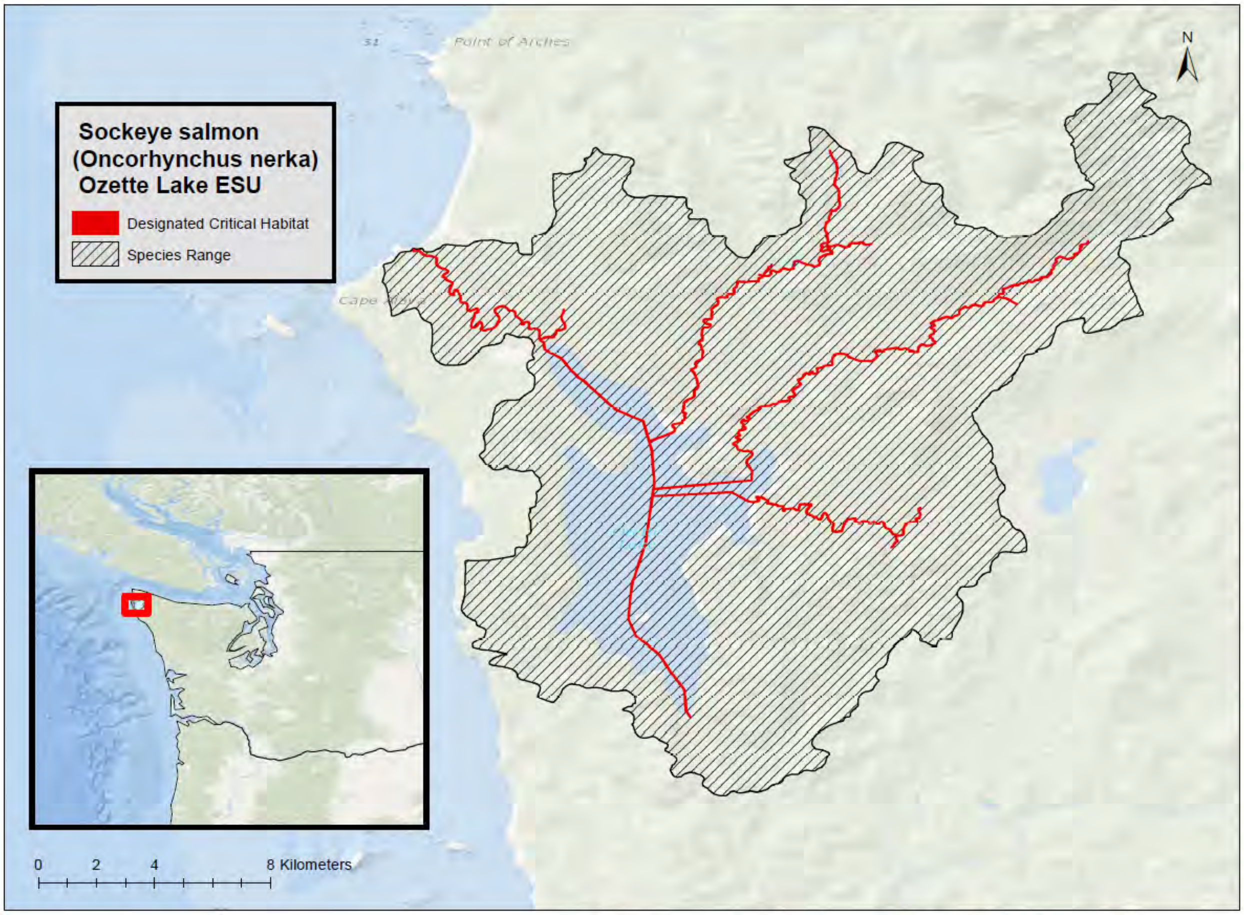

Figure 14. Range and Designated Critical Habitat of the Ozette Lake ESU of Sockeye Salmon.

The sockeye salmon is an anadromous species, although some sockeye spend their entire lives (about five years) in freshwater. Adult sockeye salmon are about three feet long and eight pounds. Sockeyes are bluish black with silver sides when they are in the ocean, and they turn bright red with a green head when they are spawning. On March 25, 1999, NMFS listed the Ozette Lake sockeye salmon ESU as threatened (64 FR 14528) and reaffirmed the ESU's status as threatened on June 28, 2005.

8.11.1 Life History

Most sockeye salmon exhibit a lake-type life history (i.e., they spawn and rear in or near lakes), though some exhibit a river-type life history. Spawning generally occurs in late summer and fall, but timing can vary greatly among populations. In lakes, sockeye salmon commonly spawn along "beaches" where underground seepage provides fresh oxygenated water. Females spawn in three to five redds over a couple of days. Incubation period is a function of water temperature and generally lasts 100 to 200 days (Burgner 1991). Sockeye salmon spawn once, generally in late summer and fall, and then die (semelparity).

Sockeye salmon fry primarily rear in lakes; river-emerged and stream-emerged fry migrate into lakes to rear. In the early fry stage from spring to early summer, juveniles forage exclusively in the warmer littoral (i.e., shoreline) zone where they depend mostly on fly larvae and pupae, copepods, and water fleas. Sub-yearling sockeye salmon move from the littoral habitat to a pelagic (i.e., open water) existence where they feed on larger zooplankton; however, flies may still make up a substantial portion of their diet. From one to three years after emergence, juvenile sockeye salmon generally rear in lakes, though some river-spawned sockeye may migrate to sea in their first year. Juvenile sockeye salmon feeding behaviors change as they transition through life stages after emergence to the time of smoltification. Distribution in lakes and prey preference is a dynamic process that changes daily and yearly depending on many factors including water temperature, prey abundance, presence of predators and competitors, and size of the juvenile. Peak emigration to the ocean occurs in mid-April to early May in southern sockeye populations (lower than 52ºN latitude) and as late as early July in northern populations (62ºN latitude) (Burgner 1991). Adult sockeye salmon return to their natal lakes to spawn after spending one to four years at sea. The diet of adult salmon consists of amphipods, copepods, squid and other fish.

8.11.2 Population Dynamics

The historical abundance of the Ozette Lake ESU of sockeye salmon is poorly documented, but may have been as high as 50,000 individuals (Blum 1988). Escapement estimates (run size minus broodstock take) from 1996 to 2006 range from a low of 1,404 in 1997 to a high of 6,461 in 2004, with a median of approximately 3,800 sockeye per year (geometric mean: 3,353) (Rawson et al. 2009). Current abundance estimates for Ozette Lake ESU sockeye salmon are presented in Table 7 below.

Table 7. Abundance Estimates for the Ozette Lake ESU of Sockeye Salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural and Hatchery (Clipped and Intact Adipose)	Adult	5,036
Natural	Juvenile	1,037,787
Listed Hatchery Adipose Clipped	Juvenile	45,750
Listed Hatchery Intact Adipose	Juvenile	259,250

Productivity has fluctuated up and down over the last few decades, but overall appears to have remained stable (NWFSC 2015b). Given the degree of uncertainty in the abundance estimates, any interpretation of trends of small magnitude or over short time periods is speculative. (NWFSC 2015b).

For the Ozette Lake sockeye salmon ESU, the proportion of beach spawners is likely low; therefore, hatchery-originated fish are not likely to greatly affect the genetics of the naturally-spawned population. However, Ozette Lake sockeye have a relatively low genetic diversity compared to other sockeye salmon populations examined in Washington State (NWFSC 2015b). Genetic differences do occur among age cohorts. However, because different age groups do not reproduce together, the population may be more vulnerable to significant reductions in population structure due to catastrophic events or unfavorable conditions affecting a single year class.

The Ozette Lake sockeye salmon ESU is composed of one historical population with multiple spawning aggregations and two populations from the Umbrella Creek and Big River sockeye hatchery programs (NWFSC 2015b). Historically, at least four lake beaches were used for spawning; today only two beach spawning locations, Allen's and Olsen's Beaches, are used. Additionally, spawning occurs in the two tributaries of the hatchery programs (NWFSC 2015b). The Umbrella creek population is a large component of the total population (averaging over 50 percent for the last decade of data).

8.11.3 Status

NMFS listed the Ozette Lake sockeye salmon ESU because of habitat loss and degradation from the combined effects of logging, road building, predation, invasive plant species, and overharvest. Ozette Lake sockeye salmon have not been commercially harvested since 1982 and only minimally harvested by the Makah Tribe since 1982 (0 to 84 fish per year); there is no known marine fishing of this ESU. Overall abundance is substantially below historical levels, and whether the decrease in abundance is a result of fewer spawning aggregations, lower abundances in each aggregation, or a combination of both factors is unknown. Regardless, this ESU's viability has not improved, and the ESU would likely have a low resilience to additional perturbations. However, recovery potential for the Ozette Lake sockeye salmon ESU is good, particularly because of protections afforded it based on the lake's location within a Olympic National Park (NWFSC 2015b).

8.11.4 Critical Habitat

NMFS designated critical habitat for Ozette Lake sockeye salmon on September 2, 2005 (70 FR 52630). Critical habitat includes juvenile summer and winter rearing areas, juvenile migration corridors, areas for growth and development to adulthood, adult migration corridors, and spawning areas.

8.11.5 Recovery Goals

We adopted a recovery plan for Lake Ozette ESU sockeye salmon (NMFS 2009c) in May 2009. The criteria of the recovery plan were based upon Rawson et al. (2009). Recovery criteria include:

- Multiple, spatially distinct and persistent spawning aggregations throughout the historical range of the population (i.e., along the lake beaches and in one or more tributaries).
- One or more persistent spawning aggregations from each major genetic and life history group historically present. Also, genetic distinctness between anadromous sockeye, and kokanee salmon in the lake.
- Abundance between 31,250 and 121,000 adult spawners, over a number of years.

8.12 Sockeye Salmon – Snake River ESU

This evolutionarily significant unit, or ESU, includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River basin (Figure 15), and also sockeye salmon from one artificial propagation program: Redfish Lake Captive Broodstock Program.

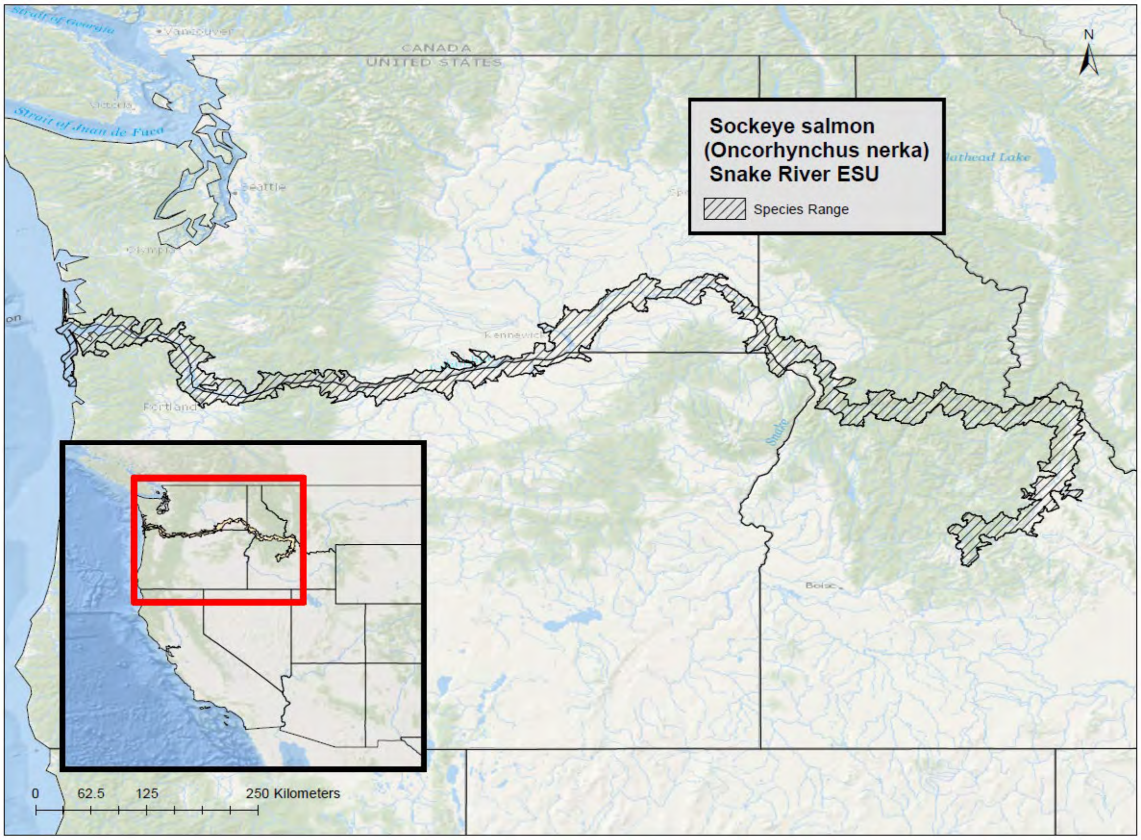

Figure 15. Geographic range of Sockeye salmon, Snake River ESU.

On November 20, 1991 NMFS listed the Snake River sockeye salmon ESU as endangered (56 FR 58619), and reaffirmed the ESU's status as endangered on June 28, 2005.

8.12.1 Life History

The life history for this ESU of sockeye salmon is the same as that presented in Section 8.11.1.

8.12.2 Population Dynamics

Adult returns over the last several years have ranged from a high of 1,579 fish in 2014 (including 453 natural-origin fish) to a low of 257 adults in 2012 (including 52 natural-origin fish). Sockeye salmon returns to Alturas Lake ranged from one fish in 2002 to 14 fish in 2010. No fish returned to Alturas Lake in 2012, 2013, or 2014 (NMFS 2015b). Current abundance estimates for the Snake River ESU of sockeye salmon are presented in Table 8 below.

Table 8. Current Abundance Estimates for Snake River ESU Sockeye Salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	546
Natural	Juvenile	19,181
Listed Hatchery Adipose Clipped	Adult	4,004
Listed Hatchery Adipose Clipped	Juvenile	242,610

The large increases in returning adults in recent years reflect improved downstream and ocean survival as well as increases in juvenile production since the early 1990s. Although total sockeye salmon returns to the Sawtooth Valley in recent years have been high enough to allow for some level of natural spawning in Redfish Lake, the hatchery program remains at its initial phase with a priority on genetic conservation and building sufficient returns to support sustained outplanting and recolonization of the species' historic range (NMFS 2015b; NWFSC 2015b).

For the Snake River ESU, the Sawtooth Hatchery is focusing on genetic conservation. An overrepresentation of genes from the anadromous population in Redfish Lake exists, but inbreeding is low, which is a sign of a successful captive broodstock program (NMFS 2015b; NWFSC 2015b).

This ESU includes all anadromous and residual sockeye salmon from the Snake River basin, Idaho, and artificially-propagated sockeye salmon from the Redfish Lake Captive Broodstock Program (USDC 2014; NMFS 2015b; NWFSC 2015b). The Interior Columbia Technical Recovery Team (ICTRT) treats Sawtooth Valley Sockeye salmon as the single major population group (MPG) within the Snake River Sockeye Salmon ESU. The MPG contains one extant population (Redfish Lake) and two to four historical populations (Alturas, Petit, Stanley, and Yellowbelly Lakes) (NMFS 2015b). At the time of listing in 1991, the only confirmed extant population included in this ESU was the beach-spawning population of sockeye salmon from Redfish Lake, with about 10 fish returning per year (NMFS 2015b).

8.12.3 Status

The Snake River sockeye salmon ESU includes only one population comprised of all anadromous and residual sockeye salmon from the Snake River Basin, Idaho, as well as artificially propagated sockeye salmon from the Redfish Lake captive propagation program. Historical evidence indicates that the Snake River sockeye once had a range of life history patterns, with spawning populations present in several of the small lakes in the Sawtooth Basin. NMFS listed the Snake River sockeye salmon ESU because of habitat loss and degradation from the combined effects of damming and hydropower development, overexploitation, fisheries management practices, and poor ocean conditions. Recent effects of climate change, such as reduced stream flows and increased water temperatures, are limiting Snake River ESU productivity (NMFS 2015b; NWFSC 2015b). Adults produced through the captive propagation program currently support the entire ESU. This ESU is still at extremely high risk across all four basic risk measures (abundance, productivity, spatial structure, and diversity) and would likely have a very low resilience to additional perturbations. Habitat improvement projects have slightly decreased the risk to the species, but habitat concerns and water temperature issues remain. Overall, although the status of the Snake River sockeye salmon ESU appears to be improving, there is no indication that the biological risk category has changed (NWFSC 2015b).

8.12.4 Critical Habitat

NMFS designated critical habitat for Snake River sockeye salmon on December 28, 1993 (58 FR 68543). The critical habitat encompasses the waters, waterway bottoms, and adjacent riparian zones of specified lakes and river reaches in the Columbia River that are or were accessible to salmon of this ESU (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams).

8.12.5 Recovery Goals

See the 2015 recovery plan for the Snake River sockeye salmon ESU for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2015b). Broadly, recovery plan goals emphasize restoring historical lake populations and improving water quality and quantity in lakes and migration corridors.

8.13 Steelhead Trout – California Central Valley DPS

The Central Valley DPS of steelhead includes naturally spawned anadromous steelhead trout originating below natural and manmade impassable barriers from the Sacramento and San Joaquin Rivers and their tributaries and excludes such fish originating from San Francisco and San Pablo Bays and their tributaries (Figure 16). Further, the Central Valley DPS of steelhead trout includes steelhead from two artificial propagation programs.

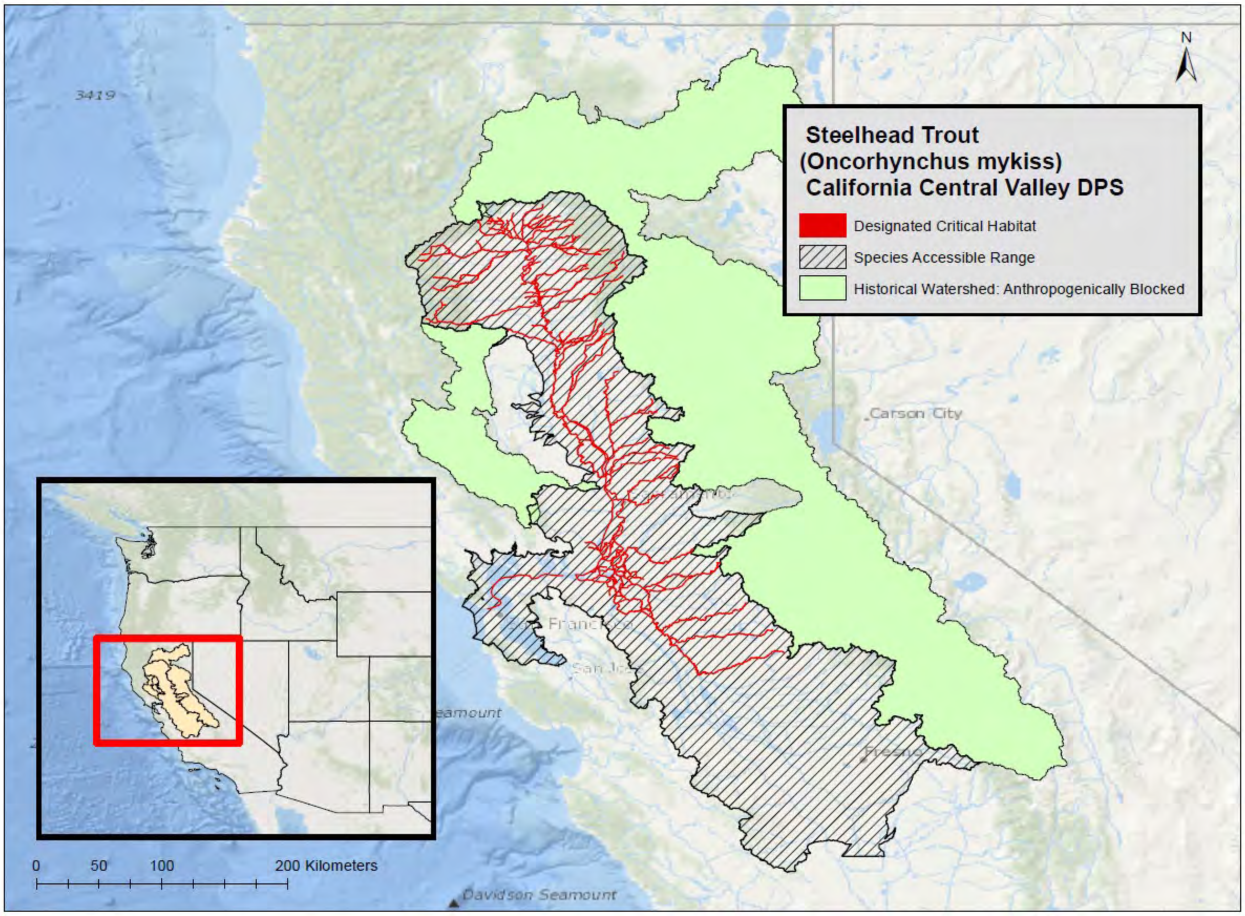

Figure 16. Geographic range and designated critical habitat of California Central Valley Steelhead.

On March 19, 1998 NMFS listed the California Central Valley DPS of steelhead as threatened (63 FR 13347) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.13.1 Life History

The Central Valley DPS of steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. The preferred water temperature range for steelhead spawning is reported to be 30°F to 52°F (CDFW 2000). The eggs hatch in three to four weeks at 50°F to 59°F, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954). Regardless of life history strategy, for the first year or two of life steelhead are found in cool, clear, fast flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002b). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools.

Steelhead typically migrate to marine waters after spending two years in freshwater. They reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year olds. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002b). Currently, Central Valley steelhead are considered "ocean-maturing" (also known as winter) steelhead, although summer steelhead may have been present prior to construction of large dams (Moyle 2002b). Ocean maturing steelhead enter freshwater with well-developed gonads and spawn shortly after river entry. Central Valley steelhead enter freshwater from August through April. They hold until flows are high enough in tributaries to enter for spawning (Moyle 2002b). Steelhead adults typically spawn from December through April, with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock et al. 1961; McEwan 2001).

8.13.2 Population Dynamics

Historic Central Valley steelhead run size may have approached one to two million adults annually (McEwan 2001). By the early 1960s, the steelhead run size had declined to about 40,000 adults (McEwan 2001). Over the past 30 years, the naturally spawned steelhead populations in the upper Sacramento River have declined substantially. Based on catch ratios at Chipps Island in the Delta and using some generous assumptions regarding survival, the average number of Central Valley steelhead females spawning naturally in the entire Central Valley during the years 1980 to 2000 was estimated at about 3,600 (Good et al. 2005). Current abundance estimates for the California Central Valley ESU of steelhead trout are presented in Table 9 below.

Table 9. Current Abundance Estimates for the California Central Valley ESU of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	1,686
Natural	Juvenile	630,403
Listed Hatchery Adipose Clipped	Adult	3,856
Listed Hatchery Adipose Clipped	Juvenile	1,600,653

California Central Valley steelhead lack annual monitoring data for calculating trends. However, the Red Bluff Diversion Dam counts and redd counts up to 1993 and later sporadic data show that the DPS has had a significant long-term downward trend in abundance (NMFS 2009a).

The Central Valley steelhead distribution ranges over a wide variety of environmental conditions and likely contains biologically significant amounts of spatially structured genetic diversity (Lindley et al. 2006). The loss of populations and reduction in abundances have reduced the large diversity that existed within the DPS. The genetic diversity of the majority of steelhead spawning runs within this DPS is also compromised by hatchery-origin fish.

Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems.

8.13.3 Status

Many watersheds in the Central Valley are experiencing decreased abundance of California Central Valley steelhead. Dam removal and habitat restoration efforts in Clear Creek appear to be benefiting steelhead as recent increases in non-clipped (wild) abundance have been observed. Despite the positive trend in Clear Creek, all other concerns raised in the previous status review remain, including low adult abundances, loss and degradation of a large percentage of the historic spawning and rearing habitat, and domination of smolt production by hatchery fish. Many other planned restoration and reintroduction efforts have yet to be implemented or completed, or are focused on Chinook salmon, and have yet to yield demonstrable improvements in habitat, let alone documented increases in naturally produced steelhead. There are indications that natural production of steelhead continues to decline and is now at a very low level. Their continued low numbers in most hatcheries, and domination by hatchery fish, makes the continued existence of naturally reproduced steelhead a concern. California Central Valley steelhead is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

8.13.4 Critical Habitat

NMFS designated critical habitat for California Central Valley steelhead on September 2, 2005 (70 FR 52488). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.13.5 Recovery Goals

See the 2014 recovery plan for the California Central Valley steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2014b). The delisting criteria for this DPS are:

- One population in the Northwestern California Diversity Group at low risk of extinction
- Two populations in the Basalt and Porous Lava Flow Diversity Group at low risk of extinction
- Four populations in the Northern Sierra Diversity Group at low risk of extinction
- Two populations in the Southern Sierra Diversity Group at low risk of extinction
- Maintain multiple populations at moderate risk of extinction.

8.14 Steelhead Trout – Central California Coast DPS

The Central California Coast DPS of Steelhead trout includes all naturally spawned populations of steelhead (and their progeny) in streams from the Russian River to Aptos Creek, Santa Cruz

County, California (inclusive). It also includes the drainages of San Francisco and San Pablo Bays (Figure 17).

On August 18, 1997 NMFS listed the Central California Coast DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.14.1 Life History

The Central California Coast DPS of steelhead is entirely composed of winter-run fish. Adults return to the Russian River and migrate upstream from December to April, and smolts emigrate between March and May (Shapovalov and Taft 1954; Hayes et al. 2004). Most spawning takes place from January through April. The life history for this DPS of steelhead trout is the same that is presented in Section 8.13.1.

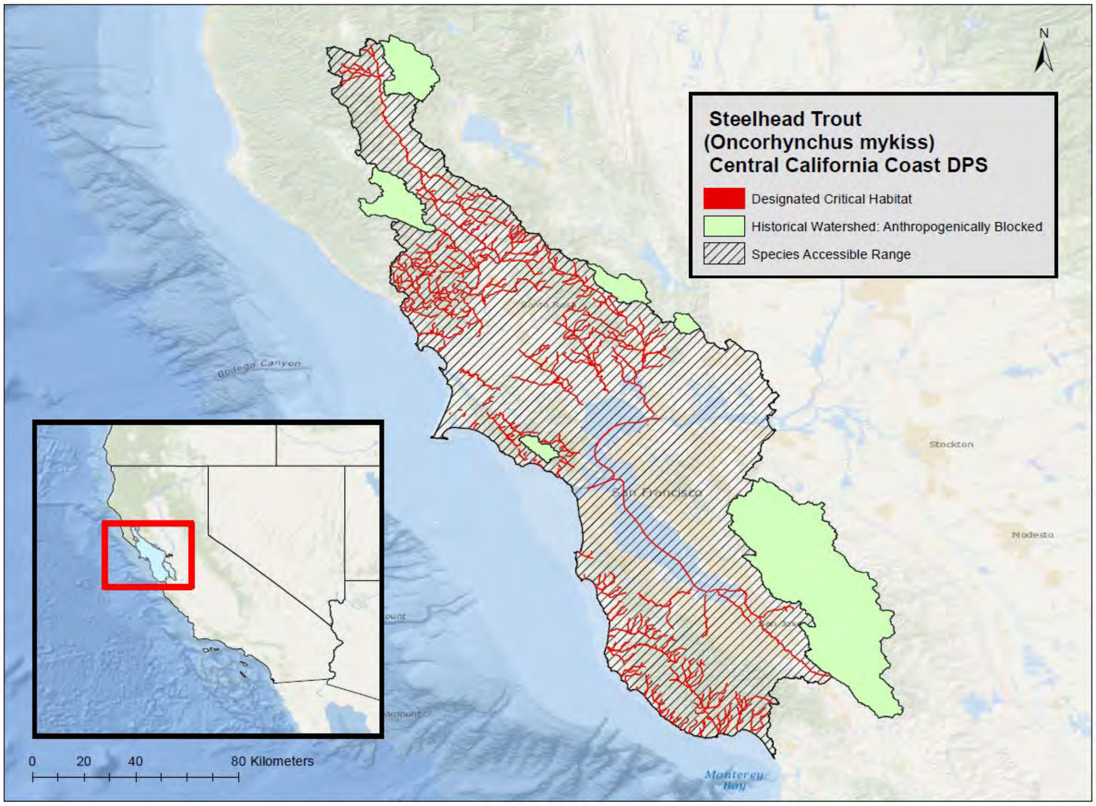

Figure 17. Geographic range and designated critical habitat of Central California Coast Steelhead.

Steelhead typically migrate to marine waters after spending two years in freshwater. They reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year olds. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002b).While age of smoltification typically ranges for one to four years, recent studies indicate that growth rates in Soquel Creek likely prevent juveniles from undergoing smoltification until age two (Sogard et al. 2009).

8.14.2 Population Dynamics

Historically, the entire Central California Coast steelhead DPS may have consisted of an average runs size of 94,000 adults in the early 1960s (Good et al. 2005). Current abundance estimates for the California Central Coast ESU of steelhead trout are presented in Table 10 below. Presence-absence data indicate that most (82 percent) sampled streams (a subset of all historical steelhead streams) had extant populations of juvenile *O. mykiss* (Adams 2000; Good et al. 2005).

Table 10. Current Abundance Estimates for the California Central Coast ESU of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	2,187
Natural	Juvenile	248,771
Listed Hatchery Adipose Clipped	Adult	3,866
Listed Hatchery Adipose Clipped	Juvenile	648,891

Though the information for individual populations is limited, available information strongly suggests that no population is viable. Long-term population sustainability is extremely low for the southern populations in the Santa Cruz mountains and in the San Francisco Bay (NMFS 2008a). Declines in juvenile southern populations are consistent with the more general estimates of declining abundance in the region (Good et al. 2005).

The interior Russian River winter-run steelhead has the largest runs with an estimate of an average of over 1,000 spawners. Due to this, Russian River winter-run steelhead may be able to be sustained over the long-term but hatchery management has eroded the population's genetic diversity (Bjorkstedt et al. 2005; NMFS 2008a).

8.14.3 Status

The Central California Coast steelhead consisted of nine historic functionally independent populations and 23 potentially independent populations (Bjorkstedt et al. 2005). Of the historic functionally independent populations, at least two are extirpated while most of the remaining are nearly extirpated. Current runs in the basins that originally contained the two largest steelhead populations for the DPS, the San Lorenzo and the Russian Rivers, both have been estimated at less than 15 percent of their abundances just 30 years earlier (Good et al. 2005). The Russian River is of particular importance for preventing the extinction and contributing to the recovery of Central California Coast steelhead (NOAA 2013b). Steelhead access to significant portions of the upper Russian River has also been blocked (Busby et al. 1996a; NMFS 2008a).

8.14.4 Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.14.5 Recovery Goals

See the 2016 recovery plan for the Central California Coast steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species. Recovery plan objectives are to:

- Reduce the present or threatened destruction, modification, or curtailment of habitat or range;
- Ameliorate utilization for commercial, recreational, scientific, or educational purposes;
- Abate disease and predation;
- Establish the adequacy of existing regulatory mechanisms for protecting Central California Coast steelhead now and into the future (i.e., post-delisting);
- Address other natural or manmade factors affecting the continued existence of Central California Coast steelhead;
- Ensure Central California Coast steelhead status is at a low risk of extinction based on abundance, growth rate, spatial structure and diversity.

8.15 Steelhead Trout – Lower Columbia River DPS

The Lower Columbia River DPS of steelhead trout includes naturally spawned steelhead originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive) and excludes such fish originating from the upper Willamette River basin above Willamette Falls (Figure 18). The Lower Columbia River DPS also includes steelhead from seven artificial propagation programs.

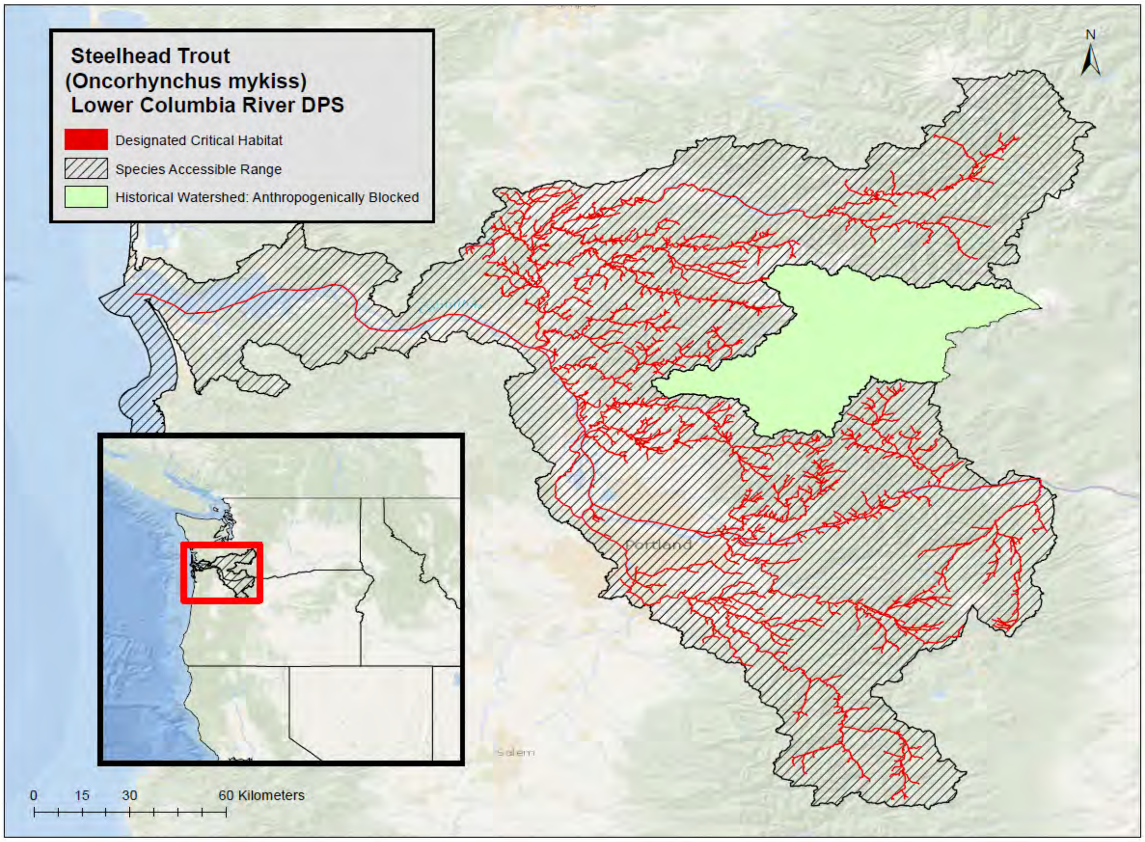

Figure 18. Geographic range and designated critical habitat of Lower Columbia River steelhead.

On March 19, 1998, NMFS listed the Lower Columbia River DPS of steelhead as threatened (63 FR 13347) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.15.1 Life History

The Lower Columbia River steelhead DPS includes both summer- and winter-run stocks. Summer-run steelhead return sexually immature to the Columbia River from May to November, and spend several months in freshwater prior to spawning. Winter-run steelhead enter freshwater from November to April, are close to sexual maturation during freshwater entry, and spawn shortly after arrival in their natal streams. Where both races spawn in the same stream, summer-run steelhead tend to spawn at higher elevations than the winter-run. The life history for this DPS of steelhead trout is the same as that presented in Section 8.13.1.

The majority of juvenile lower Columbia River steelhead remain for two years in freshwater environments before ocean entry in spring. Both winter- and summer-run adults normally return after two years in the marine environment. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002b).

8.15.2 Population Dynamics

The Winter-run Western Cascade MPG includes native winter-run steelhead in 14 demographically independent populations (DIPs) from the Cowlitz River to the Washougal River. Abundances have remained fairly stable and have remained low, averaging in the hundreds of fish. Notable exceptions to this were the Clackamas and Sandy River winter-run steelhead populations, that are exhibiting recent rises in natural-origin returns abundance and maintaining low levels of hatchery-origin steelhead on the spawning grounds (NWFSC 2015b). In the Summer-run Cascade MPG, there are four summer-run steelhead populations. Absolute abundances have been in the hundreds of fish. In the Winter-run Gorge MPG both the Lower and Upper Gorge population surveys for winter steelhead are very limited and abundance levels in the Hood River have been low but relatively stable. In the Summer-run Gorge MPG adult abundance in the Wind River remains stable, but at a low level (hundreds of fish). Current abundance estimates for the Lower Columbia River DPS of steelhead trout are presented in Table 11 below.

Table 11. Current Abundance Estimates for the Lower Columbia River DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	12,920
Natural	Juvenile	352,146
Listed Hatchery Adipose Clipped and Intact	Adult	22,297
Listed Hatchery Adipose Clipped	Juvenile	1,197,156
Listed Hatchery Intact Adipose	Juvenile	9,138

Population trends for the Winter-run Western Cascade MPG are fairly stable. Long- and short-term trends for three independent populations within the Summer-run Cascade MPG are positive; though the 2014 surveys indicate a drop in abundance for all three. Population trends in the Winter-run Gorge MPG is relatively stable. The overall status of the Summer-run Gorge MPG is uncertain.

Total steelhead hatchery releases in the Lower Columbia River Steelhead DPS have decreased since the last status review, declining from a total (summer and winter run) release of approximately 3.5 million to 3 million from 2008 to 2014. Some populations continue to have relatively high fractions of hatchery-origin spawners, whereas others (e.g., Wind River) have relatively few hatchery origin spawners.

There are four MPGs comprised of 23 DIPs, including six summer-run steelhead populations and 17 winter-run populations (NWFSC 2015b). Summer steelhead spawning areas in the Lower

Columbia River are found above waterfalls and other features that create seasonal barriers to migration. There have been a number of large-scale efforts to improve accessibility (one of the primary metrics for spatial structure) in this ESU. Trap and haul operations were begun on the Lewis River in 2012 for winter-run steelhead, reestablishing access to historically occupied habitat above Swift Dam. In 2014, 1033 adult winter steelhead (integrated program fish) were transported to the upper Lewis River; however, juvenile collection efficiency is still below target levels. In addition, there have been a number of recovery actions throughout the ESU to remove or improve culverts and other small-scale passage barriers.

8.15.3 Status

The Lower Columbia River steelhead had 17 historically independent winter steelhead populations and six independent summer steelhead populations (McElhany et al. 2003; Myers et al. 2006). All historic Lower Columbia River steelhead populations are considered extant. However, spatial structure within the historically independent populations, especially on the Washington side, has been substantially reduced by the loss of access to the upper portions of some basins due to tributary hydropower development. The majority of winter-run steelhead populations in this DPS continue to persist at low abundances (NWFSC 2015b). Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead DIPs were similarly stable, but at low abundance levels. Habitat degradation continues to be a concern for most populations. Even with modest improvements in the status of several winter-run populations, none of the populations appear to be at fully viable status, and similarly none of the MPGs meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015b).

8.15.4 Critical Habitat

Critical habitat was designated for the Lower Columbia River steelhead on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.15.5 Recovery Goals

The Lower Columbia River DPS of steelhead are included in the Lower Columbia River recovery plan (NMFS 2013a). For this DPS, threats in all categories must be reduced, but the most crucial elements are protecting favorable tributary habitat and restoring habitat in the Upper Cowlitz, Cispus, North Fork Toutle, Kalama and Sandy subbasins (for winter steelhead), and the East Fork Lewis, and Hood, subbasins (for summer steelhead). Protection and improvement is also need among the South Fork Toutle and Clackamas winter steelhead populations.

8.16 Steelhead Trout – Middle Columbia River DPS

The Middle Columbia River DPS of steelhead trout includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Wind and Hood Rivers (exclusive) to and including the

Yakima River and excludes such fish originating from the Snake River Basin (Figure 19). Further, this DPS includes steelhead from seven artificial propagation programs.

On March 25, 1999 NMFS listed the Middle Columbia River (MCR) DPS of steelhead as threatened (64 FR 14517) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.16.1 Life History

Middle Columbia River steelhead populations are mostly of the summer-run type. Adult steelhead enter freshwater from June through August. The only exceptions are populations of inland winter-run steelhead which occur in the Klickitat River and Fifteenmile Creek (Busby et al. 1996a). The life history for this DPS of steelhead trout is the same as that presented in Section 8.13.1.

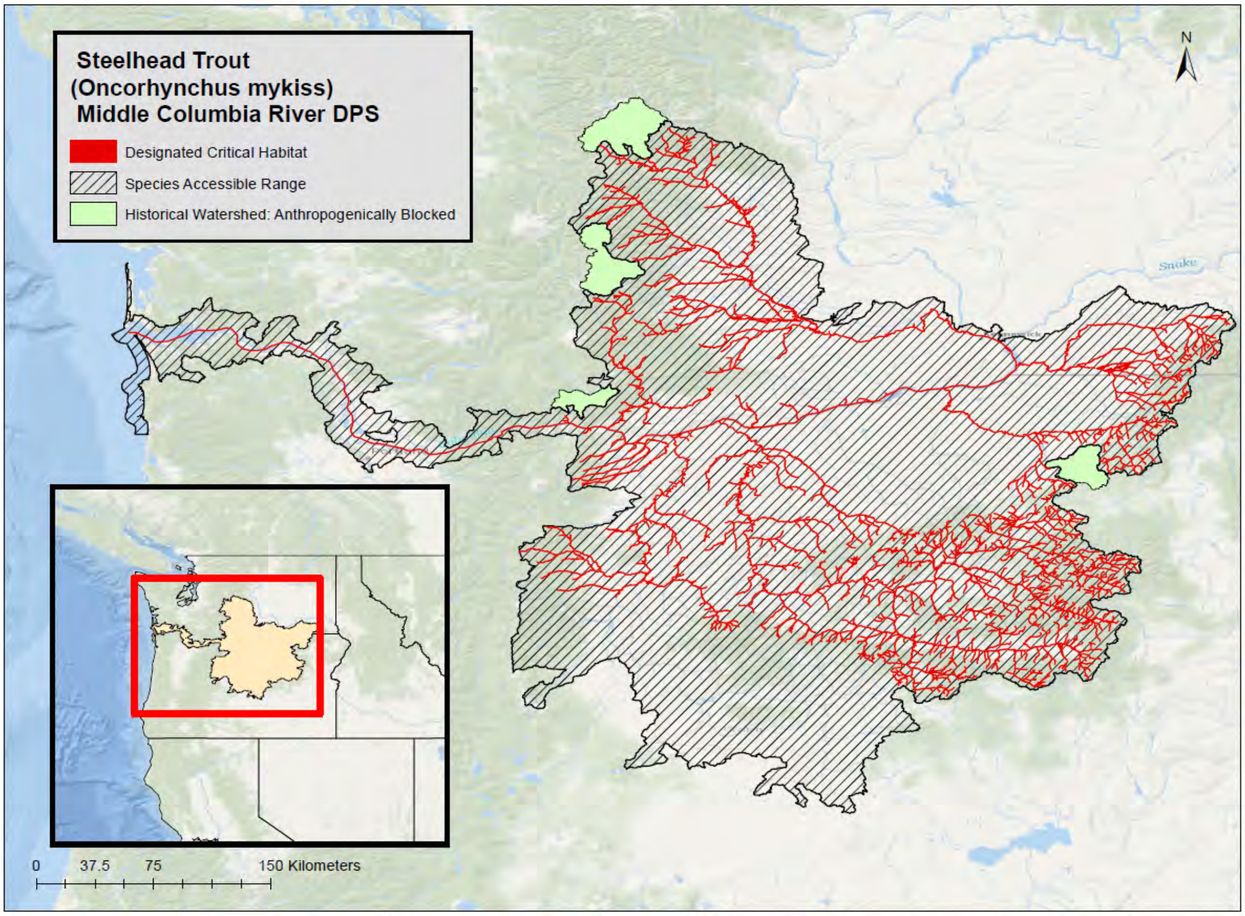

Figure 19. Geographic range and designated critical habitat of Middle Columbia River steelhead.

The majority of juveniles smolt and out-migrate as two-year olds. Most of the rivers in this region produce about equal or higher numbers of adults having spent one year in the ocean as adults having spent two years. However, summer-run steelhead in Klickitat River have a life cycle more like LCR steelhead whereby the majority of returning adults have spent two years in the ocean (Busby et al. 1996a). Adults may hold in the river up to a year before spawning. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002b).

8.16.2 Population Dynamics

Historic run estimates for the Yakima River imply that annual species abundance may have exceeded 300,000 returning adults (Busby et al. 1996a). The five-year average (geometric mean) return of natural Middle Columbia River steelhead for 1997 to 2001 was up from basin estimates of previous years. Returns to the Yakima River, the Deschutes River, and sections of the John Day River system were substantially higher compared to 1992 to 1997 (Good et al. 2005). The five-year average for these basins is 298 and 1,492 fish, respectively (Good et al. 2005). Current abundance estimates for the Middle Columbia River DPS of steelhead trout are presented in Table 12 below.

Table 12. Current Abundance Estimates for the Middle Columbia River DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	5,052
Natural	Juvenile	407,697
Listed Hatchery Adipose Clipped	Adult	448
Listed Hatchery Adipose Clipped	Juvenile	444,973
Listed Hatchery Intact Adipose	Adult	112
Listed Hatchery Intact Adipose	Juvenile	110,469

There have been improvements in the viability ratings for some of the component populations, but the Middle Columbia River Steelhead DPS is not currently meeting the viability criteria described in the Mid-Columbia Steelhead Recovery Plan.

The ICTRT identified 17 extant populations in this DPS (ICTRT 2003; McClure et al. 2005). The populations fall into four MPGs: Cascade eastern slope tributaries (five extant and two extirpated populations), the John Day River (five extant populations), the Walla Walla and Umatilla rivers (three extant and one extirpated populations), and the Yakima River (four extant populations).

8.16.3 Status

Within the Middle Columbia River DPS of steelhead, the ICTRT identified 16 extant populations in four MPGs (Cascades Eastern Slopes Tributaries, John Day River, Walla Walla and Umatilla Rivers, and Yakima River) and one unaffiliated independent population (Rock Creek) (ICTRT

2003). There are two extinct populations in the Cascades Eastern Slope MPG: the White Salmon River and the Deschutes Crooked River above the Pelton/Round Butte Dam complex. Present population structure is delineated largely on geographical proximity, topography, distance, ecological similarities or differences. Using criteria for abundance and productivity, the ICTRT modeled a gaps analysis for each of the four MPGs in this DPS under three different ocean conditions and a base hydro condition (most recent 20-year survival rate). The results showed that none of the MPGs would be able to achieve a 5 percent or less risk of extinction over 100 years without recovery actions. It is important to consider that significant gaps in factors affecting spatial structure and diversity also contribute to the risk of extinction for these fish.

8.16.4 Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, and freshwater migration corridors.

8.16.5 Recovery Goals

See the 2009 recovery plan for the Middle Columbia River steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species with criteria based on biological viability outlining the thresholds for each MPG, including abundance and productivity thresholds, as well as spatial structure and diversity criteria (NMFS 2009b).

8.17 Steelhead Trout – Northern California DPS

The Northern California DPS of steelhead trout includes naturally spawned steelhead originating below natural and manmade impassable barriers in California coastal river basins from Redwood Creek to and including the Gualala River (Figure 21).

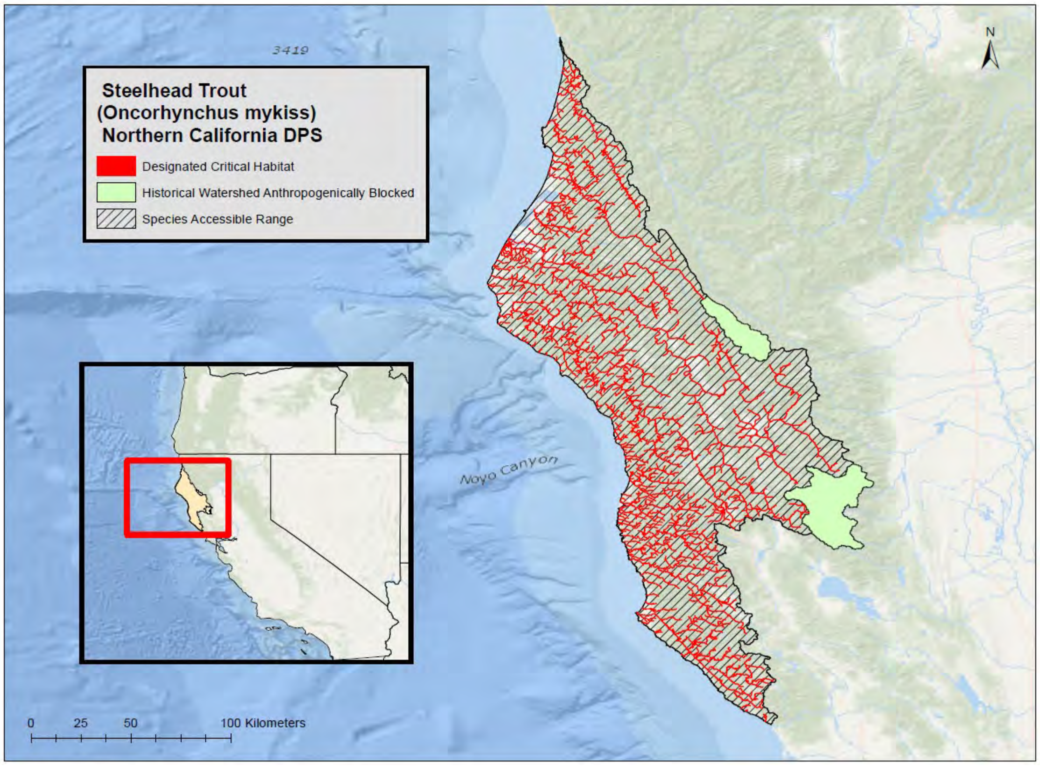

Figure 20. Geographic range and designated critical habitat of Northern California DPS steelhead.

On June 7, 2000 NMFS listed the Northern California DPS of steelhead as threatened (65 FR 36074) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.17.1 Life History

The Northern California DPS of steelhead includes both winter- and summer –run steelhead. In the Mad and Eel Rivers, immature steelhead may return to freshwater as "half-pounders" after spending only two to four months in the ocean. Generally, a half-pounder will overwinter in freshwater and return to the ocean in the following spring.

Juvenile out-migration appears more closely associated with size than age but generally, throughout their range in California, juveniles spend two years in freshwater (Busby et al. 1996a). Smolts range from 14 to 21 cm in length. Juvenile steelhead may migrate to rear in lagoons throughout the year with a peak in the late spring/early summer and in the late fall/early winter period (Shapovalov and Taft 1954; Zedonis 1992).

Steelhead spend anywhere from one to five years in salt water, however, two to three years are most common (Busby et al. 1996a). Ocean distribution is not well known but coded wire tag recoveries indicate that most Northern California steelhead migrate north and south along the continental shelf (Barnhart 1986).

8.17.2 Population Dynamics

Most populations for which there are population estimates available remain well below viability targets; however, the short-term increases observed for many populations, despite the occurrence of a prolonged drought in northern California, suggests this DPS is not at immediate risk of extinction. Current abundance estimates for the Northern California DPS of steelhead trout are presented in Table 14 below.

Table 13. Current Abundance Estimates for the Northern California DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	7,221
Natural	Juvenile	821,389

Overall, the available data for winter-run populations— predominately in the North Coastal, North-Central Coastal, and Central Coastal strata— indicate that all populations are well below viability targets, most being between five percent and 13 percent of these goals. For the two Mendocino Coast populations with the longest time series, Pudding Creek and Noyo River, the 13-year trends have been negative and neutral, respectively (Spence 2016). However, the short-term (six-year) trend has been generally positive for all independent populations in the North-Central Coastal and Central Coastal strata, including the Noyo River and Pudding Creek (Spence 2016). Data from Van Arsdale Station likewise suggests that, although the long-term trend has been negative, run sizes of natural-origin steelhead have stabilized or are increasing (Spence 2016). Thus, we have no strong evidence to indicate conditions for winter-run populations in the DPS have worsened appreciably since the last status review (Williams et al. 2011). Summer-run populations continue to be of significant concern because of how few populations currently exist. The Middle Fork Eel River population has remained remarkably stable for nearly five decades and is closer to its viability target than any other population in the DPS (Spence 2016). Although the time series is short, the Van Duzen River appears to be supporting a population numbering in the low hundreds. However, the Redwood Creek and Mattole River populations appear small, and little is known about other populations including the Mad River and other tributaries of the Eel River (i.e., Larabee Creek, North Fork Eel, and South Fork Eel).

Artificial propagation was identified as negatively affecting wild stocks of salmonids through interactions with non-native fish, introductions of disease, genetic changes, competition for space and food resources, straying and mating with native populations, loss of local genetic adaptations, mortality associated with capture for broodstock and palliating the destruction of habitat and concealing problems facing wild stocks.

8.17.3 Status

The available data for winter-run populations— predominately in the North Coastal, North-Central Coastal, and Central Coastal strata— indicate that all populations are well below viability targets, most being between five percent and 13 percent of these goals. For the two Mendocino Coast populations with the longest time series, Pudding Creek and Noyo River, the 13-year trends have been negative and neutral, respectively (Spence 2016). However, the short-term (six-year) trend has been generally positive for all independent populations in the North-Central Coastal and Central Coastal strata, including the Noyo River and Pudding Creek (Spence 2016). Data from Van Arsdale Station likewise suggests that, although the long-term trend has been negative, run sizes of natural-origin steelhead have stabilized or are increasing (Spence 2016). Thus, we have no strong evidence to indicate conditions for winter-run populations in the DPS have worsened appreciably since the last status review (Williams et al. 2011). Summer-run populations continue to be of significant concern because of how few populations currently exist. The Middle Fork Eel River population has remained remarkably stable for nearly five decades and is closer to its viability target than any other population in the DPS (Spence 2016). Although the time series is short, the Van Duzen River appears to be supporting a population numbering in the low hundreds. However, the Redwood Creek and Mattole River populations appear small, and little is known about other populations including the Mad River and other tributaries of the Eel River (i.e., Larabee Creek, North Fork Eel, and South Fork Eel). Most populations for which there are population estimates available remain well below viability targets; however, the short-term increases observed for many populations, despite the occurrence of a prolonged drought in northern California, suggests this DPS is not at an immediate risk of extinction.

8.17.4 Critical Habitat

NMFS designated critical habitat for Northern California DPS steelhead on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.17.5 Recovery Goals

See the 2016 recovery plan for the Northern California steelhead DPS for complete down-listing/delisting criteria for recovery goals for the DPS (NMFS 2016f).

8.18 Steelhead Trout – Puget Sound DPS

This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Georgia Strait (Figure 22). The DPS also includes steelhead from six artificial propagation programs. On May 11, 2007 NMFS listed the Puget Sound DPS of steelhead as threatened (72 FR 26722).

8.18.1 Life History

The Puget Sound steelhead DPS contains both winter-run and summer-run steelhead. Adult winter-run steelhead generally return to Puget Sound tributaries from December to April (NMFS 2005). Spawning occurs from January to mid-June, with peak spawning occurring from mid-April through May. Prior to spawning, maturing adults hold in pools or in side channels to avoid high winter flows. Less information exists for summer-run steelhead as their smaller run size and higher altitude headwater holding areas have not been conducive for monitoring. Based on information from four streams, adult run time occur from mid-April to October with a higher concentration from July through September (NMFS 2005).

The majority of juveniles reside in the river system for two years with a minority migrating to the ocean as one or three-year olds. Smoltification and seaward migration occur from April to mid-May. The ocean growth period for Puget Sound steelhead ranges from one to three years in the ocean (Busby et al. 1996a). Juveniles or adults may spend considerable time in the protected marine environment of the fjord-like Puget Sound during migration to the high seas.

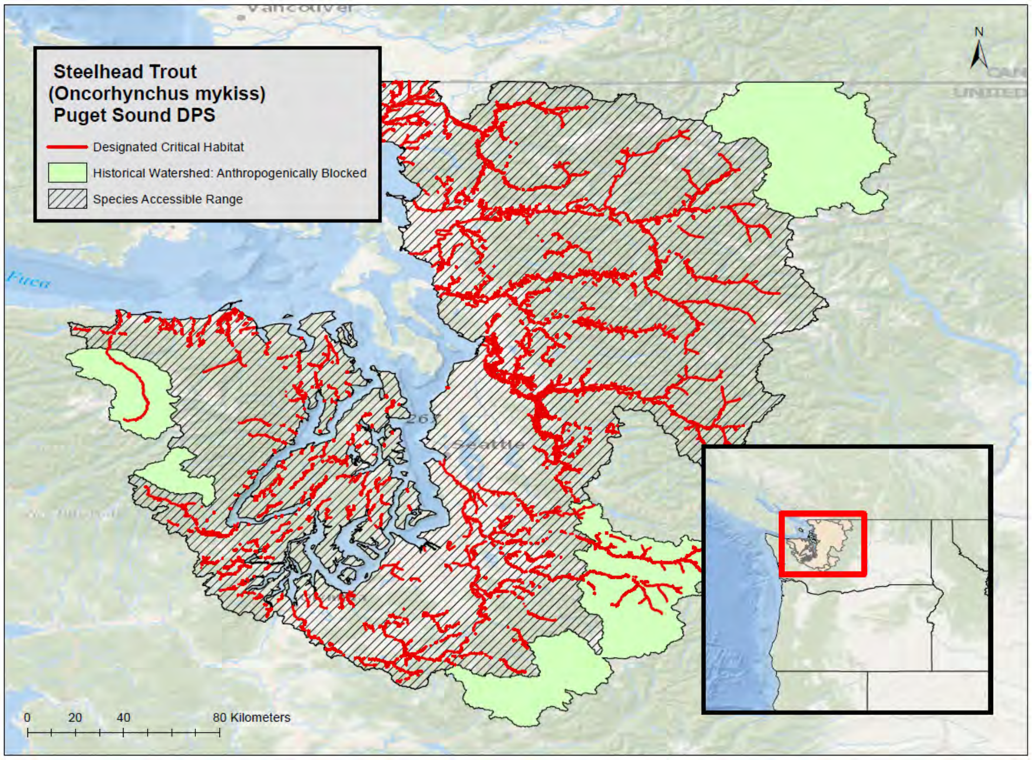

Figure 21. Geographic range and designated critical habitat of Puget Sound DPS steelhead.

8.18.2 Population Dynamics

Abundance of adult steelhead returning to nearly all Puget Sound rivers has fallen substantially since estimates began for many populations in the late 1970s and early 1980s. Inspection of geometric means of total spawner abundance from 2010 to 2014 indicates that nine of 20 populations evaluated had geometric mean abundances fewer than 250 adults and 12 of 20 had fewer than 500 adults.

Smoothed trends in abundance indicate modest increases since 2009 for 13 of the 22 DIPs. Between the two most recent five-year periods (2005 to 2009 and 2010 to 2014), the geometric mean of estimated abundance increased by an average of 5.4 percent. For seven populations in the Northern Cascades MPG, the increase was 3 percent; for five populations in the Central & South Puget Sound major MPG, the increase was 10 percent; and for six populations in the Hood Canal & Strait of Juan de Fuca MPG, the increase was 4.5 percent. However, several of these upward trends are not statistically different from neutral, and most populations remain small. Long-term (15-year) trends in natural spawners are predominantly negative NWFSC (2015a). Current abundance estimates for the Puget Sound DPS of steelhead trout are presented in Table 15 and Table 16 below.

Table 14. Expected 2019 Puget Sound steelhead listed hatchery releases (NMFS 2020).

Sub-basin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Dungeness/Elwha	Dungeness	2018	Winter	10,000	-
	Hurd Creek	2018	Winter	-	34,500
Duwamish/Green	Flaming Geyser	2018	Winter	-	15,000
	Icy Creek	2018	Summer	50,000	-
			Winter	-	28,000
	Soos Creek	2018	Summer	50,000	-
Puyallup	White River	2018	Winter	-	35,000
Total Annual Release Number				110,000	112,500

Table 15. Abundance of Puget Sound steelhead spawner escapements (natural-origin and hatchery-production combined) from 2012-2016 (NMFS 2020).

Demographically Independent Populations	Spawners	Expected Number of Outmigrants
Central and South Puget Sound MPG		
Cedar River	3	391
Green River	977	111,179

Demographically Independent Populations	**Spawners**	**Expected Number of Outmigrants**
Nisqually River	759	86,323
N. Lake WA/Lake Sammamish	-	-
Puyallup/Carbon River	603	68,646
White River	629	71,638
Hood Canal and Strait of Juan de Fuca MPG		
Dungeness River[c]	26	2,984
East Hood Canal Tribs.	89	10,120
Elwha River	878	99,954
Sequim/Discovery Bay Tribs.	19	2,186
Skokomish River	862	98,066
South Hood Canal Tribs.	73	8,304
Strait of Juan de Fuca Tribs.	173	19,697
West Hood Canal Tribs.	122	13,858
North Cascades MPG		
Nooksack River	1,790	203,631
Pilchuck River	868	98,709
Samish River/ Bellingham Bay Tribs.	977	111,167
Skagit River	8,038	914,353
Snohomish/Skykomish Rivers	1,053	119,762
Snoqualmie River	824	93,772
Stillaguamish River	476	54,170
Tolt River	70	7,988
TOTAL	19,313	2,196,901

Only two hatchery stocks genetically represent native local populations (Hamma and Green River natural winter-run). The remaining programs, which account for the vast preponderance of production, are either out-of-DPS derived stocks or were within-DPS stocks that have diverged substantially from local populations. The WDFW estimated that 31 of the 53 stocks were of native origin and predominantly natural production (Washington Department of Fish and Wildlife (WDFW) 1993).

Fifty-three populations of steelhead have been identified in this DPS, of which 37 are winter-run. Summer-run populations are distributed throughout the DPS but are concentrated in northern Puget Sound and Hood Canal; only the Elwha River and Canyon Creek support summer-run steelhead in the rest of the DPS. The Elwha River run, however, is descended from introduced Skamania Hatchery summer-run steelhead. Historical summer-run steelhead in the Green River and Elwha River were likely extirpated in the early 1900s.

8.18.3 Status

For all but a few putative demographically independent populations of steelhead in Puget Sound, estimates of mean population growth rates obtained from observed spawner or redd counts are declining—typically three to 10 percent annually. Extinction risk within 100 years for most populations in the DPS is estimated to be moderate to high, especially for draft populations in the putative South Sound and Olympic MPGs. Collectively, these analyses indicate that steelhead in the Puget Sound DPS remain at risk of extinction throughout all or a significant portion of their range in the foreseeable future, but are not currently in danger of imminent extinction. The Biological Review for the latest 5-Year Review of the Puget Sound DPS of steelhead trout identified degradation and fragmentation of freshwater habitat, with consequent effects on connectivity, as the primary limiting factors and threats facing the Puget Sound steelhead DPS. The status of the listed Puget Sound steelhead DPS has not changed substantially since the 2007 listing. Most populations within the DPS are showing continued downward trends in estimated abundance, a few sharply so. The limited available information indicates that this DPS remains at a moderate risk of extinction.

8.18.4 Critical Habitat

NMFS designated critical habitat for Puget Sound steelhead on February 2, 2016 (81 FR 9251). The specific areas designated for Puget Sound steelhead include approximately 2,031 stream miles (3,269 kilometers) within the geographical area presently occupied by this DPS (Figure 22).

8.18.5 Recovery Goals

NMFS published a final recovery plan for the Puget Sound ESU of steelhead trout on December 20, 2019 (NMFS 2019b). The recovery plan's primary goals are as follows:

- The Puget Sound steelhead DPS achieves biological viability and the ecosystems upon which the DPS depends are conserved such that it is sustainable and persistent and no longer needs federal protection under the ESA; and
- The five listing factors from the ESA, section 4 (a)(1) are addressed. The five listing factors from the ESA, section 4(a)(1), include:

  - The present or threatened destruction, modification, or curtailment of the species' habitat or range;
  - Overutilization for commercial, recreational, scientific, or educational purposes;
  - Disease or predation;
  - Inadequacy of existing regulatory mechanisms; and
  - Other natural or human-made factors affecting the species' continued existence.

Delisting criteria for the Puget Sound DPS of steelhead trout are detailed in NMFS (2019b).

8.19 Steelhead Trout – Snake River Basin DPS

The Snake River Basin DPS of steelhead trout includes naturally spawned steelhead originating below natural and manmade impassable barriers from the Snake River Basin (Figure 23), and also steelhead from six artificial propagation programs.

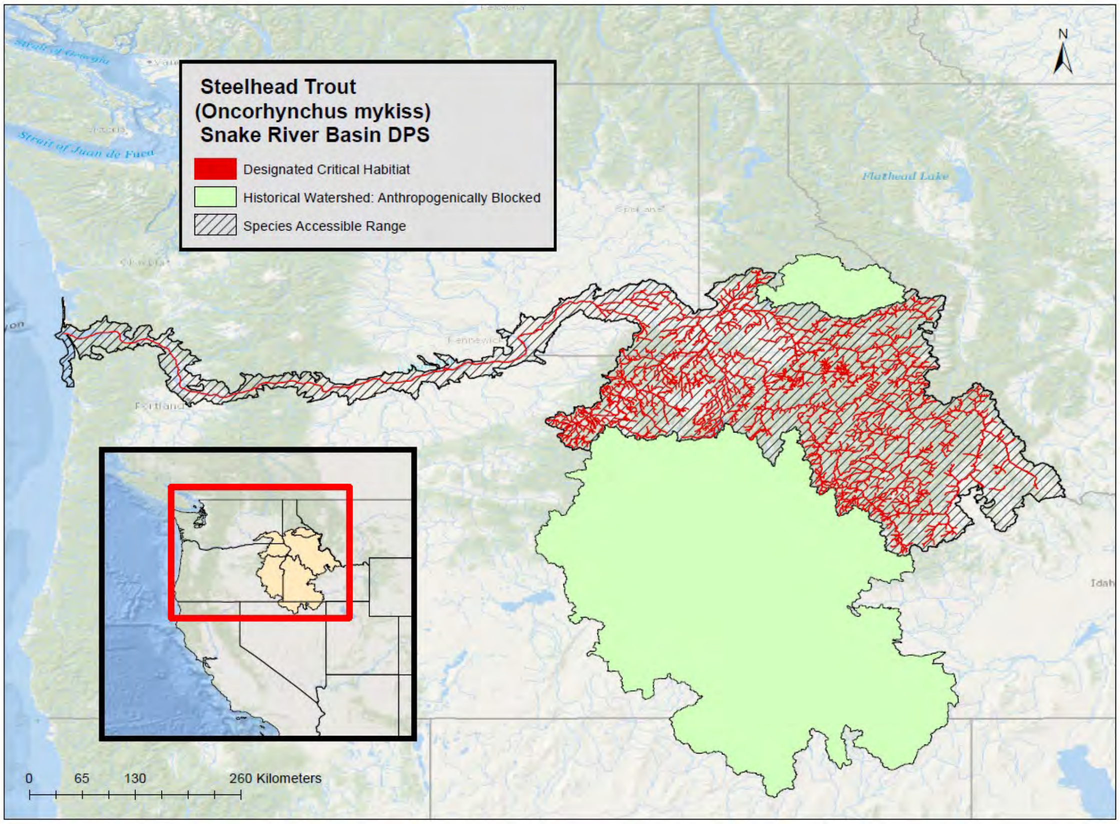

Figure 22. Geographic range and designated critical habitat of Snake River Basin steelhead.

On August 18, 1997 NMFS listed the Snake River Basin DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.19.1 Life History

Snake River Basin steelhead are generally classified as summer-run fish. They enter the Columbia River from late June to October. After remaining in the river through the winter, Snake River Basin steelhead spawn the following spring (March to May). Managers recognize two life history patterns within this DPS primarily based on ocean age and adult size upon return: A-run or B-run. A-run steelhead are typically smaller, have a shorter freshwater and ocean residence (generally one year in the ocean), and begin their up-river migration earlier in the year. B-run steelhead are larger, spend more time in freshwater and the ocean (generally two years in ocean), and appear to start their upstream migration later in the year. Snake River Basin steelhead usually smolt after two or three years.

The life history for this DPS of steelhead trout is the same as that presented in Section 8.13.1.

8.19.2 Population Dynamics

There is uncertainty for wild populations of Snake River Basin DPS steelhead trout given limited data for adult spawners in individual populations. Regarding population growth rate, there are mixed long- and short-term trends in abundance and productivity. Overall, the abundances remain well below interim recovery criteria. Current abundance estimates for the Snake River Basin DPS of steelhead trout are presented in Table 17 below.

Table 16. Current Abundance Estimates for the Snake River Basin DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	10,547
Natural	Juvenile	798,341
Listed Hatchery Adipose Clipped	Adult	79,510
Listed Hatchery Adipose Clipped	Juvenile	3,300,152
Listed Hatchery Intact Adipose	Adult	16,137
Listed Hatchery Intact Adipose	Juvenile	705,490

8.19.3 Status

Four out of the five MPGs are not meeting the specific objectives in the draft recovery plan being written by NMFS based on the updated status information available for this review, and the status of many individual populations remains uncertain (NWFSC 2015b). The Grande Ronde MPG is tentatively rated as viable; more specific data on spawning abundance and the relative contribution of hatchery spawners for the Lower Grande Ronde and Wallowa populations would improve future assessments. A great deal of uncertainty still remains regarding the relative proportion of hatchery fish in natural spawning areas near major hatchery release sites within individual populations.

8.19.4 Critical Habitat

Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.19.5 Recovery Goals

NMFS published a final recovery plan for the Snake River Basin DPS of steelhead trout on November 30, 2017 (NMFS 2017d). The ESA recovery goal for Snake River Basin steelhead is that: The ecosystems upon which the steelhead depend are conserved such that the DPS is self-sustaining in the wild and no longer need ESA protection.

More information on the Snake River Basin DPS' recovery goals and delisting criteria are found in NMFS (2017d).

8.20 Steelhead Trout – South-Central California Coast DPS

The South-Central California Coast DPS of steelhead trout includes naturally spawned steelhead originating below natural and manmade impassable barriers from the Pajaro River to (but not including) the Santa Maria River. No artificially propagated steelhead populations that reside within the historical geographic range of this DPS are included in this designation. The two largest basins overlapping within the range of this DPS include the inland basins of the Pajaro River and the Salinas River (Figure 24).

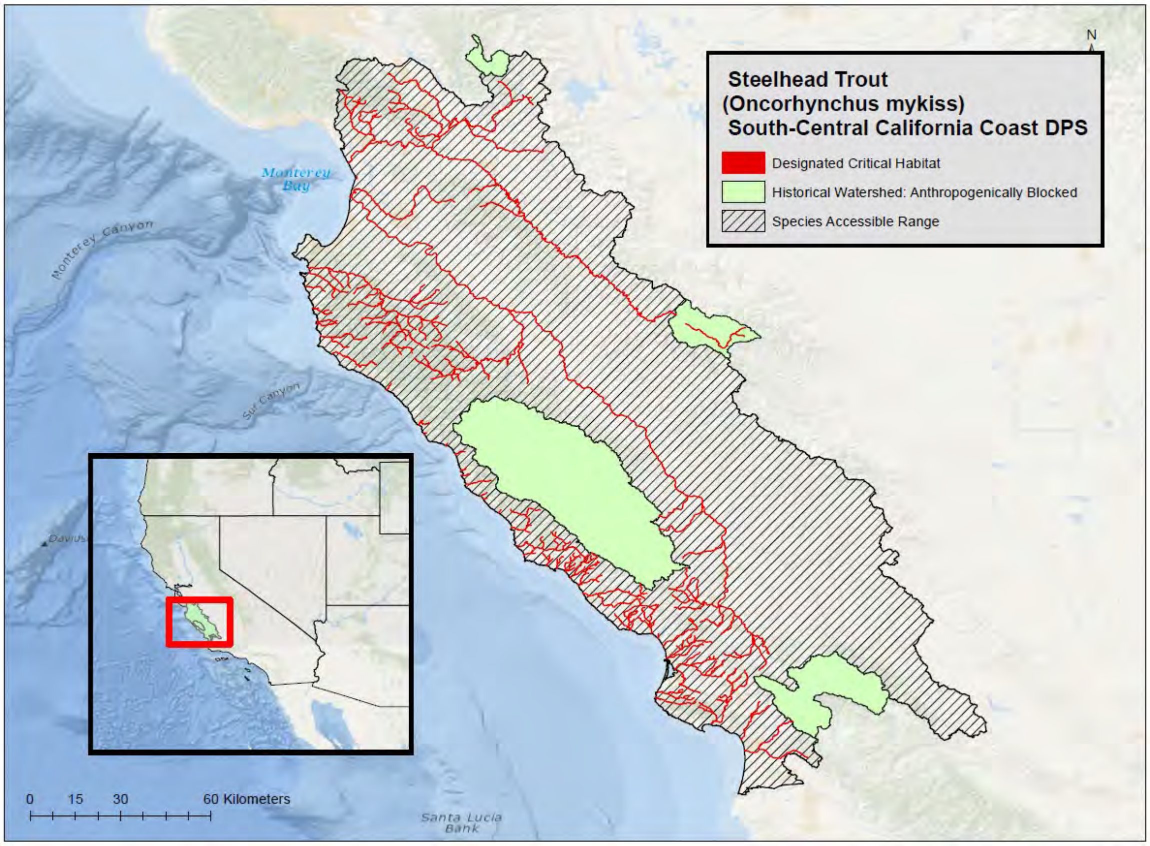

Figure 23. Geographic range and designated critical habitat of South-Central California Coast steelhead.

On August 18, 1997 NMFS listed the South-Central California Coast DPS of steelhead as threatened (62 FR 43937) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 5248).

8.20.1 Life History

There is limited life history information for steelhead in this DPS.

Only winter steelhead are found in the South-Central California Coast DPS of steelhead trout. Most spawning takes place from January through April. The life history for this DPS of steelhead trout is the same as that presented in Section 8.13.1.

8.20.2 Population Dynamics

The data summarized in the most recent status review indicate small (generally <10 fish) but surprisingly persistent annual runs of anadromous *O. mykiss* are currently being monitored across a limited but diverse set of basins within the range of this DPS, but interrupted in years when the mouth of the coastal estuaries fail to open to the ocean due to low flows (Williams et al. 2011). Current abundance estimates for the South-Central California Coast DPS of steelhead trout are presented in Table 18 below.

Table 17. Current Abundance Estimates for the South-Central California Coast DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	695
Natural	Juvenile	79,057

8.20.3 Status

Following the dramatic rise in South-Central California's human population after World War II and the associated land and water development within coastal drainages (particularly major dams and water diversions), steelhead abundance rapidly declined, leading to the extirpation of populations in many watersheds and leaving only sporadic and remnant populations in the remaining, more highly modified watersheds such as the Salinas River and Arroyo Grande Creek watersheds (NMFS 2013d). A substantial portion of the upper watersheds, which contain the majority of historical spawning and rearing habitats for anadromous *O. mykiss*, remain intact (though inaccessible to anadromous fish) and protected from intensive development as a result of their inclusion in the Los Padres National Forest (NMFS 2013d).

8.20.4 Critical Habitat

Critical habitat was designated for this species on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.20.5 Recovery Goals

See the 2013 recovery plan for the South-Central California Coast steelhead DPS (NMFS 2013d) for complete down-listing/delisting criteria for recovery goals for the species. The recovery criteria are built upon having a viable population, one that has a negligible risk (less than five percent) of extinction due to demographic variation, natural environmental variation, and genetic diversity changes over a hundred year period, for the DPS as a whole and for each of the core populations within the recovery planning area.

8.21 Steelhead Trout – Upper Columbia River DPS

The Upper Columbia River DPS of steelhead trout includes naturally spawned anadromous steelhead originating below natural and manmade impassable barriers from the Columbia River and its tributaries upstream of the Yakima River to the U.S.-Canada border (Figure 25). Also, the Upper Columbia River DPS includes steelhead from six artificial propagation programs.

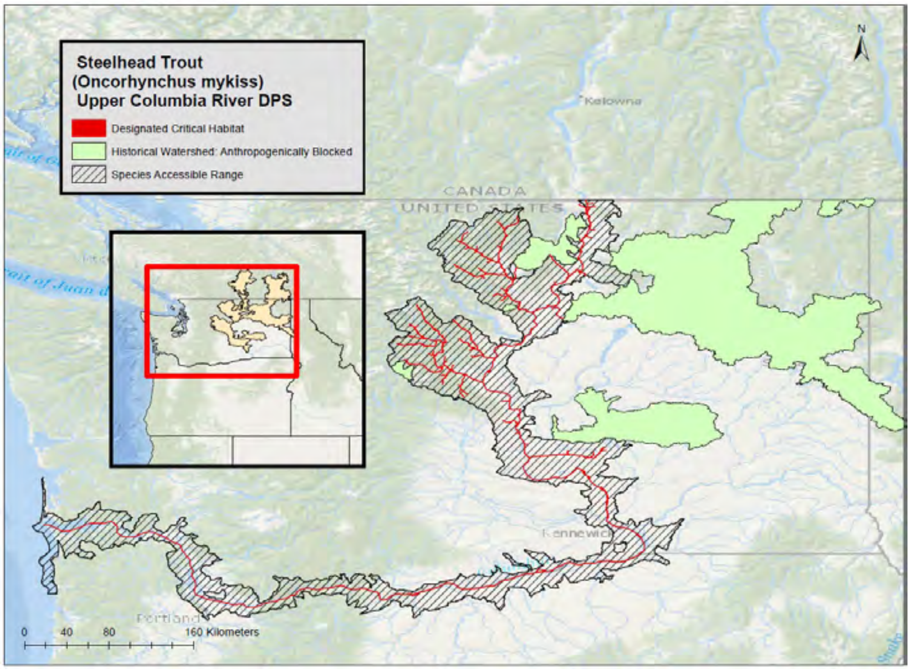

Figure 24. Geographic range and designated critical habitat of Upper Columbia River steelhead.

On August 18, 1997 NMFS listed the Upper Columbia River DPS of steelhead as endangered (62 FR 43937) and reaffirmed the DPS's status as endangered on January 5, 2006 (71 FR 834).

8.21.1 Life History

All Upper Columbia River steelhead are summer-run steelhead. Adults return in the late summer and early fall, with most migrating relatively quickly to their natal tributaries. A portion of the returning adult steelhead overwinter in mainstem reservoirs, passing over upper-mid-Columbia dams in April and May of the following year. Spawning occurs in the late spring of the year following river entry. Juvenile steelhead spend one to seven years rearing in freshwater before migrating to sea. Smolt out migrations are predominantly year class two and three (juveniles), although some of the oldest smolts are reported from this DPS at seven years. Most adult steelhead return to freshwater after one or two years at sea.

8.21.2 Population Dynamics

The most recent estimates of natural-origin spawner abundance for each of the four populations in the Upper Columbia River DPS of steelhead show fairly consistent patterns throughout the years. None of the populations has reached their recovery goal numbers during any of the years (500 for the Entiat, 2,300 for the Methow, 2,300 for the Okanogan, and 3,000 for Wenatchee). Current abundance estimates for the Upper Columbia River DPS of steelhead trout are presented in Table 19 below.

Table 18. Current Abundance Estimates for the Upper Columbia River DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	3,988
Natural	Juvenile	169,120
Listed Hatchery Adipose Clipped	Juvenile	662,848
Listed Hatchery Intact Adipose	Adult	2,403
Listed Hatchery Intact Adipose	Juvenile	144,067

Upper Columbia River steelhead populations have increased relative to the low levels observed in the 1990s, but natural origin abundance and productivity remain well below viability thresholds for three out of the four populations. In spite of recent increases, natural origin abundance and productivity remain well below viability thresholds for three out of the four populations, and the Okanogan River natural-origin spawner abundance estimates specifically are well below the recovery goal for that population. Three of four extant natural populations are considered to be at high risk of extinction and one at moderate risk.

All populations are at high risk for losing diversity, largely driven by chronic high levels of hatchery spawners within natural spawning areas and lack of genetic diversity among the populations.

The Upper Columbia River steelhead DPS is composed of three MPGs, two of which are isolated by dams. With the exception of the Okanogan population, the Upper Columbia River populations were rated as low risk for a loss of spatial structure (i.e., the physical process that drives diversity, as well as the features of a river system, and access to those features).

8.21.3 Status

Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat and unchanged for the Methow (NWFSC 2015b). However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations. Short-term patterns in those indicators appear to be largely driven by year-to year fluctuations in survival rates in areas outside of these watersheds. All three populations continued to be rated at low risk for spatial structure but at high risk for diversity criteria. Although the status of the ESU is improved relative to measures available at the time of listing, all three populations remain at high risk (NWFSC 2015b).

8.21.4 Critical Habitat

Critical habitat was designated for the Upper Columbia River DPS of steelhead trout on September 2, 2005 (70 FR 52630). Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.21.5 Recovery Goals

See the 2007 recovery plan for the Upper Columbia River steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2007b). Recovery plan goals involve addressing factors surrounding the abundance, productivity, spatial structure, and diversity of Upper Columbia River steelhead DPS related to hydropower, hatcheries, harvest, and habitat.

8.22 Steelhead Trout – Upper Willamette River DPS

This DPS includes naturally spawned anadromous winter-run *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Willamette River and its tributaries upstream of Willamette Falls to and including the Calapooia River (Figure 26).

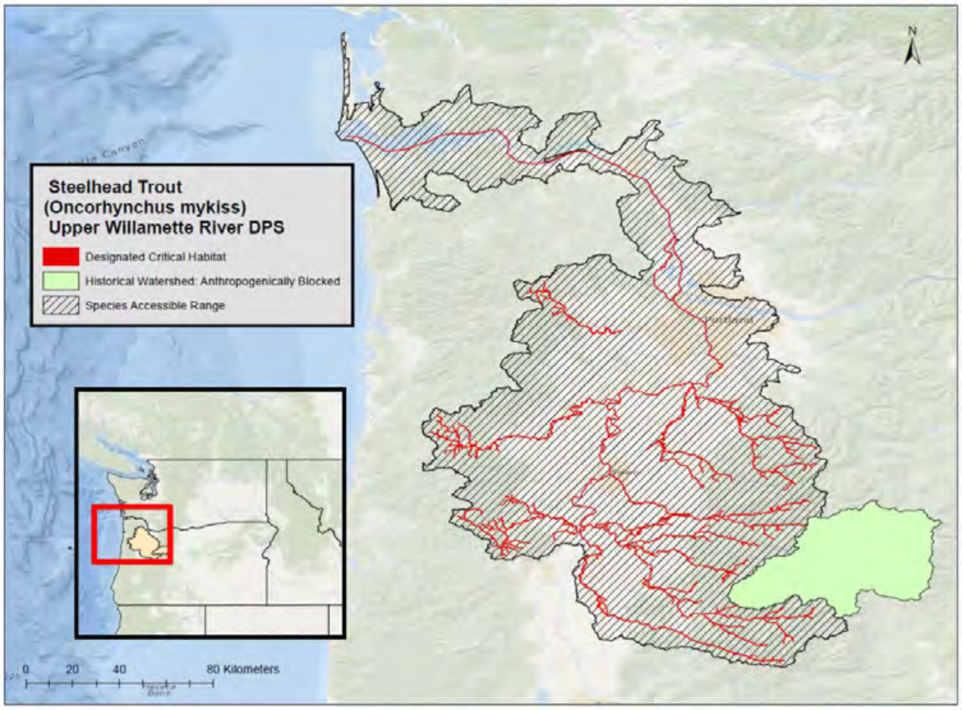

Figure 25. Geographic range and designated critical habitat of upper Willamette River steelhead.

On March 25, 1999 NMFS listed the Upper Willamette River DPS of steelhead as threatened (64 FR 14517) and reaffirmed the DPS's status as threatened on January 5, 2006 (71 FR 834).

8.22.1 Life History

Native steelhead in the Upper Willamette are a late-migrating winter group that enters freshwater in January and February (Howell et al. 1985). Upper Willamette River steelhead do not ascend to their spawning areas until late March or April, which is late compared to other West Coast winter steelhead. Spawning occurs from April to June 1. The unusual run timing may be an adaptation for ascending the Willamette Falls, which may have facilitated reproductive isolation of the stock. The smolt migration past Willamette Falls also begins in early April and proceeds into early June, peaking in early- to mid-May (Howell et al. 1985). Smolts generally migrate through the Columbia via Multnomah Channel rather than the mouth of the Willamette River. As with other coastal steelhead, the majority of juvenile smolts outmigrate after two years; adults return to their natal rivers to spawn after spending two years in the ocean. Repeat spawners are predominantly female and generally account for less than 10 percent of the total run size (Busby et al. 1996a).

8.22.2 Population Dynamics

For the Upper Willamette steelhead DPS, the declines in abundance noted during the previous status review continued through 2010 to 2015, and accessibility to historical spawning habitat remains limited, especially in the North Santiam River. Although the recent magnitude of these declines is relatively moderate, the NWFSC (NWFSC 2015b) notes that continued declines would be a cause for concern.

Recent estimates of escapement in the Molalla River indicate abundance is stable but at a depressed level, and the lack of migration barriers indicates this limitation is likely due to habitat degradation (NWFSC 2015b). In the North Santiam, radio-tagging studies and counts at Bennett Dam between 2010 and 2014 estimate the average abundance of returning winter-run adults is following a long-term negative trend (NWFSC 2015b). In the South Santiam live counts at Foster Dam indicate a negative trend in abundance from 2010 to 2014, and redd survey data indicate consistent low numbers of spawners in tributaries (NWFSC 2015b). Radio-tagging studies in the Calapooia from 2012 to 2014 suggest that abundances have been depressed but fairly stable, however long-term trends in redd counts conducted since 1985 are generally negative (NWFSC 2015b). Current abundance estimates for the Upper Willamette River DPS of steelhead trout are presented in Table 20 below.

Table 19. Current Abundance Estimates for the Upper Willamette River DPS of Steelhead Trout (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	2,912
Natural	Juvenile	143,898

Genetic analysis suggests that there is some level introgression among native late-winter steelhead and summer-run steelhead (Van Doornik et al. 2015), and up to approximately 10 percent of the juvenile steelhead at Willamette Falls and in the Santiam Basin may be hybrids (Johnson et al. 2013). While winter-run steelhead have largely maintained their genetic distinctiveness over time (Van Doornik et al. 2015), there are still concerns that hybridization will decrease the overall productivity of the native population. In addition, releases of large numbers of hatchery-origin summer steelhead may temporarily exceed rearing capacities and displace winter-run juvenile steelhead (NWFSC 2015b).

There are four demographically independent populations (DIPs) within the Upper Willamette River DPS of steelhead. Historical observations, hatchery records, and genetics suggest that the presence of Upper Willamette River DPS steelhead in many tributaries on the west side of the upper basin is the result of recent introductions. Nevertheless, the Willamette/Lower Columbia Technical Recovery Team recognized that although west side Upper Willamette River DPS steelhead does not represent a historical population, those tributaries may provide juvenile rearing habitat or may be temporarily (for one or more generations) colonized during periods of high abundance. Hatchery summer-run steelhead that are released in the subbasins are from an out-of-basin stock, and are not part of the DPS, nor are stocked summer steelhead that have become established in the McKenzie River (NMFS 2011h).

8.22.3 Status

Four basins on the east side of the Willamette River historically supported independent populations for the Upper Willamette River DPS steelhead, all of which remain extant. Data indicate that currently the two largest populations within the DPS are the Santiam River populations. Mean spawner abundance in both the North and South Santiam River is about 2,100 native winter-run steelhead. However, about 30 percent of all habitat has been lost due to human activities (McElhany et al. 2007). The North Santiam population has been substantially affected by the loss of access to the upper North Santiam basin. The South Santiam subbasin has lost habitat behind non-passable dams in the Quartzville Creek watershed. Notwithstanding the lost spawning habitat, the DPS continues to be spatially well distributed, occupying each of the four major subbasins.

Overall, the declines in abundance noted during the previous review continued through the period from 2010 to 2015 (NWFSC 2015b). There is considerable uncertainty in many of the abundance estimates, except for perhaps the tributary dam counts. Radio-tagging studies suggest that a considerable proportion of winter-run steelhead ascending Willamette Falls do not enter the DIPs that constitute this DPS; these fish may be nonnative early winter-run steelhead that appear to have colonized the western tributaries, misidentified summer-run steelhead, or late winter-run steelhead that have colonized tributaries not historically part of the DPS.

8.22.4 Critical Habitat

NMFS designated critical habitat for this species on September 2, 2005. Critical habitat includes freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas.

8.22.5 Recovery Goals

See the 2011 recovery plan for the Upper Willamette River steelhead DPS (NMFS 2011g) for complete down-listing/delisting criteria for recovery goals for the species. To qualify for delisting, the recovery plan recommends biologically based viability criteria, defined at the level of the DPS, strata (spatially related populations), and component populations. The viability criteria has five essential elements: stratified approach, the number of viable populations, the presence and status of representative populations, non-deterioration (i.e., all extant populations are maintained), and safety factors (i.e., buffering against risk of catastrophic events to ensure a population's viability).

8.23 Chinook Salmon – California Coastal ESU

The California Coastal Chinook salmon ESU includes all naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River (Humboldt County, CA) to the Russian River (Sonoma County, CA) (Figure 27).

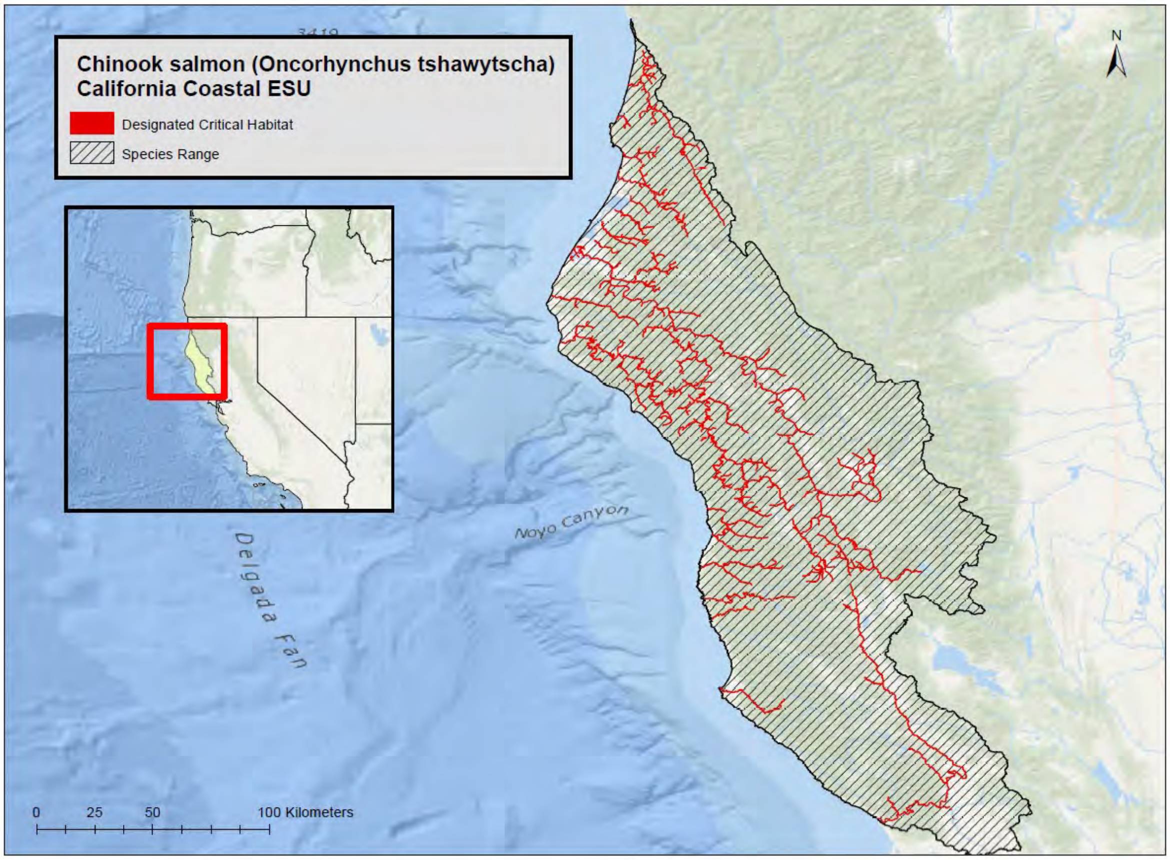

Figure 26. Geographic range and designated critical habitat of California coastal ESU Chinook salmon.

Chinook salmon, also referred to as king salmon in California, are the largest of the Pacific salmon. Spawning adults are olive to dark maroon in color, without conspicuous streaking or blotches on the sides. Spawning males are darker than females, and have a hooked jaw and slightly humped back. They can be distinguished from other spawning salmon by the color pattern, particularly the spotting on the back and tail, and by the dark, solid black gums of the lower jaw (Moyle 2002b). On September 16, 1999, NMFS listed the California Coastal ESU of Chinook salmon as a "threatened" species (FR 64 50394). On June 28, 2005, NMFS confirmed the listing of California Coastal Chinook salmon as threatened under the ESA and also added seven artificially propagated populations from the following hatcheries or programs to the listing.

8.23.1 Life History

California Coastal Chinook salmon are a fall-run, ocean-type fish. Although a spring-run (river-type) component existed historically, it is now considered extinct (Bjorkstedt et al. 2005). The different populations vary in run timing depending on latitude and hydrological differences between watersheds. Entry of California Coastal Chinook salmon into the Russian River depends on increased flow from fall storms, usually in November to January. Juveniles of this ESU migrate downstream from April through June and may reside in the estuary for an extended period before entering the ocean.

The length of time required for embryo incubation and emergence from the gravel is dependent on water temperature. For maximum embryo survival, water temperatures reportedly must be between 41°F and 55.4°F and oxygen saturation levels must be close to maximum. Under those conditions, embryos hatch in 40 to 60 days and remain in the gravel as alevins (the life stage between hatching and egg sack absorption) for another 4 to 6 weeks before emerging as fry. Juveniles may reside in freshwater for 12 to 16 months, but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching.

Juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey et al. 1991). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson et al. 1982; MacFarlane and Norton 2002). Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey et al. 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability.

8.23.2 Population Dynamics

Comparison of historical and current abundance information indicates that independent populations of Chinook salmon are depressed in many basins (Bennet 2005; Good et al. 2005; NMFS 2008a). Current abundance estimates for adult and juvenile California Coastal Chinook salmon are estimated to be 7,034 and 1,278,078 individuals, respectively (See Table 21).

Table 20. Average abundance for CC Chinook salmon natural-origin spawners (NMFS 2020).

Population	**Years**	**Spawners**	**Expected Number of Outmigrants**[ab]
Redwood Creek	2009-2013	1,745	317,067
Mad River	2010-2015	71	12,900
Freshwater Creek	2010-2015	6	1,090
Eel River mainstem	2010-2015	1,198	217,677
Eel River (Tomki Creek)	2010-2015	70	12,719
Eel River (Sproul Creek)	2010-2015	103	18,715
Mattole River	2007-2009, 2012, 2013	648	117,742

Population	Years	Spawners	Expected Number of Outmigrants[ab]
Russian River	2009 - 2014	3,137	569,993
Ten Mile River	2009 - 2014	6	1,090
Noyo River	2009 - 2014	14	2,544
Big River	2009 - 2014	13	2,362
Albion River	2009 - 2014	15	2,726
Navarro River	2009 - 2014	3	545
Garcia River	2009 - 2014	5	909
ESU Average		7,034	1,278,078

[a] Expected number of outmigrants=Total spawners*50 percent proportion of females*3,634 eggs per female*10 percent survival rate from egg to outmigrant.

[b] Based upon number of natural-origin spawners.

The available data, a mixture of short-term (6-year or less) population estimates or expanded red (nest) estimates and longer-term partial population estimates and spawner/red indexes, provide no indication that any of the independent populations (likely to persist in isolation) are approaching viability targets. Overall, there is a lack of compelling evidence to suggest that the status of these populations has improved or deteriorated appreciably since the previous status review (Williams et al. 2011).

At the ESU level, the loss of the spring-run life history type represents a significant loss of diversity within the ESU, as has been noted in previous status reviews (Williams et al. 2011). Concern remains about the extremely low numbers of Chinook salmon in most populations of the North-Central Coast and Central Coast strata, which diminishes connectivity across the ESU. However, the fact that Chinook salmon have regularly been reported in the Ten Mile, Noyo, Big, Navarro, and Garcia rivers represents a significant improvement in our understanding of the status of these populations in watersheds where they were thought to have been extirpated. These observations suggest that spatial gaps between extant populations are not as extensive as previously believed.

The California Coastal Chinook ESU includes all naturally spawned populations of Chinook salmon from rivers and streams south of the Klamath River to the Russian River, California (64 FR 50394; September 16, 1999). Seven artificial propagation programs are considered to be part of the ESU: The Humboldt Fish Action Council (Freshwater Creek), Yager Creek, Redwood Creek, Hollow Tree, Van Arsdale Fish Station, Mattole Salmon Group, and Mad River Hatchery fall-run Chinook hatchery programs. These artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (NMFS 2016c).

8.23.3 Status

The California Coastal Chinook ESU was historically comprised of 38 populations which included 32 fall-run populations and 6 spring-run populations across four Diversity Strata (NWFSC 2015b). All six of the spring-run populations were classified as functionally independent, but are considered extinct (NMFS 2016c). NMFS (2016c) cited continued evidence of low population sizes relative to historical abundance, mixed trends in the few available time series of abundance indices available, and low abundance and extirpation of populations in the southern part of the ESU. In addition, the apparent loss of the spring-run life history type throughout the entire ESU as a significant diversity concern. The 2016 recovery plan determined that the four threats of greatest concern to the ESU are channel modification, roads and railroads, logging and wood harvesting, and both water diversion and impoundments and severe weather patterns.

8.23.4 Critical Habitat

NMFS designated critical habitat for the California Coastal Chinook salmon on September 2, 2005 (70 FR 52488). It includes multiple California watershed hydrological units north from Redwood Creek and south to Russian River.

8.23.5 Recovery Goals

Recovery goals, objectives and criteria for the California Coastal chinook salmon are fully outlined in NMFS (2016f). Recovery plan objectives are to:

- Reduce the present or threatened destruction, modification, or curtailment of habitat or range;
- Ameliorate utilization for commercial, recreational, scientific, or educational purposes;
- Abate disease and predation;
- Establish the adequacy of existing regulatory mechanisms for protecting California Coastal Chinook salmon now and into the future (i.e., post-delisting);
- Address other natural or manmade factors affecting the continued existence of California Coastal Chinook salmon; and
- Ensure the status of California Coastal Chinook salmon is at a low risk of extinction based on abundance, growth rate, spatial structure and diversity.

8.24 Chinook Salmon – Central Valley Spring-Run ESU

The Chinook salmon, Central Valley spring-run ESU includes naturally spawned spring-run Chinook salmon originating from the Sacramento River and its tributaries, and also spring-run Chinook salmon from the Feather River Hatchery Spring-run Chinook Program (Figure 30).

On September 16, 1999, NMFS listed the Central Valley ESU of spring-run Chinook salmon as a "threatened" species (FR 64 50394). Historically, spring-run Chinook salmon occurred in the headwaters of all major river systems in the Central Valley where natural barriers to migration were absent. The only known streams that currently support self-sustaining populations of nonhybridized spring-run Chinook salmon in the Central Valley are Mill, Deer and Butte creeks. Each of these populations is small and isolated (NMFS 2014b).

8.24.1 Life History

Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February, and enter the Sacramento River between March and September, primarily in May and June (Yoshiyama et al. 1998; Moyle 2002b). Spring-run Chinook salmon generally enter rivers as sexually immature fish and must hold in freshwater for up to several months before spawning. While maturing, adults hold in deep pools with cold water. Spawning normally occurs between mid- August and early October, peaking in September (Moyle 2002b).

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

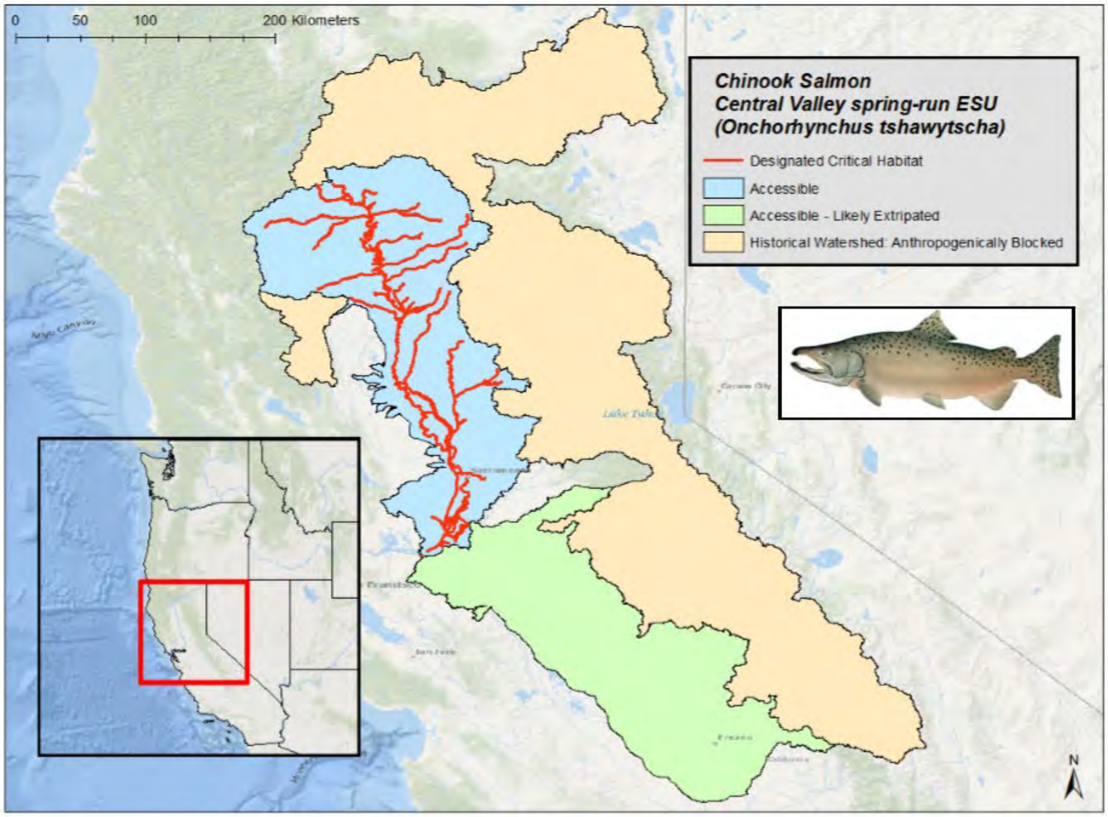

Figure 27. Geographic range and designated critical habitat of Central Valley spring-run ESU Chinook salmon.

8.24.2 Population Dynamics

The Central Valley as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s. Current abundance estimates for the Central Valley spring-run ESU of Chinook salmon are presented in Table 22 below.

Table 21. Average abundance estimates for Central Valley Spring Run Chinook salmon natural- and hatchery-origin spawners from 2013 to 2017 (NMFS 2020).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants [b]
Southern Cascades Stratum				
Battle Creek	191	0	0%	39,761
Mill Creek	302	0	0%	62,807
Deer Creek	409	0	0%	85,049
Butte Creek	2,750	0	0%	572,056
Big Chico Creek	0	0	0%	0
Antelope Creek	3	0	0%	598
Coastal Range Stratum				
Clear Creek	73	0	0%	15,143
Cottonwood / Beegum creeks	0.3	0	0%	60
Northern Sierra Stratum				
Feather River	0	2,273	100%	-
ESU Average	3,727	2,273	37.9%	775,474

[a] Geometric mean (2013-2017) of post-fishery spawners.

[b]Based upon number of natural-origin spawners.

Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation. The majority of Central Valley spring-run Chinook salmon are found to return as three-year olds, therefore looking at returns every three years is used as an estimate of the CRR. In the past, the CRR has fluctuated between just over 1.0 to just under 0.5, and in the recent years with high returns (2012 and 2013), CRR jumped to 3.84 and 8.68 respectively. CRR for 2014 was 1.85, and the CRR for 2015 with very low returns was a record low of 0.14. Low returns in 2015 were further decreased due to high temperatures and most of the Central Valley spring-run Chinook salmon tributaries experienced some pre-spawn mortality. Butte Creek experienced the highest prespawn mortality in 2015, resulting in a carcass survey CRR of only 0.02.

Threats to the genetic integrity of spring-run Chinook salmon was identified as a serious concern to the species when it was listed in 1999 (Myers et al. 1998a; FR 64 50394). Three main factors compromised the genetic integrity of spring-run Chinook salmon: (1) the lack of reproductive isolation following dam construction throughout the Central Valley resulting in introgression with fall-run Chinook salmon in the wild; (2) within basin and inter-basin mixing between spring and fall broodstock for artificial propagation, resulting in introgression in hatcheries; and (3) releasing hatchery-produced juvenile Chinook salmon in the San Francisco estuary, which contributes to the straying of returning adults throughout the Central Valley (NMFS 2014b).

The Central Valley Technical Recovery Team delineated 18 or 19 historic independent populations of Central Valley spring-run Chinook salmon, and a number of smaller dependent populations, that are distributed among four diversity groups (southern Cascades, northern Sierra, southern Sierra, and Coast Range) (Lindley et al. 2004). Of these independent populations, only three are extant (Mill, Deer, and Butte creeks) and they represent only the northern Sierra Nevada diversity group. Of the dependent populations, Central Valley spring-run Chinook salmon are found in Battle, Clear, Cottonwood, Antelope, Big Chico, and Yuba creeks, as well as the Sacramento and Feather rivers and a number of tributaries of the San Joaquin River including Mokelumne, Stanislaus, and Tuolumne rivers. The 2005 listing determination concluded that the Feather River Fish Hatchery spring-run Chinook salmon production should be included in the Central Valley spring-run Chinook salmon ESU (NWFSC 2015b).

8.24.3 Status

Although spring-run Chinook salmon were probably the most abundant salmonid in the Central Valley, this ESU has suffered the most severe declines of any of the four Chinook salmon runs in the Sacramento River Basin (Fisher 1994). The ESU is currently limited to independent populations in Mill, Deer, and Butte Creeks, persistent and presumably dependent populations in the Feather and Yuba rivers and in Big Chico, Antelope, and Battle Creeks, and a few ephemeral or dependent populations in the Northwestern California region (e.g., Beegum, Clear, and Thomes Creeks). The Central Valley spring-run Chinook salmon ESU is currently faced with three primary threats: (1) loss of most historic spawning habitat; (2) degradation of the remaining habitat; and (3) genetic introgression with the Feather River fish hatchery spring-run Chinook salmon strays. The potential effects of climate change are likely to adversely affect spring-run Chinook salmon and their recovery (NMFS 2014b).

8.24.4 Critical Habitat

NMFS published a final rule designating critical habitat for Central Valley spring-run Chinook on September 2, 2005 (70 FR 52488).

8.24.5 Recovery Goals

Recovery goals, objectives and criteria for the Central Valley spring-run Chinook are fully outlined in the 2014 Recovery Plan (NMFS 2014b). The ESU delisting criteria for the spring-run Chinook are:

- One population in the Northwestern California Diversity Group at low risk of extinction;
- Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction;
- Four populations in the Northern Sierra Diversity Group at low risk of extinction;
- Two populations in the Southern Sierra Diversity Group at low risk of extinction; and
- Maintain multiple populations at moderate risk of extinction.

8.25 Chinook Salmon – Lower Columbia River ESU

Chinook salmon, Lower Columbia River ESU includes naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon Rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls (Figure 29).

On March 24, 1999, NMFS listed the Lower Columbia River ESU of Chinook salmon as a “threatened” species (64 FR 14308). The listing was revisited and confirmed as “threatened” in 2005 (70 FR 37160).

8.25.1 Life History

Lower Columbia River Chinook salmon display three run types including early fall-runs, late fall-runs, and spring-runs. Presently, the fall-run is the predominant life history type. Spring-run Chinook salmon were numerous historically. Fall-run Chinook salmon enter freshwater typically in August through October. Early fall-run spawn within a few weeks in large river mainstems. The late fall-run enters in immature conditions, has a delayed entry to spawning grounds, and resides in the river for a longer time between river entry and spawning. Spring-run Chinook salmon enter freshwater in March through June to spawn in upstream tributaries in August and September.

Offspring of fall-run spawning may migrate as fry to the ocean soon after yolk absorption (i.e., ocean-type), at 30 to 45 millimeters in length (Healey 1991). In the Lower Columbia River system, however, the majority of fall-run Chinook salmon fry migrate either at 60 to 150 days post-hatching in the late summer or autumn of their first year. Offspring of fall-run spawning may also include a third group of yearling juveniles that remain in freshwater for their entire first year before emigrating. The spring-run Chinook salmon migrates to the sea as yearlings

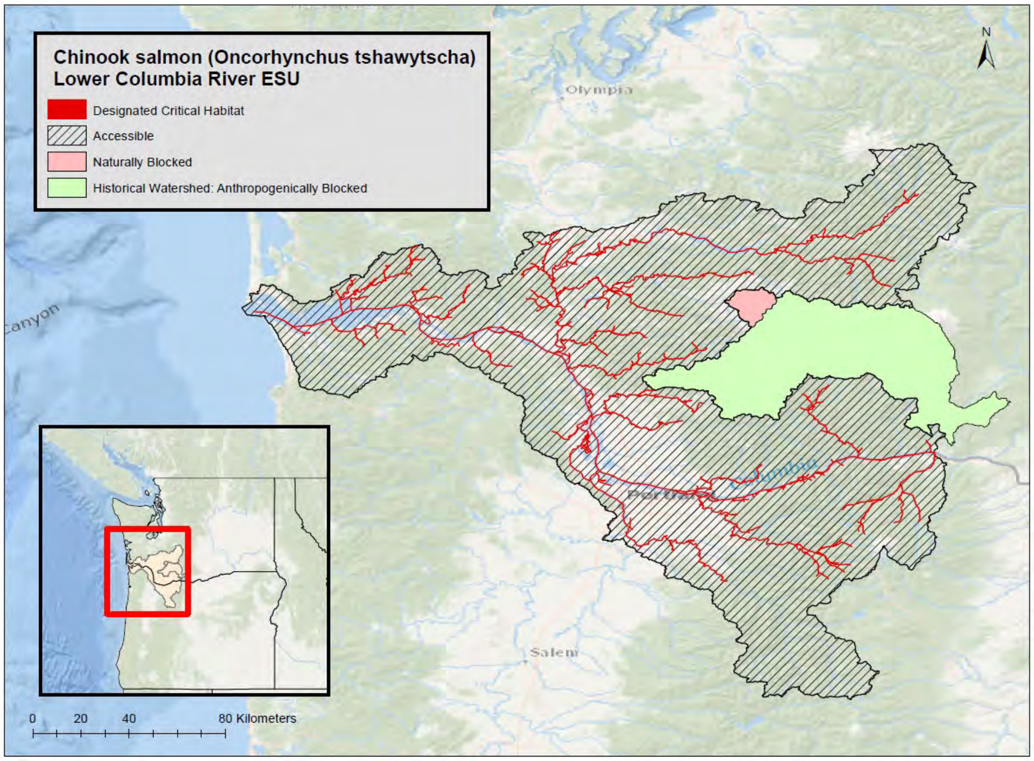

Figure 28. Geographic range and designated critical habitat of Lower Columbia River ESU Chinook salmon.

(stream-type) typically in spring. However, the natural timing of Lower Columbia River spring-run Chinook salmon emigration is obscured by hatchery releases (Myers et al. 2006). Once at sea, the ocean-type Columbia River Chinook salmon tend to migrate along the coast, while stream-type Lower Columbia River Chinook salmon appear to move far off the coast into the central North Pacific Ocean (Healey 1991; Myers et al. 2006). Adults return to tributaries in the Lower Columbia River predominately as three- and four-year-olds for fall-run fish and four- and five-year-olds for spring-run fish.

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.25.2 Population Dynamics

Populations of Lower Columbia River Chinook salmon have declined substantially from historical levels. Many of the ESU's populations are believed to have very low abundance of natural-origin spawners (100 fish or fewer), which increases genetic and demographic risks. Other populations have higher total abundance, but several of these also have high proportions of hatchery-origin spawners. Current abundance estimates for the Lower Columbia River ESU of Chinook salmon are presented in Table 23 below.

Table 22. Abundance Estimates for the Lower Columbia River ESU of Chinook Salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	29,469
Natural	Juvenile	11,745,027
Listed Hatchery Intact Adipose	Juvenile	962,458
Listed Hatchery Clipped and Intact Adipose	Adult	38,594
Listed Hatchery Adipose Clip	Juvenile	31,353,395

The genetic diversity of all populations (except the late fall-run Chinook salmon) has been eroded by large hatchery influences and periodically by low effective population sizes. The near loss of the spring-run life history type remains an important concern for maintaining diversity within the ESU.

The ESU spans three distinct ecological regions: Coastal, Cascade, and Gorge. Distinct life-histories (run and spawn timing) within ecological regions in this ESU were identified as MPGs. In total, 32 historical demographically independent populations (DIPs) were identified in this ESU, 9 spring-run, 21 fall-run, and 2 late-fall run, organized in 6 MPGs (based on run timing and ecological region). The basin-wide spatial structure has remained generally intact. However, the loss of about 35 percent of historic habitat has affected distribution within several Columbia River subbasins.

8.25.3 Status

Populations of Lower Columbia River Chinook salmon have declined substantially from historical levels. Out of the 32 populations that make up this ESU, only the two late-fall runs (the North Fork Lewis and Sandy) are considered viable. Most populations (26 out of 32) have a very low probability of persistence over the next 100 years and some are extirpated or nearly so. Five of the six strata fall significantly short of the recovery plan criteria for viability. Low abundance, poor productivity, losses of spatial structure, and reduced diversity all contribute to the very low persistence probability for most Lower Columbia River Chinook salmon populations. Hatchery contribution to naturally spawning fish remains high for a number of populations, and it is likely that many returning unmarked adults are the progeny of hatchery origin parents, especially where large hatchery programs operate. Continued land development and habitat degradation in combination with the potential effects of climate change will present a continuing strong negative influence into the foreseeable future.

8.25.4 Critical Habitat

NMFS designated critical habitat for Lower Columbia River Chinook salmon on September 2, 2005 (70 FR 52630). It includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Hood Rivers, as well as specific stream reaches in a number of tributary subbasins.

8.25.5 Recovery Goals

Recovery plan targets for this species are tailored for each life history type, and within each type, specific population targets are identified (NMFS 2013b). For spring Chinook salmon, all populations are affected by aspects of habitat loss and degradation. Four of the nine populations require significant reductions in every threat category. Protection and improvement of tributary and estuarine habitat are specifically noted.

For fall Chinook salmon, recovery requires restoration of the Coast and Cascade strata to high probability of persistence, to be achieved primarily by ensuring habitat protection and restoration. Very large improvements are needed for most fall Chinook salmon populations to improve their probability of persistence.

For late fall Chinook salmon, recovery requires maintenance of the North Fork Lewis and Sandy populations which are comparatively healthy, together with improving the probability of persistence of the Sandy population from its current status of "high" to "very high." Improving the status of the Sandy population depends largely on harvest and hatchery changes. Habitat improvements to the Columbia River estuary and tributary spawning areas are also necessary. Of the 32 DIPs in this ESU, only the two late-fall run populations (Lewis River and Sandy River) could be considered viable or nearly so (NWFSC 2015b).

8.26 Chinook Salmon – Puget Sound ESU

The Puget Sound ESU includes naturally spawned Chinook salmon originating from rivers flowing into Puget Sound from the Elwha River (inclusive) eastward, including rivers in Hood Canal, South Sound, North Sound and the Georgia Strait. Twenty-six artificial propagation programs are included as part of the Puget Sound ESU (Figure 32).

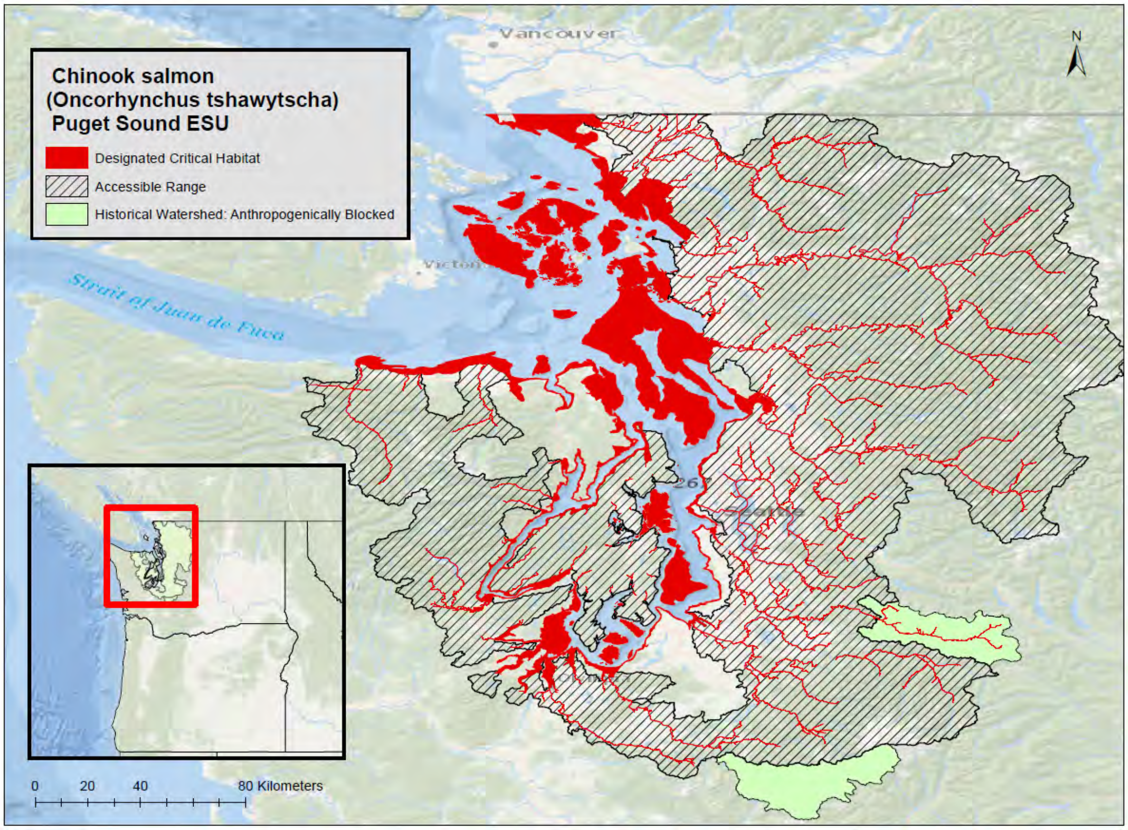

Figure 29. Geographic range and designated critical habitat of Puget Sound ESU Chinook salmon.

On March 24, 1999, NMFS listed the Puget Sound ESU of Chinook salmon as a "threatened" species (64 FR 14308). The listing was revisited and confirmed as "threatened" in 2005 (70 FR 37160).

8.26.1 Life History

Puget Sound Chinook salmon populations are both early-returning (August) and late-returning (mid-September and October) spawners (Healey 1991). Juvenile Chinook salmon within the Puget Sound generally exhibit an "ocean-type" life history. However, substantial variation occurs with regard to juvenile residence time in freshwater versus estuarine environments. Hayman (Hayman et al. 1996) described three juvenile life histories for Chinook salmon with varying freshwater and estuarine residency times in the Skagit River system in northern Puget Sound. In this system, 20 percent to 60 percent of sub-yearling migrants rear for several months in freshwater habitats while the remaining fry migrate to rear in the Skagit River estuary and delta (Beamer et al. 2005). Juveniles in tributaries to Lake Washington exhibit both a stream rearing and a lake rearing strategy. Lake rearing fry are found in highest densities in nearshore shallow (<1 meter) habitat adjacent to the opening of tributaries or at the mouth of tributaries where they empty into the lake (Tabor et al. 2006). Puget Sound Chinook salmon also have several estuarine rearing juvenile life history types that are highly dependent on estuarine areas for rearing (Beamer et al. 2005). In the estuaries, fry use tidal marshes and connected tidal channels including dikes and ditches developed to protect and drain agricultural land. During their first ocean year, immature Chinook salmon use nearshore areas of Puget Sound during all seasons and can be found long distances from their natal river systems (Brennan et al. 2004).

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.26.2 Population Dynamics

Estimates of the historic abundance range from 1,700 to 51,000 potential Puget Sound Chinook salmon spawners per population. During the period from 1996 to 2001, the geometric mean of natural spawners in populations of Puget Sound Chinook salmon ranged from 222 to just over 9,489 fish. Thus, the historical estimates of spawner capacity are several orders of magnitude higher than spawner abundances currently observed throughout the ESU (Good et al. 2005). Current abundance estimates for the Puget Sound ESU of Chinook salmon are found in Table 24 and Table 25 below.

Table 23. Average abundance estimates for Puget Sound Chinook salmon natural- and hatchery-origin spawners 2012-2016 (NMFS 2020).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
Georgia Strait MPG					
NF Nooksack River[d]	181	945	83.95%	16,000	90,009
SF Nooksack River[d]	18	15	45.04%	9,100	2,597
Strait of Juan de Fuca MPG					
Elwha River	130	2,156	94.30%	15,100	182,895
Dungeness River	189	213	52.91%	4,700	32,163
Hood Canal MPG					
Skokomish River	224	1,158	83.82%	12,800	110,505
Mid-Hood Canal	165	117	41.55%	11,000	22,589
Whidbey Basin MPG					
Skykomish River	2,001	1,466	42.29%	17,000	277,348
Snoqualmie River	881	219	19.93%	17,000	87,978
NF Stillaguamish River	385	291	43.04%	17,000	54,137

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Minimum Viability Abundance[b]	Expected Number of Outmigrants[c]
SF Stillaguamish River	42	29	40.57%	15,000	5,676
Upper Skagit River	9,505	120	1.25%	17,000	770,047
Lower Skagit River	2,207	13	0.60%	16,000	177,643
Upper Sauk River	1,106	5	0.46%	3,000	88,899
Lower Sauk River	559	3	0.59%	5,600	44,984
Suiattle River	590	5	0.77%	600	47,582
Cascade River	205	7	3.12%	1,200	16,937
Central / South Sound MPG					
Sammamish River	125	885	87.64%	10,500	80,823
Cedar River	883	440	33.26%	11,500	105,864
Duwamish/Green River	1,120	4,171	78.83%	17,000	423,326
Puyallup River	565	1,240	68.72%	17,000	144,384
White River	569	1,438	71.64%	14,200	160,622
Nisqually River	747	606	44.81%	13,000	108,281
ESU Average	22,398	15,543	40.97%		3,035,288

a Five-year geometric mean of post-fishery spawners (2013-2017).

b Ford 2011

c Expected number of outmigrants=Total spawners*40% proportion of females*2,000 eggs per female*10% survival rate from egg to outmigrant

d 2012-2016 five year geometric mean (2017 data not available).

Table 24. Expected 2019 Puget Sound Chinook salmon hatchery releases (NMFS 2020).

Sub-basin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Deschutes	Tumwater Falls	2018	Fall	3,800,000	-

Sub-basin	**Artificial propagation program**	**Brood year**	**Run Timing**	**Clipped Adipose Fin**	**Intact Adipose Fin**
Dungeness-Elwha	Dungeness	2018	Spring	-	50,000
	Elwha	2017	Fall	-	200,000
		2018	Fall	250,000	2,250,000
	Gray Wolf River	2018	Spring	-	50,000
	Hurd Creek	2018	Spring	-	50,000
	Upper Dungeness Pond	2018	Spring	-	50,000
Duwamish	Icy Creek	2017	Fall	300,000	-
	Palmer	2018	Fall	-	1,000,000
	Soos Creek	2018	Fall	3,000,000	200,000
Hood Canal	Hood Canal Schools	2018	Fall	-	500
	Hoodsport	2017	Fall	120,000	-
		2018	Fall	3,000,000	-
Kitsap	Bernie Gobin	2017	Spring	40,000	-
		2018	Fall	-	200,000
			Summer	2,300,000	100,000
	Garrison	2018	Fall	850,000	-
	George Adams	2018	Fall	3,375,000	425,000
	Gorst Creek	2018	Fall	730,000	-
	Grovers Creek	2018	Fall	1,250,000	-
	Hupp Springs	2018	Spring	-	400,000
	Lummi Sea Ponds	2018	Fall	500,000	-
	Minter Creek	2018	Fall	1,250,000	-
Lake Washington	Salmon in the Schools	2018	Fall	-	540
	Issaquah	2018	Fall	2,000,000	-
Nisqually	Clear Creek	2018	Fall	3,300,000	200,000

Sub-basin	**Artificial propagation program**	**Brood year**	**Run Timing**	**Clipped Adipose Fin**	**Intact Adipose Fin**
	Kalama Creek	2018	Fall	600,000	-
	Nisqually MS	2018	Fall	-	90
Nooksack	Kendall Creek	2018	Spring	800,000	-
	Skookum Creek	2018	Spring	-	1,000,000
Puyallup	Clarks Creek	2018	Fall	400,000	-
	Voights Creek	2018	Fall	1,600,000	-
	White River	2017	Spring	-	55,000
		2018	Spring	-	340,000
San Juan Islands	Glenwood Springs	2018	Fall	725,000	-
Skokomish	McKernan	2018	Fall	-	100,000
Skykomish	Wallace River	2017	Summer	500,000	-
		2018	Summer	800,000	200,000
Stillaguamish	Brenner	2018	Fall	-	200,000
	Whitehorse Pond	2018	Summer	220,000	-
Georgia Strait	Samish	2018	Fall	3,800,000	200,000
Upper Skagit	Marblemount	2018	Spring	387,500	200,000
			Summer	200,000	-
Total Annual Release Number				36,297,500	7,271,130

Available data on total abundance since 1980 indicate that although abundance trends have fluctuated between positive and negative for individual populations, there are widespread negative trends in natural-origin Chinook salmon spawner abundance across the ESU (Ford 2011a). Productivity remains low in most populations, and hatchery-origin spawners are present in high fractions in most populations outside of the Skagit watershed. Available data now shows that most populations have declined in abundance over the past 7 to 10 years. Further, escapement levels for all populations remain well below the Technical Recovery Team planning ranges for recovery, and most populations are consistently below the spawner-recruit levels identified by the Technical Recovery Team as consistent with recovery (Ford 2011a).

Current estimates of diversity show a decline over the past 25 years, indicating a decline of salmon in some areas and increases in others. Salmon returns to the Whidbey Region increased in abundance while returns to other regions declined. In aggregate, the diversity of the ESU as a whole has been declining over the last 25 years.

The Puget Sound technical recovery team identified 22 extant populations, grouped into five major geographic regions, based on consideration of historical distribution, geographic isolation, dispersal rates, genetic data, life history information, population dynamics, and environmental and ecological diversity.

8.26.3 Status

All Puget Sound Chinook salmon populations are well below escapement abundance levels identified as required for recovery to low extinction risk in the recovery plan. In addition, most populations are consistently below the productivity goals identified in the recovery plan as necessary for recovery. Although trends vary for individual populations across the ESU, most populations have declined in total natural origin recruit abundance since the last status review; and natural origin recruit escapement trends since 1995 are mostly stable. Several of the risk factors identified in the previous status review (Good et al. 2005) are still present, including high fractions of hatchery fish in many populations and widespread loss and degradation of habitat. Although this ESU's total abundance is a greatly reduced from historic levels, recent abundance levels do not indicate that the ESU is at immediate risk of extinction. This ESU remains relatively well distributed over 22 populations in five geographic areas across the Puget Sound. Although current trends are concerning, the available information indicates that this ESU remains at moderate risk of extinction (NMFS 2011a).

8.26.4 Critical Habitat

Critical habitat was designated for the Puget Sound ESU of Chinook salmon on September 2, 2005 (70 FR 52630) and includes 1,683 miles of stream channels, 41 square miles of lakes, and 2,182 miles of nearshore marine habitat.

8.26.5 Recovery Goals

The recovery plan consists of two documents: the Puget Sound salmon recovery plan (Shared Strategy for Puget Sound 2007) and a supplement by NMFS (2006d). The recovery plan adopts ESU and population level viability criteria recommended by the Puget Sound Technical Recovery Team (PSTRT) (Ruckelshaus et al. 2002). The PSTRT's biological recovery criteria will be met when all of the following conditions are achieved:

- The viability status of all populations in the ESU is improved from current conditions, and when considered in the aggregate, persistence of the ESU is assured;
- Two to four Chinook salmon populations in each of the five biogeographical regions of the ESU achieve viability, depending on the historical biological characteristics and acceptable risk levels for populations within each region;

- At least one population from each major genetic and life history group historically present within each of the five biogeographical regions is viable;
- Tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations are functioning in a manner that is sufficient to support an ESU-wide recovery scenario; Production of Chinook salmon from tributaries to Puget Sound not identified as primary freshwater habitat for any of the 22 identified populations occurs in a manner consistent with ESU recovery; and
- Populations that do not meet the viability criteria for all viable salmonid population parameters are sustained to provide ecological functions and preserve options for ESU recovery.

8.27 Chinook Salmon – Sacramento River Winter-Run ESU

The Sacramento River winter-run Chinook salmon ESU includes winter-run Chinook salmon spawning naturally in the Sacramento River and its tributaries, as well as winter-run Chinook salmon that are part of the conservation hatchery program at the Livingston Stone National Fish Hatchery (Figure 33). On January 4, 1994, NMFS listed the Sacramento River winter-run ESU of Chinook salmon as Endangered (59 FR 440).

8.27.1 Life History

Winter-run Chinook salmon are unique because they spawn during summer months when air temperatures usually approach their yearly maximum. As a result, winter-run Chinook salmon require stream reaches with cold water sources that will protect embryos and juveniles from the warm ambient conditions in summer. Adult winter-run Chinook salmon immigration and holding (upstream spawning migration) through the Delta and into the lower Sacramento River occurs from December through July, with a peak during the period extending from January through April (USFWS 1995). Winter-run Chinook salmon are sexually immature when upstream migration begins, and they must hold for several months in suitable habitat prior to spawning. Spawning occurs between late-April and mid-August, with a peak in June and July as reported by the California Division of Fish and Wildlife annual escapement surveys (2000 to 2006).

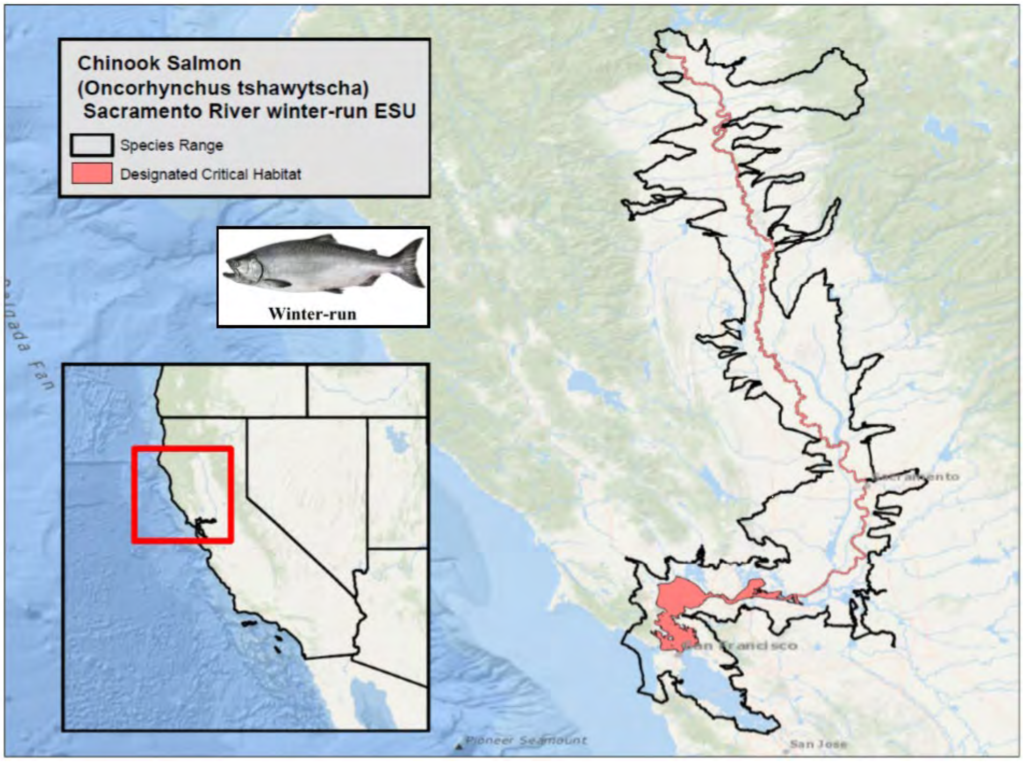

Figure 30. Geographic range and designated critical habitat of the Sacramento River winter-run ESU of Chinook salmon

Winter-run Chinook salmon embryo incubation in the Sacramento River can extend into October (Vogel et al. 1988). Winter-run Chinook salmon fry rearing in the upper Sacramento River exhibit peak abundance during September, with fry and juvenile emigration past the Red Bluff Diversion Dam primarily occurring from July through November (Poytress and Carrillo 2010; Poytress and Carrillo 2011; Poytress and Carrillo 2012). Emigration of winter-run Chinook salmon juveniles past Knights Landing, located approximately 155.5 river miles downstream of the Red Bluff Diversion Dam, reportedly occurs between November and March, peaking in December, with some emigration continuing through May in some years (Snider and Titus 2000).

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.27.2 Population Dynamics

Over the last 10 years of available data (2003 to 2013), the abundance of spawning winter-run Chinook adults ranged from a low of 738 in 2011 to a high of 17,197 in 2007, with an average of 6,298 (NMFS 2011c). Current abundance estimates for the Sacramento winter-run ESU of Chinook salmon are found in Table 26 below.

Table 25. Average abundance estimates for Sacramento winter-run Chinook salmon natural- and hatchery-origin spawners 2013 to 2017 (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	210
Natural	Juvenile	195,354
Listed Hatchery Adipose Clip	Adult	2,232
Listed Hatchery Adipose Clip	Juvenile	200,000

The population declined from an escapement of near 100,000 in the late 1960s to fewer than 200 in the early 1990s (Good et al. 2005). More recent population estimates of 8,218 (2004), 15,730 (2005), and 17,153 (2006) show a three-year average of 13,700 returning winter-run Chinook salmon. However, the run size decreased to 2,542 in 2007 and 2,850 in 2008. Monitoring data indicated that approximately 5.6 percent of winter-run Chinook salmon eggs spawned in the Sacramento River in 2014 survived to the fry life stage (three to nearly 10 times lower than in previous years). The drought in 2015 made this another challenging year for winter-run Chinook salmon (NMFS 2016i).

The rising proportion of hatchery fish among returning adults threatens to increase the risk of extinction. Lindley et al. (2007) recommend that in order to maintain a low risk of genetic introgression with hatchery fish, no more than five percent of the naturally spawning population should be composed of hatchery fish. Since 2001, hatchery origin winter-run Chinook salmon have made up more than five percent of the run, and in 2005 the contribution of hatchery fish exceeded 18 percent (Lindley et al. 2007).

The range of winter-run Chinook salmon has been greatly reduced by Keswick and Shasta dams on the Sacramento River and by hydroelectric development on Battle Creek. Currently, winter-run Chinook salmon spawning is limited to the main-stem Sacramento River between Keswick Dam (River Mile [RM] 302) and the Red Bluff Diversion Dam (RM 243) where the naturally spawning population is artificially maintained by cool water releases from the dams. Within the Sacramento River, the spatial distribution of spawners is largely governed by water year type and the ability of the Central Valley Project to manage water temperatures (NMFS 2014b).

8.27.3 Status

The Sacramento River winter-run Chinook salmon ESU is composed of just one small population that is currently under severe stress caused by California's 2011 to 2017 drought, one of California's worst droughts on record. Current estimates of natural born adults are estimated to consist of 210 individuals. The population subsists in large part due to agency-managed cold-water releases from Shasta Reservoir during the summer and artificial propagation from Livingston Stone National Fish Hatchery's winter-run Chinook salmon conservation program.

Winter-run Chinook salmon are dependent on sufficient cold-water storage in Shasta Reservoir, and it has long been recognized that a prolonged drought had devastating impacts, possibly leading to the species' extinction. The probability of extended droughts is increasing as the effects of climate change continue (NMFS 2016b). In addition to drought, another important threat to winter-run Chinook salmon is a lack of suitable rearing habitat in the Sacramento River and Delta to allow for sufficient juvenile growth and survival (NMFS 2016b).

8.27.4 Critical Habitat

NMFS designated critical habitat for the Sacramento winter-run Chinook on June 16, 1993 (58 FR 33212).

8.27.5 Recovery Goals

Recovery goals, objectives and criteria for the Sacramento River winter-run Chinook are fully outlined in the 2014 Recovery Plan (NMFS 2014b). In order to achieve the downlisting criteria, the species would need to be composed of two populations – one viable and one at moderate extinction risk. Having a second population would improve the species' viability, particularly through increased spatial structure and abundance, but further improvement would be needed to reach the goal of recovery. To delist winter-run Chinook salmon, three viable populations are needed. Thus, the downlisting criteria represent an initial key step along the path to recovering winter-run Chinook salmon.

8.28 Chinook Salmon – Snake River Fall-Run ESU

The listed ESU currently includes all natural-origin fall-run Chinook salmon originating from the mainstem Snake River below Hells Canyon Dam (the lowest of three impassable dams that form the Hells Canyon Complex) and from the Tucannon River, Grande Ronde River, Imnaha River, Salmon River, and Clearwater River subbasins. The listed ESU also includes fall-run Chinook salmon from four artificial propagation programs (NMFS 2011b; NMFS 2015e) (Figure 34).

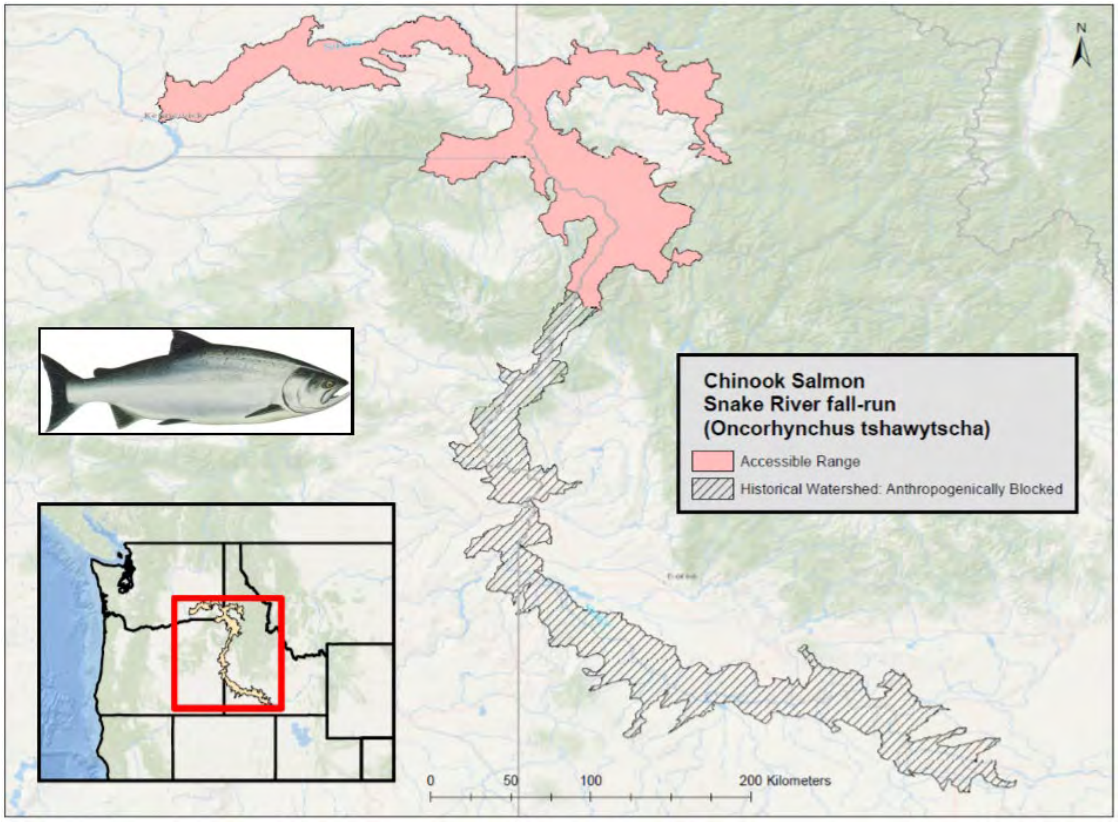

Figure 31. Geographic range of Snake River fall-run ESU Chinook salmon.

NMFS first listed Snake River fall Chinook salmon as a threatened species under the ESA on April 22, 1992 (57 FR 14658). NMFS reaffirmed the listing status in June 28, 2005 (70 FR 37160), and reaffirmed the status again in its 2014 (79 FR 20802).

8.28.1 Life History

Snake River fall-run Chinook return to the Columbia River in August and September, pass the Bonneville Dam from mid-August to the end of September, and enter the Snake River between early September and mid-October (DART 2013). Once they reach the Snake River, fall Chinook salmon generally travel to one of five major spawning areas and spawn from late October through early December (Connor et al. 2014).

Upon emergence from the gravel, most young fall Chinook salmon move to shoreline riverine habitat (NMFS 2015e). Some fall Chinook salmon smolts sustain active migration after passing Lower Granite Dam and enter the ocean as sub yearlings, whereas some delay seaward migration and enter the ocean as yearlings (Connor et al. 2005; McMichael et al. 2008; NMFS 2015e). Snake River fall Chinook salmon can be present in the estuary as juveniles in winter, as fry from March to May, and as fingerlings throughout the summer and fall (Fresh et al. 2005; Roegner et al. 2012; Teel et al. 2014).

Once in the Northern California Current, dispersal patterns differ for yearlings and sub yearlings. Sub yearlings migrate more slowly, are found closer to shore in shallower water, and do not disperse as far north as yearlings (Trudel et al. 2009; Tucker et al. 2011; Sharma and Quinn 2012; Fisher et al. 2014b). Snake River basin fall Chinook salmon spend one to four years in the Pacific Ocean, depending on gender and age at the time of ocean entry (Connor et al. 2005).

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.28.2 Population Dynamics

The naturally spawning fall Chinook salmon in the lower Snake River have included both returns originating from naturally spawning parents and from returning hatchery releases. The geometric mean natural-origin adult abundance from 2005 to 2014 of annual spawner escapement estimates was 6,418, with a standard error of 0.19 (NMFS 2015e). Current abundance estimates for the Snake River fall-run ESU of Chinook salmon are presented in Table 27 below.

Table 26. Average Abundance Estimates for the Snake River Fall-Run ESU of Chinook Salmon from 2015 to 2019 (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	10,337
Natural	Juvenile	692,819
Listed Hatchery Adipose Clip	Adult	15,508
Listed Hatchery Adipose Clip	Juvenile	2,483,713
Listed Hatchery Intact Adipose	Adult	13,551
Listed Hatchery Intact Adipose	Juvenile	2,862,418

Past estimates of productivity for this population (1990 to 2009 brood years) was 1.53 with a standard error of 0.18. This estimate of productivity, however, may be problematic for two reasons: (1) the increasingly small number of years that actually contribute to the productivity estimate means that there is increasing statistical uncertainty surrounding that estimate, and (2) the years contributing to the estimate are now far in the past and may not accurately reflect the true productivity of the current population NMFS (2015e).

Genetic samples from the aggregate population in recent years indicate that composite genetic diversity is being maintained and that the Snake River Fall Chinook hatchery stock is similar to the natural component of the population, an indication that the actions taken to reduce the potential introgression of out-of-basin hatchery strays has been effective. Overall, the current genetic diversity of the population represents a change from historical conditions and, applying the ICTRT (McClure et al.) guidelines, the rating for this metric is moderate risk (NMFS 2015e).

The ICTRT identified three populations of this species, although only the lower mainstem population exists at present, and it spawns in the lower main stem of the Clearwater, Imnaha, Grande Ronde, Salmon, and Tucannon rivers. The extant population of Snake River fall-run

Chinook salmon is the only remaining population from an historical ESU that also included large mainstem populations upstream of the current location of the Hells Canyon Dam complex (ICTRT 2003; McClure et al. 2005). The population is at moderate risk for diversity and spatial structure (Ford 2011a).

8.28.3 Status

As late as the late 1800s, approximately 408,500 to 536,180 fall Chinook salmon are believed to have returned annually to the Snake River. The run began to decline in the late 1800s and then continued to decline through the early and mid-1900s as a result of overfishing and other human activities, including the construction of major dams. This ESU has one extant population. The extant population is at moderate risk for both diversity and spatial structure and abundance and productivity. The overall viability rating for this population is 'viable.' Overall, the status of Snake River fall Chinook salmon has clearly improved compared to the time of listing and compared to prior status reviews. The single extant population in the ESU is currently meeting the criteria for a rating of 'viable' developed by the ICTRT, but the ESU as a whole is not meeting the recovery goals described in the recovery plan for the species, which require the single population to be "highly viable with high certainty" and/or will require reintroduction of a viable population above the Hells Canyon Dam complex.

8.28.4 Critical Habitat

NMFS designated critical habitat for Snake River fall-run Chinook salmon on December 28, 1993 (58 FR 68543).

8.28.5 Recovery Goals

Recovery goals, objectives and criteria for the Snake River fall-run Chinook are fully outlined in the 2015 Recovery Plan (NMFS 2015e). The ESA recovery goal for Snake River fall-run Chinook salmon is that: the ecosystems upon which Snake River fall Chinook salmon depend are conserved such that the ESU is self-sustaining in the wild and no longer needs ESA protection.

8.29 Chinook Salmon – Snake River Spring/Summer-Run ESU

The Snake River spring/summer Chinook salmon ESU includes all naturally spawned populations of spring/summer Chinook salmon in the mainstem Snake River and the Tucannon River, Grand Ronde River, Imnaha River, and Salmon River subbasins (Figure 35). The ESU is broken into five MPG. Together, the MPGs contain 28 extant independent naturally spawning populations, three functionally extirpated populations, and one extirpated population. The Upper Salmon River MPG contains eight extant populations and one extirpated population. The Middle Fork Salmon River MPG contains nine extant populations. The South Fork Salmon River MPG contains four extant populations. The Grande Ronde/Imnaha Rivers MPG contains six extant populations, with two functionally extirpated populations. The Lower Snake River MPG contains one extant population and one functionally extirpated population. The South Fork and

Middle Fork Salmon Rivers currently support most of the natural spring/summer Chinook salmon production in the Snake River drainage (NMFS 2016g).

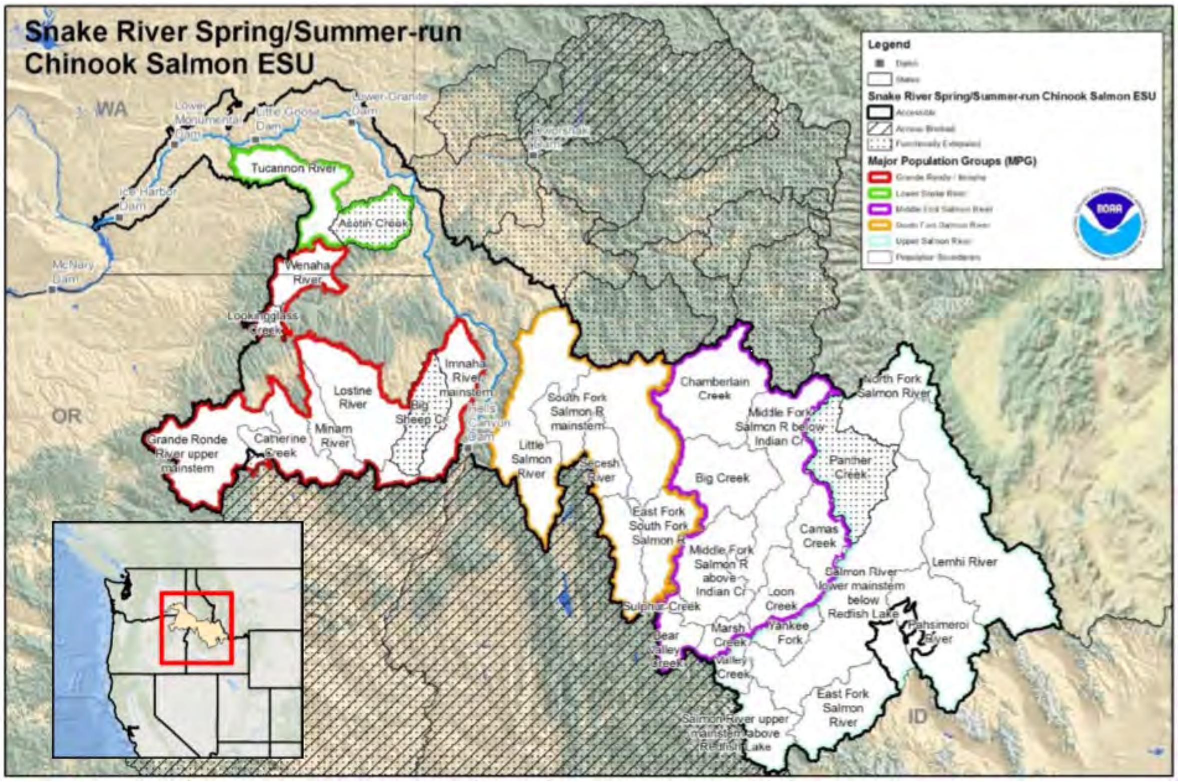

Figure 32. Geographic range and major population groups of Snake River spring/summer-run ESU Chinook salmon.

Snake River spring/summer-run Chinook salmon, an ESU was listed as a threatened species under the ESA on April 22, 1992 (57 FR 14658). NMFS reaffirmed the listing on June 28, 2005 (70 FR 37160) and made minor technical corrections to the listing on April 14, 2014 (79 FR 20802).

8.29.1 Life History

Adult spring-run Chinook salmon destined for the Snake River return to the Columbia River from the ocean in early spring and pass Bonneville Dam beginning in early March and ending May 31st. Snake River summer-run Chinook salmon return to the Columbia River from June through July. Adults from both runs hold in deep pools in the mainstem Columbia and Snake Rivers and the lower ends of the spawning tributaries until late summer, when they migrate into the higher elevation spawning reaches. Generally, Snake River spring-run Chinook salmon spawn in mid- through late August. Snake River summer-run Chinook salmon spawn approximately one month later than spring-run fish and tend to spawn lower in the tributary drainages, although their spawning areas often overlap with those of spring-run spawners.

The eggs that Snake River spring and summer Chinook salmon deposit in late summer and early fall incubate over the following winter, and hatch in late winter and early spring. Juveniles rear through the summer, overwinter, and typically migrate to sea in the spring of their second year of life, although some juveniles may spend an additional year in freshwater. Depending on the tributary and the specific habitat conditions, juveniles may migrate extensively from natal reaches into alternative summer-rearing or overwintering areas. Most yearling fish are thought to spend relatively little time in the estuary compared to sub-yearling ocean-type fish however there is considerable variation in residence times in different habitats and in the timing of estuarine and ocean entry among individual fish (McElhany et al. 2000; Holsman et al. 2012).

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.29.2 Population Dynamics

This section includes abundance, population growth rate, and genetic diversity as it relates MPGs within the Snake River spring/summer-run ESU of Chinook salmon. Current abundance estimates of the Snake River spring/summer-run ESU of Chinook salmon are presented in Table 28 below.

Table 27. Average Abundance Estimates for the Snake River Spring/Summer-Run ESU of Chinook Salmon for 2014-2018 (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	12,798
Natural	Juvenile	1,296,641
Listed Hatchery Adipose Clip	Adult	2,387
Listed Hatchery Adipose Clip	Juvenile	4,760,250
Listed Hatchery Intact Adipose	Adult	421
Listed Hatchery Intact Adipose	Juvenile	868,679

Lower Snake River MPG: Abundance and productivity remain the major concern for the Tucannon River population. Natural spawning abundance (10-year geometric mean) has increased but remains well below the minimum abundance threshold for the single extant population in this MPG. Poor natural productivity continues to be a major concern. The integrated spatial structure/diversity risk rating for the Lower Snake River MPG is moderate.

Grande Ronde/Imnaha MPG: The Wenaha River, Lostine/Wallowa River and Minam River populations showed substantial increases in natural abundance relative to the previous ICTRT review, although each remains below their respective minimum abundance thresholds. The Catherine Creek and Upper Grande Ronde populations each remain in a critically depressed state. Geometric mean productivity estimates remain relatively low for all populations in the MPG. The Upper Grande Ronde population is rated at high risk for spatial structure and diversity while the remaining populations are rated at moderate.

South Fork Salmon River MPG: Natural spawning abundance (10-year geometric mean) estimates increased for the three populations with available data series. Productivity estimates for these populations are generally higher than estimates for populations in other MPGs within the ESU. Viability ratings based on the combined estimates of abundance and productivity remain at high risk, although the survival/capacity gaps relative to moderate and low risk viability curves are smaller than for other ESU populations. Spatial structure/diversity risks are currently rated moderate for the South Fork Mainstem population (relatively high proportion of hatchery spawners) and low for the Secesh River and East Fork South Fork populations.

Middle Fork Salmon River MPG: Natural-origin abundance and productivity remains extremely low for populations within this MPG. As in the previous ICTRT assessment, abundance and productivity estimates for Bear Valley Creek and Chamberlain Creek (limited data series) are the closest to meeting viability minimums among populations in the MPG. Spatial structure/diversity risk ratings for Middle Fork Salmon River MPG populations are generally moderate. This primarily is driven by moderate ratings for genetic structure assigned by the ICTRT because of uncertainty arising from the lack of direct genetic samples from within the component populations.

Upper Salmon River MPG: Abundance and productivity estimates for most populations within this MPG remain at very low levels relative to viability objectives. The Upper Salmon Mainstem has the highest relative abundance and productivity combination of populations within the MPG. Spatial structure/diversity risk ratings vary considerably across the Upper Salmon River MPG. Four of the eight populations are rated at low or moderate risk for overall spatial structure and diversity and could achieve viable status with improvements in average abundance/productivity. The high spatial structure/diversity risk rating for the Lemhi population is driven by a substantial loss of access to tributary spawning/rearing habitats and the associated reduction in life-history diversity. High-risk ratings for Pahsimeroi River, East Fork Salmon River, and Yankee Fork Salmon River are driven by a combination of habitat loss and diversity concerns related to low natural abundance combined with chronically high proportions of hatchery spawners in natural areas.

8.29.3 Status

The historical run of Chinook in the Snake River likely exceeded one million fish annually in the late 1800s, by the 1950s the run had declined to nearly 100,000 adults per year. The adult counts fluctuated throughout the 1980s but then declined further, reaching a low of 2,200 fish in 1995. Currently, the majority of extant spring/summer Chinook salmon populations in the Snake River spring/summer Chinook salmon ESU remain at high overall risk of extinction, with a low probability of persistence within 100 years. Factors cited in the 1991 status review as contributing to the species' decline since the late 1800s include overfishing, irrigation diversions, logging, mining, grazing, obstacles to migration, hydropower development, and questionable management practices and decisions (Matthews and Waples 1991). In addition, new threats such as those posed by toxic contamination, increased predation by non-native species, and effects due to climate change are emerging (NMFS 2016a).

8.29.4 Critical Habitat

Critical habitat for Snake River spring/summer Chinook salmon was designated on December 28, 1993 (58 FR 68543) and revised slightly on October 25, 1999 (64 FR 57399).

8.29.5 Recovery Goals

Recovery goals, scenarios and criteria for the Snake River spring and summer-run Chinook salmon are fully outlined in the 2016 proposed recovery plan (NMFS 2016g). The status levels targeted for populations within an ESU or DPS are referred to collectively as the "recovery scenario" for the ESU or DPS. NMFS has incorporated the viability criteria into viable recovery scenarios for each Snake River spring/summer Chinook salmon and steelhead MPG. The criteria should be met for an MPG to be considered viable or low (5 percent or less) risk of extinction, and thus contribute to the larger objective of ESU or DPS viability.

8.30 Chinook Salmon – Upper Columbia River Spring-Run ESU

The Snake River spring/summer Chinook salmon ESU includes all naturally spawned populations of spring/summer Chinook salmon in the mainstem Snake River and the Tucannon River, Grand Ronde River, Imnaha River, and Salmon River subbasins as well as spring/summer Chinook salmon from 11 artificial propagation programs (NMFS 2016g) (Figure 34).

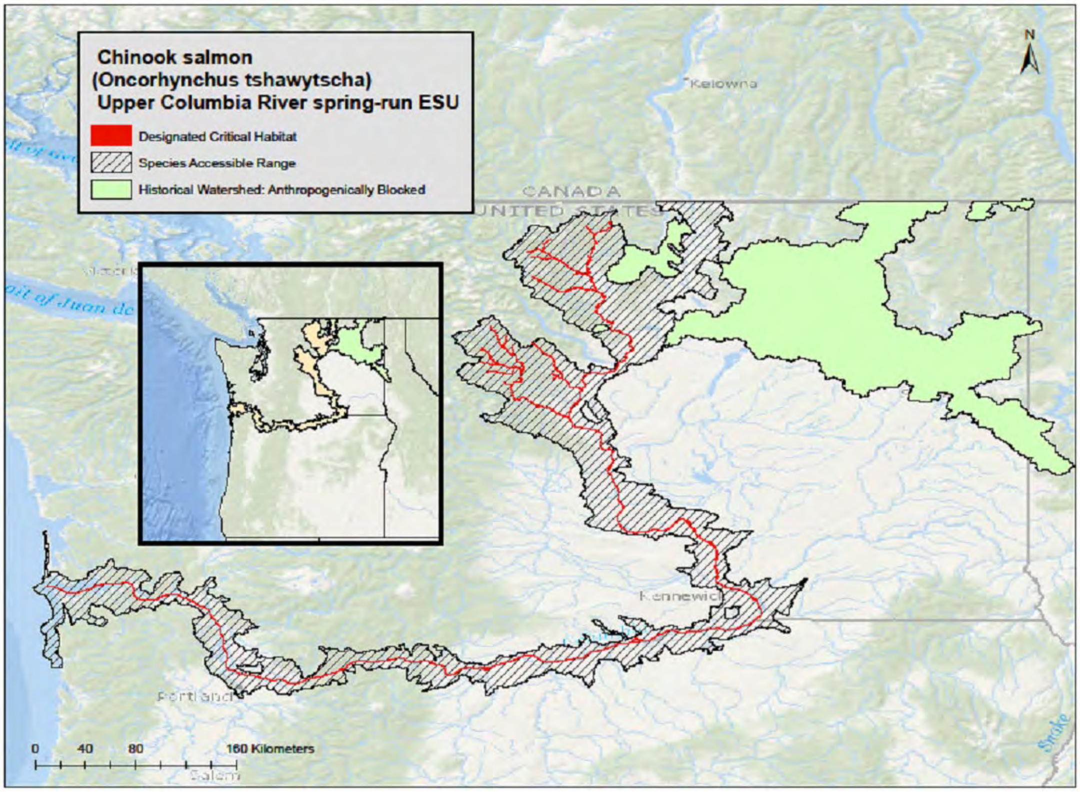

Figure 33. Geographic range and designated critical habitat of Chinook salmon, upper Columbia River ESU.

Upper Columbia River spring-run Chinook salmon, an ESU was listed as an endangered species under the ESA on March 24, 1999 (64 FR 14308). NMFS reaffirmed the listing on June 28, 2005 (70 FR 37160).

8.30.1 Life History

Adult Spring Chinook in the Upper Columbia Basin begin returning from the ocean in the early spring, with the run into the Columbia River peaking in mid-May. Spring Chinook enter the Upper Columbia tributaries from April through July. After migration, they hold in freshwater tributaries until spawning occurs in the late summer, peaking in mid to late August. Juvenile spring Chinook spend a year in freshwater before migrating to salt water in the spring of their second year of life. Most Upper Columbia spring Chinook return as adults after two or three years in the ocean. Some precocious males, or jacks, return after one winter at sea. A few other males mature sexually in freshwater without migrating to the sea. However, four and five year old fish that have spent two and three years at sea, respectively, dominate the run. Fecundity ranges from 4,200 to 5,900 eggs, depending on the age and size of the female.

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.30.2 Population Dynamics

For all populations, average abundance over the recent 10-year period is below the average abundance thresholds that the ICTRT identifies as a minimum for low risk (ICTRT 2008b; ICTRT 2008a; ICTRT 2008c). The geometric mean spawning escapements from 1997 to 2001 were 273 for the Wenatchee population, 65 for the Entiat population, and 282 for the Methow population. These numbers represent only 8 percent to 15 percent of the minimum abundance thresholds. The 10-year geometric mean abundance of adult natural-origin spawners has increased for each population relative to the levels reported in the 2011 status review, but natural origin escapements remain below the corresponding ICTRT thresholds. Current abundance estimates of the upper Columbia River spring-run ESU of Chinook salmon are presented in Table 29 below.

Table 28. Five Year Average (2015 to 2020) Abundance Estimates for the Upper Columbia River Spring-Run ESU of Chinook Salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	2,872
Natural	Juvenile	468,820
Listed Hatchery Adipose Clip	Adult	6,226
Listed Hatchery Adipose Clip	Juvenile	621,759

Listed Hatchery Intact Adipose	Adult	3,364
Listed Hatchery Intact Adipose	Juvenile	368,642

Overall abundance and productivity remains rated at high risk for each of the three extant populations in this MPG/ESU (NWFSC 2015b). The short-term lambda estimate for the Wenatchee River is 0.60; the Entiat River is 0.94; and the Methow River is 0.46.

The ICTRT characterizes the diversity risk to all Upper Columbia River Spring-run Chinook populations as "high". The high risk is a result of reduced genetic diversity from homogenization of populations that occurred under the Grand Coulee Fish Maintenance Project in 1939-1943.

Spring Chinook currently spawn and rear in the upper main Wenatchee River upstream from the mouth of the Chiwawa River, overlapping with summer Chinook in that area (Peven et al. 1994). The primary spawning areas of spring Chinook in the Wenatchee subbasin include Nason Creek and the Chiwawa, Little Wenatchee, and White rivers. The current spawning distribution for spring Chinook in the Entiat subbasin has been described as the Entiat River (river mile 16.2 to 28.9) and the Mad River (river mile 32 1.5-5.0) (NMFS 2007b). Spring Chinook of the Methow population currently spawn in the mainstem Methow River and the Twisp, Chewuch, and Lost drainages (NMFS 2007b). A few also spawn in Gold, Wolf, and Early Winters creeks.

8.30.3 Status

This ESU comprises four independent populations. Three are at high risk and one is functionally extirpated. Current estimates of natural origin spawner abundance increased relative to the levels observed in the prior review for all three extant populations, and productivities were higher for the Wenatchee and Entiat populations and unchanged for the Methow population. However, abundance and productivity remained well below the viable thresholds called for in the Upper Columbia Recovery Plan for all three populations. Although the status of the ESU is improved relative to measures available at the time of listing, all three populations remain at high risk (NWFSC 2015b).

8.30.4 Critical Habitat

NMFS designated critical habitat for Upper Columbia River Spring-run Chinook salmon on September 2, 2005 (70 FR 52630).

8.30.5 Recovery Goals

Recovery goals, objectives and detailed criteria for the Central Valley spring-run Chinook are fully outlined in the 2016 Recovery Plan. The general recovery objectives are:

- Increase the abundance of naturally produced spring Chinook spawners within each population in the Upper Columbia ESU to levels considered viable.

- Increase the productivity (spawner ratios and smolts/redds[3]) of naturally produced spring Chinook within each population to levels that result in low risk of extinction.
- Restore the distribution of naturally produced spring Chinook to previously occupied areas (where practical) and allow natural patterns of genetic and phenotypic diversity to be expressed.

8.31 Chinook Salmon – Upper Willamette River ESU

This evolutionarily significant unit, or ESU, includes naturally spawned spring-run Chinook salmon originating from the Clackamas River and from the Willamette River and its tributaries above Willamette Falls (Figure 35). Also, the Upper Willamette River spring-run ESU of Chinook salmon originate from six artificial propagation programs.

The upper Willamette River spring-run Chinook salmon ESU was listed as an endangered species under the ESA on March 24, 1999 (64 FR 14308). NMFS reaffirmed the listing on June 28, 2005 (70 FR 37160).

8.31.1 Life History

Upper Willamette River Chinook salmon exhibit an earlier time of entry into the Columbia River than other spring-run Chinook salmon ESUs (Myers et al. 1998b). Adults appear in the lower Willamette River in February, but the majority of the run ascends Willamette Falls in April and May, with a peak in mid- to late May. However, present-day salmon ascend the Willamette Falls via a fish ladder. Consequently, the migration of spring Chinook salmon over Willamette Falls extends into July and August (overlapping with the beginning of the introduced fall-run of Chinook salmon).

The adults hold in deep pools over summer and spawn in late fall or early winter when winter storms augments river flows. Fry may emerge from February to March and sometimes as late as June (Myers et al. 2006). Juvenile migration varies with three distinct juvenile emigration "runs": fry migration in late winter and early spring; sub-yearling (0 year +) migration in fall to early winter; and yearlings (1 year +) migrating in late winter to spring. Sub-yearlings and yearlings rear in the mainstem Willamette River where they also use floodplain wetlands in the lower Willamette River during the winter-spring floodplain inundation period.

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[3] Gravel nests excavated by spawning females.

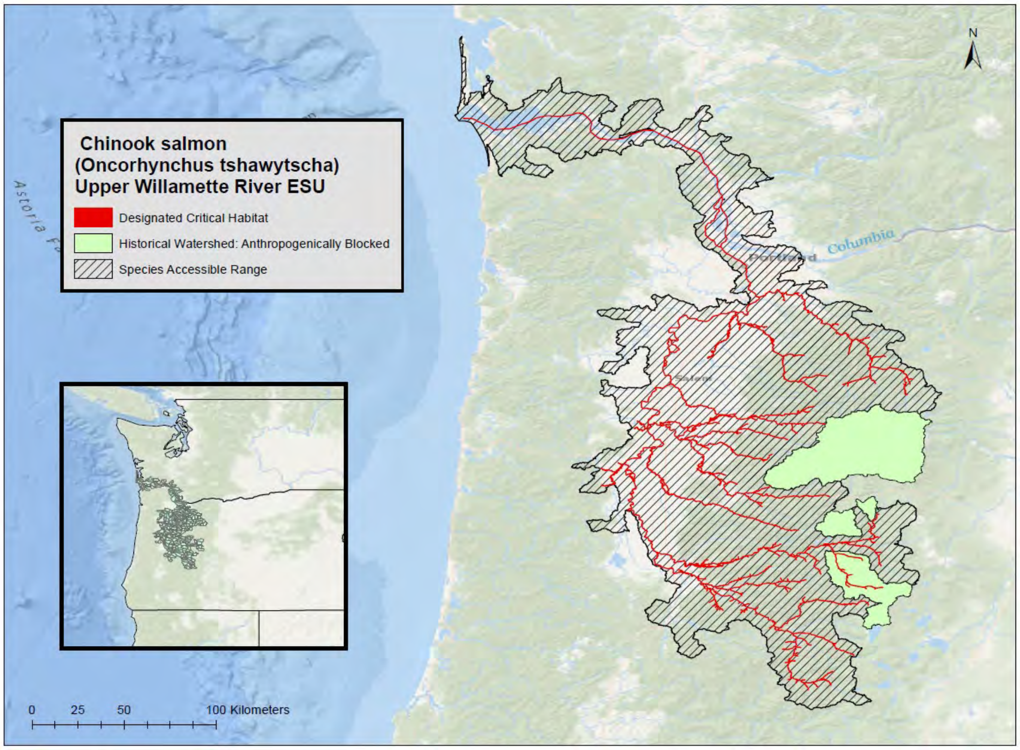

Figure 34. Geographic range and designated critical habitat of Chinook salmon, upper Willamette River ESU

The life history for this ESU of Chinook salmon is the same as presented in Section 8.23.1.

8.31.2 Population Dynamics

Abundance levels for five of the seven DIPs in this ESU remain well below their recovery goals. Of these, the Calapooia River may be functionally extinct and the Molalla River remains critically low (although perhaps only marginally better than the zero viable salmonid population score estimated in the Recovery Plan; (ODFW and NFMS 2011). Abundances in the North and South Santiam rivers have risen since the 2010 review, but still range only in the high hundreds of fish. The proportion of natural origin spawners improved in the North and South Santiam basins, but was still well below identified recovery goals. Improvement in the status of the Middle Fork Willamette River relates solely to the return of natural adults to Fall Creek; however, the capacity of the Fall Creek basin alone is insufficient to achieve the recovery goals for this DIP. The Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Overall, populations appear to be at either moderate or high risk, there has been likely little net change in the viable salmonid population score for the ESU since the last review, so the ESU remains at moderate risk (NWFSC 2015b). Current abundance estimates of the Upper Willamette River spring-run ESU of Chinook salmon are presented in Table 30 below.

Table 29. Average Abundance Estimates for the Upper Willamette River Spring-Run ESU of Chinook Salmon from 2014 to 2018 for Adults and 2015 to 2020 for Juveniles (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	10,203
Natural	Juvenile	1,275,681
Listed Hatchery Clipped and Intact Adipose	Adult	31,476
Listed Hatchery Adipose Clip	Juvenile	5,210,226
Listed Hatchery Intact Adipose	Juvenile	157

Access of fall-run Chinook salmon to the upper Willamette River and the mixing of hatchery stocks within the ESU have threatened the genetic integrity and diversity of the species. Much of the genetic diversity that existed between populations has been homogenized (Myers et al. 2006).

Radio-tagging results from 2014 suggest that few fish strayed into west-side tributaries (no detections) and relatively fewer fish were unaccounted for between Willamette Falls and the tributaries, 12.9 percent of clipped fish and 5.3 percent of unclipped fish (NWFSC 2015b). In contrast to most of the other populations in this ESU, McKenzie River Chinook salmon have access to much of their historical spawning habitat, although access to historically high quality habitat above Cougar Dam (South Fork McKenzie River) is still limited by poor downstream juvenile passage. Similarly, natural-origin returns to the Clackamas River have remained flat, despite adults having access to much of their historical spawning habitat.

8.31.3 Status

The Upper Willamette River Chinook ESU is considered to be extremely depressed, likely numbering less than 10,000 fish compared to a historical abundance estimate of 300,000 (NMFS 2011g). There are seven demographically independent populations of spring-run Chinook salmon in the Upper Willamette River Chinook salmon ESU: Clackamas, Molalla, North Santiam, South Santiam, Calapooia, McKenzie, and the Middle Fork Willamette (NMFS 2011g). The Clackamas and McKenzie Rivers have previously been viewed as natural population strongholds, but have both experienced declines in abundance despite having access to much of their historical spawning habitat. Juvenile spring Chinook produced by hatchery programs are released throughout many of the subbasins and adult Chinook returns to the ESU are typically 80 to 90 percent hatchery origin fish. Access to historical spawning and rearing areas is restricted by large dams in the four historically most productive tributaries, and in the absence of effective passage programs will continue to be confined to more lowland reaches where land development, water temperatures, and water quality may be limiting. Pre-spawning mortality levels are generally high in the lower tributary reaches where water temperatures and fish densities are generally the highest.

8.31.4 Critical Habitat

NMFS designated critical habitat for this species on September 2, 2005 (70 FR 52630).

8.31.5 Recovery Goals

Recovery goals, objectives and detailed criteria for the Upper Willamette River Chinook are fully outlined in the 2011 Recovery Plan (2011g). The 2011 recovery plan outlines five potential scenario options for meeting the viability criteria for recovery. Of the five scenarios, "scenario one" reportedly represented the most balanced approach given limitations in some populations. The approach in this scenario is to recover the McKenzie (core and genetic legacy population) and the Clackamas populations to an extinction risk status of very low risk (beyond minimal viability thresholds), to recover the North Santiam and Middle Fork Willamette populations (core populations) to an extinction risk status of low risk, to recover the South Santiam population to moderate risk, and improve the status of the remaining populations from very high risk to high risk.

8.32 Chum Salmon – Columbia River ESU

The Columbia River ESU of chum salmon includes naturally spawned chum salmon originating from the Columbia River and its tributaries in Washington and Oregon (Figure 36), and also chum salmon from two artificial propagation programs.

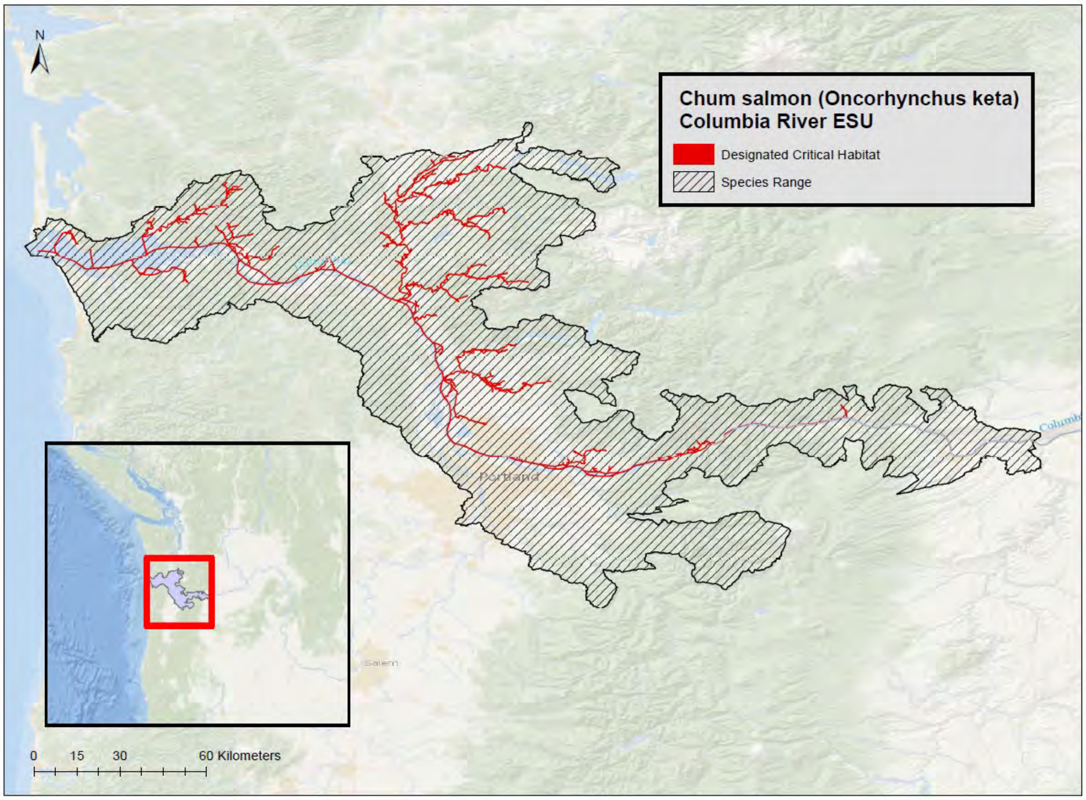

Figure 35. Geographic range and designated critical habitat of chum salmon, Columbia River ESU.

Chum salmon are an anadromous (i.e., adults migrate from marine to freshwater streams and rivers to spawn) and semelparous (i.e., they spawn once and then die) fish species. Adult chum salmon are typically between eight and fifteen pounds, but they can get as large as 45 pounds and 3.6 feet long. Males have enormous canine-like fangs and a striking calico pattern body color (front two-thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) during spawning. Females are less flamboyantly colored and lack the extreme dentition of the males. Ocean stage chum salmon are metallic greenish-blue along the back with black speckles. Chum salmon have the widest natural geographic and spawning distribution of the Pacific salmonids. On March 25, 1999, NMFS listed the Hood Canal summer-run ESU and the Columbia River ESU of chum salmon as threatened (64 FR 14508). NMFS reaffirmed the status of these two ESUs as threatened on June 28, 2005 (70 FR 37160).

8.32.1 Life History

Most chum salmon mature and return to their birth stream to spawn between three and five years of age, with 60 to 90 percent of the fish maturing at four years of age. Age at maturity appears to follow a latitudinal trend (i.e., greater in the northern portion of the species' range). Chum salmon typically spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to 100 kilometers from the sea. Juveniles out-migrate to seawater almost immediately after emerging from the gravel covered redds (Salo 1991b). The survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

Chum salmon spend two to five years in feeding areas in the northeast Pacific Ocean, which is a greater proportion of their life history compared to other Pacific salmonids. Chum salmon distribute throughout the North Pacific Ocean and Bering Sea, although North American chum salmon (as opposed to chum salmon originating in Asia), rarely occur west of 175 East longitude (Johnson et al. 1997a). North American chum salmon migrate north along the coast in a narrow band that broadens in southeastern Alaska, although some data suggests that chum may travel directly offshore into the north Pacific Ocean (Johnson et al. 1997a).

8.32.2 Population Dynamics

Chum populations in the Columbia River historically reached hundreds of thousands to a million adults each year (NMFS 2017a). In the past 50 years, the average has been a few thousand a year. The majority of populations in the Columbia River chum ESU remain at high to very high risk, with very low abundances (NWFSC 2015b). Ford (2011b) concluded that 14 out of 17 of chum populations in this ESU were either extirpated or nearly extirpated. Current abundance estimates of the Columbia River ESU of chum salmon are presented in Table 31 below.

Table 30. Abundance Estimates for the Columbia River ESU of Chum Salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	10,644
Natural	Juvenile	6,626,218
Listed Hatchery Intact Adipose	Adult	426
Listed Hatchery Intact Adipose	Juvenile	601,503

Only one population (Grays River) is at low risk, with spawner abundances in the thousands, and demonstrating a recent positive trend. Two other populations (Washougal River and Lower Gorge) maintain moderate numbers of spawners and appear to be relatively stable (NWFSC 2015b). The overall trend since 2000 is negative, with the recent peak in abundance (2010 to 2011) being considerably lower than the previous peak in 2002.

There are currently four hatchery programs in the Lower Columbia River releasing juvenile chum salmon: Grays River Hatchery, Big Creek Hatchery, Lewis River Hatchery, and Washougal Hatchery (NMFS 2017a). Total annual production from these hatcheries has not exceeded 500,000 fish. All of the hatchery programs in this ESU use integrated stocks developed to supplement natural production. Other populations in this ESU persist at very low abundances and the genetic diversity available would be very low (NWFSC 2015b). Diversity has been greatly reduced at the ESU level because of presumed extirpations and low abundance in the remaining populations (fewer than 100 spawners per year for most populations) (LCFRB 2010; NMFS 2013a).

The Columbia River chum salmon ESU includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. The ESU consists of three populations: Grays River, Hardy Creek and Hamilton Creek in Washington State. Chum salmon from four artificial propagation programs also contribute to this ESU.

8.32.3 Status

The majority of the populations within the Columbia River chum salmon ESU are at high to very high risk, with very low abundances (NWFSC 2015b). These populations are at risk of extirpation due to demographic stochasticity and Allee effects. One population, Grays River, is at low risk, with spawner abundances in the thousands and demonstrating a recent positive trend. The Washougal River and Lower Gorge populations maintain moderate numbers of spawners and appear to be relatively stable. The life history of chum salmon is such that ocean conditions have a strong influence on the survival of emigrating juveniles. The potential prospect of poor ocean conditions for the near future may put further pressure on the Columbia River chum salmon ESU (NWFSC 2015b). Freshwater habitat conditions may be negatively influencing spawning and early rearing success in some basins, and contributing to the overall low productivity of the ESU. Columbia River chum salmon were historically abundant and subject to substantial harvest until the 1950s (NWFSC 2015b). There is no directed harvest of this ESU and the incidental harvest rate has been below one percent for the last five years (NWFSC 2015b). Land development, especially in the low gradient reaches that chum salmon prefer, will continue to be a threat to most chum salmon populations due to projected increases in the population of the greater Vancouver-Portland area and the Lower Columbia River overall (Metro 2015). The Columbia River chum salmon ESU remains at a moderate to high risk of extinction (NWFSC 2015b).

8.32.4 Critical Habitat

NMFS designated critical habitat for the Columbia River chum salmon ESU in 2005 (70 FR 52630). This designation includes defined areas in the following subbasins: Middle Columbia/Hood, Lower Columbia/Sandy, Lewis, Lower Columbia/Clatskanie, Lower Cowlitz, and Lower Columbia sub-basin and river corridor (Figure 36).

8.32.5 Recovery Goals

The ESU recovery strategy for Columbia River chum salmon focuses on improving tributary and estuarine habitat conditions, reducing or mitigating hydropower impacts, and reestablishing chum salmon populations where they may have been extirpated (NMFS 2013b). The goal of the strategy is to increase the abundance, productivity, diversity, and spatial structure of chum salmon populations such that the Coast and Cascade chum salmon strata are restored to a high probability of persistence and the persistence probability of the two Gorge populations improves. For details on Columbia River chum salmon ESU recovery goals, including complete down-listing/delisting criteria, see the NMFS 2013 recovery plan (NMFS 2013b).

8.33 Chum Salmon – Hood Canal Summer-Run ESU

The chum salmon, Hood Canal summer-run ESU includes naturally spawned summer-run chum salmon originating from Hood Canal and its tributaries as well as from Olympic Peninsula rivers between Hood Canal and Dungeness Bay (Figure 37). Also, summer-run chum salmon originate from four artificial propagation programs.

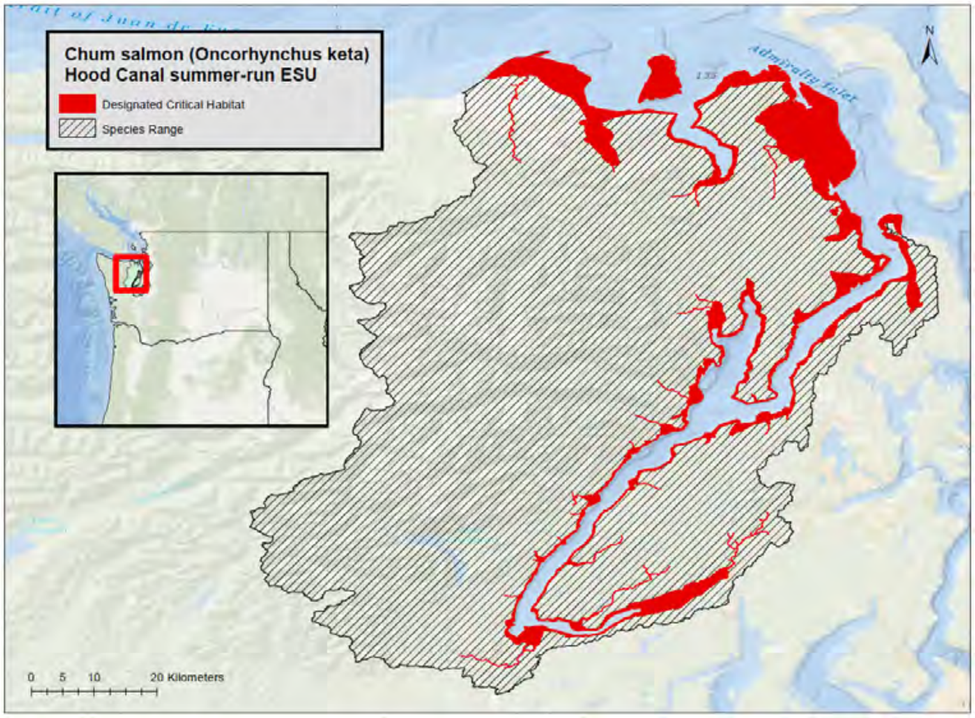

Figure 36. Geographic range and designated critical habitat of chum salmon, Hood Canal ESU.

Chum salmon are anadromous (i.e., adults migrate from marine to freshwater streams and rivers to spawn) and semelparous (i.e., they spawn once and then die) fish species. Adult chum salmon are typically between eight and fifteen pounds, but they can get as large as 45 pounds and 3.6 feet long. Males have enormous canine-like fangs and a striking calico pattern body color (front two-thirds of the flank marked by a bold, jagged, reddish line and the posterior third by a jagged black line) during spawning. Females are less flamboyantly colored and lack the extreme dentition of the males. Ocean stage chum salmon are metallic greenish-blue along the back with black speckles. Chum salmon have the widest natural geographic and spawning distribution of the Pacific salmonids. On March 25, 1999, NMFS listed the Hood Canal Summer-run ESU and the Columbia River ESU of chum salmon as threatened (64 FR 14508). NMFS reaffirmed the status of these two ESUs as threatened on June 28, 2005 (70 FR 37160).

8.33.1 Life History

Chum life history is described in section 8.32.1.

8.33.2 Population Dynamics

Of the sixteen populations that comprise the Hood Canal Summer-run chum ESU, seven are considered "functionally extinct" (Skokomish, Finch Creek, Anderson Creek, Dewatto, Tahuya, Big Beef Creek and Chimicum). NMFS examined average escapements (geometric means) for five-year intervals and estimated trends over the intervals for all natural spawners and for natural-origin only spawners. For both populations, abundance was relatively high in the 1970s, lowest for the period 1985 to 1999, and high again from 2005 to 2015 (NWFSC 2015b). Current abundance estimates of the Hood Canal summer-run ESU of chum salmon are presented in Table 32 and Table 33 below.

Table 31. Hood Canal summer-run juvenile chum salmon hatchery releases (NMFS 2020).

Sub-basin	Artificial propagation program	Brood year	Run Timing	Clipped Adipose Fin	Intact Adipose Fin
Hood Canal	LLTK – Lilliwaup	2018	Summer	-	150,000
Total Annual Release Number				-	150,000

Table 32. Abundance of natural-origin and hatchery-origin Hood Canal summer-run chum salmon spawners in escapements 2013 to 2017 (NMFS 2020).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[b]	% Hatchery Origin	Expected Number of Outmigrants[c]
Strait of Juan de Fuca Population				
Jimmycomelately Creek	1,288	0	0.00%	188,313
Salmon Creek	1,836	0	0.00%	268,531
Snow Creek	311	0	0.00%	45,541
Chimacum Creek	902	0	0.00%	131,971
Population Average[d]	4,337	0	0.00%	634,355
Hood Canal Population				
Big Quilcene River	6,437	0	0.00%	941,450

Population Name	**Natural-origin Spawners**[a]	**Hatchery-origin Spawners**[b]	**% Hatchery Origin**	**Expected Number of Outmigrants**[c]
Little Quilcene River	122	0	0.00%	17,795
Big Beef Creek	10	0	0.00%	1,532
Dosewallips River	2,021	0	0.00%	295,524
Duckabush River	3,172	0	0.00%	463,856
Hamma River	2,944	10	0.34%	432,056
Anderson Creek	3	0	0.00%	376
Dewatto River	95	0	0.00%	13,947
Lilliwaup Creek	857	1,141	57.10%	292,159
Tahuya River	205	299	59.36%	73,777
Union River	2,789	2	0.07%	408,166
Skokomish River	2,154	0	0.00%	314,960
Population Average[d]	20,809	1,452	6.52%	3,255,599
ESU Average	25,146	1,452	5.46%	3,889,955

a Five-year geometric mean of post fishery natural-origin spawners (2015 to 2019).

b Five-year geometric mean of post fishery hatchery-origin spawners (2015 to 2019).

c Expected number of outmigrants=Total spawners*45% proportion of females*2,500 eggs per female*13% survival rate from egg to outmigrant.

d Averages are calculated as the geometric mean of the annual totals (2015 to 2019).

The overall trend in spawning abundance is generally stable for the Hood Canal population (all natural spawners and natural-origin only spawners) and for the Strait of Juan de Fuca population (all natural spawners). Productivity rates, which were quite low during the five-year period from 2005 to 2009 (Ford 2011b), increased from 2011 to 2015 and were greater than replacement rates from 2014-2015 for both MPGs (NWFSC 2015b).

There were likely at least two ecological diversity groups within the Strait of Juan de Fuca population and at least four ecological diversity groups within the Hood Canal population. With the possible exception of the Dungeness River aggregation within the Strait of Juan de Fuca population, Hood Canal ESU summer chum spawning groups exist today that represent each of the ecological diversity groups within the two populations (NMFS 2017a). Diversity values (Shannon diversity index) were generally lower in the 1990s for both independent populations within the ESU, indicating that most of the abundance occurred at a few spawning sites (NWFSC

2015b). Although the overall linear trend in diversity appears to be negative, the last five-year interval shows the highest average value for both populations within the Hood Canal ESU.

The Hood Canal summer-run chum salmon ESU includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington. The nine populations are well distributed throughout the ESU range except for the eastern side of Hood Canal (Johnson et al. 1997a). Two independent MPGs have been identified for this ESU: (1) spawning aggregations from rivers and creeks draining into the Strait of Juan de Fuca, and (2) spawning aggregations within Hood Canal proper (Sands 2009).

8.33.3 Status

The two most recent status reviews (2011 and 2015) indicate some positive signs for the Hood Canal summer-run chum salmon ESU. Diversity has increased from the low levels seen in the 1990s due to both the reintroduction of spawning aggregates and the more uniform relative abundance between populations; considered a good sign for viability in terms of spatial structure and diversity (Ford 2011b). Spawning distribution within most streams was also extended further upstream with increased abundance. At present, spatial structure and diversity viability parameters for each population nearly meet the viability criteria (NWFSC 2015b). Spawning abundance has remained relatively high compared to the low levels observed in the early 1990's (Ford 2011b). Natural-origin spawner abundance has shown an increasing trend since 1999, and spawning abundance targets in both populations were met in some years (NWFSC 2015b). Despite substantive gains towards meeting viability criteria in the Hood Canal and Strait of Juan de Fuca summer chum salmon populations, the ESU still does not meet all of the recovery criteria for population viability at this time (NWFSC 2015b). Overall, the Hood Canal Summer-run chum salmon ESU remains at a moderate risk of extinction.

8.33.4 Critical Habitat

NMFS designated critical habitat for Hood Canal summer-run chum salmon in 2005 (70 FR 52630) and includes 79 miles of stream channels and 377 miles of nearshore marine habitat (Figure 37).

8.33.5 Recovery Goals

The recovery strategy for Hood Canal Summer-run chum salmon focuses on habitat protection and restoration throughout the geographic range of the ESU, including both freshwater habitat and nearshore marine areas within a one-mile radius of the watersheds' estuaries (NMFS 2007a). The recovery plan includes an ongoing harvest management program to reduce exploitation rates, a hatchery supplementation program, and the reintroduction of naturally spawning summer chum aggregations to several streams where they were historically present. The Hood Canal plan gives first priority to protecting the functioning habitat and major production areas of the ESU's eight extant stocks, keeping in mind the biological and habitat needs of different life-history stages, and second priority to restoration of degraded areas, where recovery of natural processes appears to be feasible (HCCC 2005). For details on Hood Canal Summer-run chum salmon ESU recovery goals, including complete down-listing/delisting criteria, see the Hood Canal Coordinating Council 2005 recovery plan (HCCC 2005) and the NMFS 2007 supplement to this recovery plan (NMFS 2007a).

8.34 Coho Salmon – Central California Coast ESU

This evolutionarily significant unit, or ESU, includes naturally spawned Coho salmon originating from rivers south of Punta Gorda, California up to and including Aptos Creek, as well as such Coho salmon originating from tributaries to San Francisco Bay. Also, Coho salmon from three artificial propagation programs are included in this ESU (Figure 40).

Coho salmon are an anadromous species (i.e., adults migrate from marine to freshwater streams and rivers to spawn). Adult Coho salmon are typically about two feet long and eight pounds. Coho have backs that are metallic blue or green, silver sides, and light bellies; spawners are dark with reddish sides; and when Coho salmon are in the ocean, they have small black spots on the back and upper portion of the tail. Central California Coast Coho salmon, an ESU was listed as threatened under the ESA on October 31, 1996 (64 FR 56138). NMFS re-classified the ESU as endangered on June 28, 2005 (70 FR 37160).

8.34.1 Life History

Central California Coast Coho salmon typically enter freshwater from November through January, and spawn into February or early March (Moyle 2002b). The upstream migration towards spawning areas coincides with large increases in stream flow (Hassler 1987). Coho salmon often are not able to enter freshwater until heavy rains have caused breaching of sand bars that form at the mouths of many coastal California streams. Spawning occurs in streams with direct flow to the ocean, or in large river tributaries (Moyle 2002b). Female Coho salmon choose a site to spawn at the head of a riffle, just downstream of a pool where water flow changes from slow to turbulent, and where medium to small size gravel is abundant (Moyle 2002b).

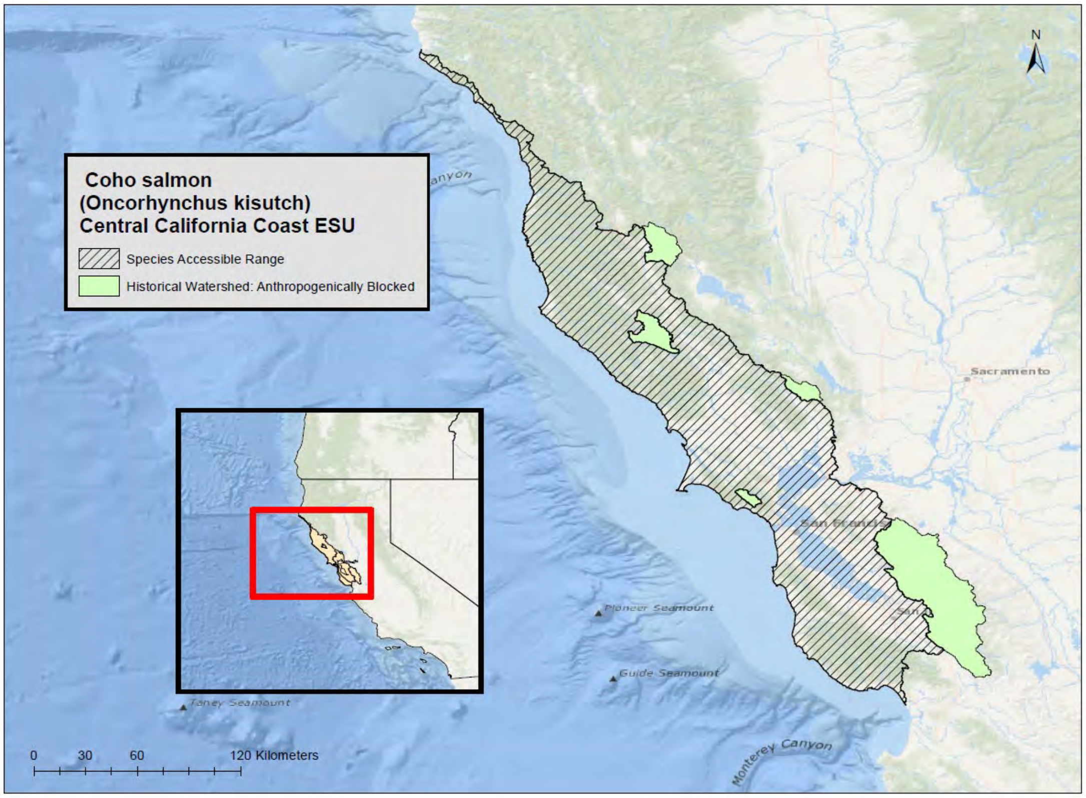

Figure 37. Geographic range of Coho salmon, Central California Coast ESU.

Eggs incubate in redds from November through April, and hatch into alevins after a period of 35 to 50 days (Shapovalov and Taft 1954). The period of incubation is inversely related to water temperature. Alevins remain in the gravel for two to ten weeks then emerge into the water column as young juveniles, known as fry. Juveniles, or fry, form schools in shallow water along the undercut banks of the stream to avoid predation. The juveniles feed heavily during this time, and as they grow they set up individual territories. Juveniles are voracious feeders, ingesting any organism that moves or drifts over their holding area. The juvenile's diet is mainly aquatic insect larvae and terrestrial insects, but small fish are taken when available (Moyle 2002b).

After one year in freshwater juvenile Coho salmon undergo physiological transformation into smolts for outmigration to the ocean. Smolts may spend time residing in the estuarine habitat prior to ocean entry, to allow for the transition to the saline environment. After entering the ocean, the immature salmon initially remain in the nearshore waters close to their natal stream. They gradually move northward, generally staying over the continental shelf (Brown et al. 1994). After approximately two years at sea, adult Coho salmon move slowly homeward. Adults begin their freshwater migration upstream after heavy fall or winter rains breach the sandbars at the mouths of coastal streams (Sandercock 1991) and/or flows are sufficient to reach upstream spawning areas.

8.34.2 Population Dynamics

Limited information exists on the abundance of Coho salmon within the Central California Coast ESU. About 200,000 to 500,000 Coho salmon were produced statewide in the 1940s (Good et al. 2005). This escapement declined to about 99,000 by the 1960s with approximately 56,000 (56 percent) originating from streams within the Central California Coast ESU. The estimated number of Coho salmon produced within the ESU in 2011 was between 2,000 and 3,000 wild adults (Gallagher et al. 2010). Current abundance estimates of the Central California Coast ESU of Coho salmon are presented in Table 34 and Table 35 below.

Table 33. Average juvenile Central California Coast Coho salmon Coho salmon hatchery releases (NMFS 2020).

Artificial propagation program	Watershed	Years	Clipped Adipose Fin
Don Clausen Fish Hatchery Captive Broodstock Program	Russian River tributaries	2014-2018	132,680
Scott Creek/King Fisher Flats Conservation Program	Gazos and San Vicente creeks	2018	12,000
Scott Creek Captive Broodstock Program	Scott Creek	2013-2017	21,200
Average Annual Release Number			165,880

Table 34. Geometric mean abundances of Central California Coast Coho salmon spawner escapements by population. Populations in bold font are independent populations (NMFS 2020).

Stratum	Population	Spawners		Expected Number of Outmigrants[b]
		Natural-origin	Hatchery-origin[a]	
Lost Coast – Navarro Point	Ten Mile River	69	-	4,830
	Usal Creek	4	-	280
	Noyo River	455	-	31,850
	Pudding Creek	184	-	12,880
	Caspar Creek	40	-	2,800
	Big River	183	-	12,810
	Little River	30		2,100

Stratum	Population	Spawners		Expected Number of Outmigrants[b]
		Natural-origin	Hatchery-origin[a]	
	Albion River	21	-	1,470
	Big Salmon Creek	3		210
Navarro Point – Gualala Point	Navarro River	102	-	7,140
	Greenwood Creek	3		210
	Garcia River	18	-	1,260
	Gualala River	-	-	-
Coastal	Russian River	364[c]	323	48,090
	Salmon Creek	-	-	-
	Walker Creek		-	-
	Lagunitas Creek	408	-	28,560
	Pine Gulch	2		140
	Redwood Creek	23	-	1,610
Santa Cruz Mountains	Pescadero Creek	1	-	70
	San Lorenzo River	1	-	70
	Waddell Creek	1	-	70
	Scott Creek	18	4	1,540
	San Vicente Creek	2	-	140
	Soquel Creek	-	-	-
ESU Total		1,932	327	158,130

a J. Jahn, pers. comm., July 2, 2013

b Expected number of outmigrants=Total spawners*50% proportion of females*2,000 eggs per female*7% survival rate from egg to outmigrant

c Arithmetic mean used due to unavailability of geometric mean

Within the Lost Coast – Navarro Point stratum and the Navarro Point – Gualala Point stratum, most independent populations show positive but non-significant population trends. Dependent populations within these stratums have declined significantly since 2011. In the Russian River and Lagunitas Creek watersheds, which are the two largest within the Central Coast strata, recent Coho salmon population trends suggest limited improvement, although both populations remain well below recovery targets. Recent sampling within Pescadero Creek and San Lorenzo River, the only two independent populations within the Santa Cruz Mountains strata, suggest Coho salmon have likely been extirpated within both basins.

Genetic studies show little homogenization of populations, i.e., transfer of stocks between basins have had little effect on the geographic genetic structure of central California Coast Coho salmon (Sonoma County Water Agency (SCWA) 2002). This ESU likely has considerable diversity in local adaptations given that the ESU spans a large latitudinal diversity in geology and ecoregions, and include both coastal and inland river basins.

The Technical Review Team identified 11 “functionally independent”, one “potentially independent” and 64 “dependent” populations in the Central California Coast ESU of Coho salmon (Bjorkstedt et al., 2005 with modifications described in Spence et al. 2008). The 75 populations were grouped into five Diversity Strata. The Russian River is of particular importance for preventing the extinction and contributing to the recovery of the Central California Coast Coho salmon ESU (NOAA 2013). The Russian River population, once the largest and most dominant source population in the ESU, is now at high risk of extinction because of low abundance and failed productivity (Spence, Bjorkstedt et al. 2008). The Lost Coast and Navarro Point contain the majority of Coho salmon remaining in the ESU.

8.34.3 Status

The low survival of juveniles in freshwater, in combination with poor ocean conditions, has led to the precipitous declines of Central California Coast ESU Coho salmon populations. Most independent populations remain at critically low levels, with those in the southern Santa Cruz Mountains strata likely extirpated. Data suggest some populations show a slight positive trend in annual escapement, but the improvement is not statistically significant. Overall, all populations remain, at best, a slight fraction of their recovery target levels, and, aside from the Santa Cruz Mountains strata, the continued extirpation of dependent populations continues to threaten the ESU's future survival and recovery.

8.34.4 Critical Habitat

Critical habitat for the Central California Coast ESU of Coho salmon was designated on May 5, 1999 (64 FR 24049).

8.34.5 Recovery Goals

See the 2012 Recovery Plan for complete down listing/delisting criteria for each of the following recovery goals (NMFS 2012a):

- Prevent extinction by protecting existing populations and their habitats;
- Maintain current distribution of Coho salmon and restore their distribution to previously occupied areas essential to their recovery;
- Increase abundance of Coho salmon to viable population levels, including the expression of all life history forms and strategies;

- Conserve existing genetic diversity and provide opportunities for interchange of genetic material between and within meta populations;
- Maintain and restore suitable freshwater and estuarine habitat conditions and characteristics for all life history stages so viable populations can be sustained naturally;
- Ensure all factors that led to the listing of the species have been ameliorated; and
- Develop and maintain a program of monitoring, research, and evaluation that advances understanding of the complex array of factors associated with Coho salmon survival and recovery and which allows for adaptively managing our approach to recovery over time.

8.35 Coho Salmon – Lower Columbia River ESU

This ESU includes naturally spawned Coho salmon originating from the Columbia River and its tributaries downstream from the Big White Salmon and Hood Rivers (inclusive) and any such fish originating from the Willamette River and its tributaries below Willamette Falls. Also, Coho salmon originate from 21 artificial propagation programs (Figure 39). The Lower Columbia River ESU of Coho salmon was listed as threatened under the ESA on June 28, 2005.

8.35.1 Life History

Lower Columbia River Coho salmon are typically categorized into early- and late-returning stocks. Early-returning (Type S) adult Coho salmon enter the Columbia River in mid-August and begin entering tributaries in early September, with peak spawning from mid-October to early November. Late-returning (Type N) Coho salmon pass through the lower Columbia from late September through December and enter tributaries from October through January. Most spawning occurs from November to January, but some occurs as late as March (LCFRB 2010).

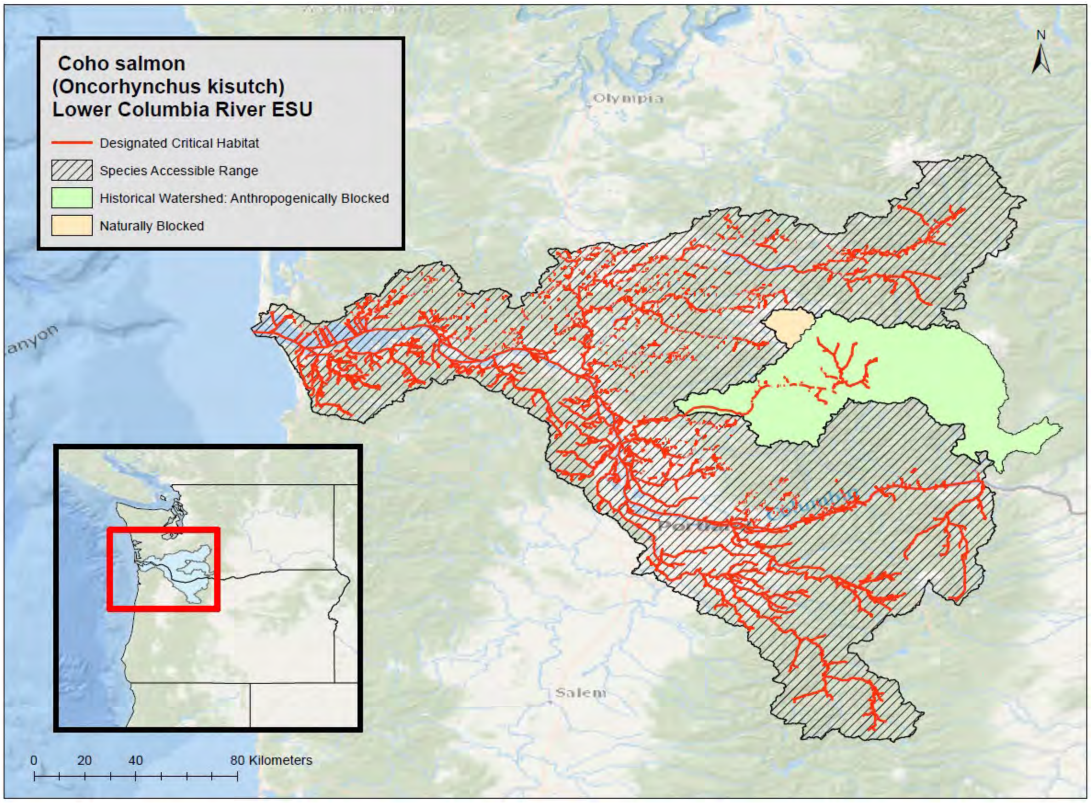

Figure 38. Geographic range and designated critical habitat of Coho salmon, Lower Columbia River ESU.

Coho salmon typically spawn in small to medium, low- to-moderate elevation streams from valley bottoms to stream headwaters. Coho salmon construct redds in gravel and small cobble substrate in pool tailouts, riffles, and glides, with sufficient flow depth for spawning activity (NMFS 2013c). Eggs incubate over late fall and winter for about 45 to 140 days, depending on water temperature, with longer incubation in colder water. Fry may thus emerge from early spring to early summer (ODFW 2010). Juveniles typically rear in freshwater for more than a year. After emergence, Coho salmon fry move to shallow, low-velocity rearing areas, primarily along the stream edges and inside channels. Juvenile Coho salmon favor pool habitat and often congregate in quiet backwaters, side channels, and small creeks with riparian cover and woody debris. Side-channel rearing areas are particularly critical for overwinter survival, which is a key regulator of freshwater productivity (LCFRB 2010).

Most juvenile Coho salmon migrate seaward as smolts in April to June, typically during their second year. Salmon that have stream-type life histories, such as Coho, typically do not linger for extended periods in the Columbia River estuary, but the estuary is a critical habitat used for feeding during the physiological adjustment to salt water. Juvenile Coho salmon are present in the Columbia River estuary from March to August. Columbia River Coho salmon typically range throughout the nearshore ocean over the continental shelf off the Oregon and Washington coasts. Early-returning (Type S) Coho salmon are typically found in ocean waters south of the Columbia River mouth. Late-returning (Type N) Coho salmon are typically found in ocean waters north of the Columbia River mouth. Most Coho salmon sexually mature at age three, except for a small percentage of males (called jacks) who return to natal waters at age two, after only five to seven months in the ocean (LCFRB 2010).

8.35.2 Population Dynamics

Washington tributaries indicate the presence of moderate numbers of Coho salmon, with total abundances in the hundreds to low thousands of fish. Oregon tributaries have abundances in the hundreds of fish. In the Western Cascade MPG, the Sandy and Clackamas Rivers were the only two populations identified in the original 1996 Status Review that appeared to be self-sustaining natural populations. Natural origin abundances in the Columbia Gorge MPG are low, with hatchery-origin fish contributing a large proportion of the total number of spawners, most notably in the Hood River. Current abundance estimates of the Lower Columbia River ESU of Coho salmon are presented in Table 36 and Table 37 below.

Table 35. Juvenile Abundance Estimates for the Lower Columbia River ESU of Coho Salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural	Juvenile	651,378
Listed Hatchery Intact Adipose	Juvenile	287,056
Listed Hatchery Adipose Clipped	Juvenile	7,055,635

Table 36. Average abundance estimates for Lower Columbia River Chinook salmon natural- and hatchery-origin spawners (NMFS 2020).

Population Name	Years	Natural-origin Spawners	Hatchery-origin Spawners	% Hatchery Origin
Coastal Stratum – Fall run				
Youngs Bay	2012-2014	233	5,606	96.01%
Grays/Chinook	2010-2014	100	357	78.12%
Big Creek	2012-2014	32	1,510	97.92%
Elochoman/ Skamokowa	2010-2014	116	580	83.33%
Clatskanie	2012-2014	98	3,193	97.02%
Mill/Abernathy/Germany	2010-2014	92	805	89.74%

Population Name	Years	Natural-origin Spawners	Hatchery-origin Spawners	% Hatchery Origin
Cascade Stratum – Fall run				
Lower Cowlitz	2010-2013	723	196	21.33%
Upper Cowlitz	2010-2013	2,873	961	25.07%
Toutle	2010-2014	3,305	5,400	62.03%
Coweeman	2010-2014	385	963	71.44%
Kalama	2010-2014	803	8,892	91.72%
Lewis	2010-2014	2,178	943	30.21%
Washougal	2010-2014	192	116	37.66%
Clackamas	2012-2014	1,272	2,955	69.91%
Sandy	2012-2014	1,207	320	20.96%
Columbia Gorge Stratum – Fall run				
Lower Gorge	2003-2007	146	-	-
Upper Gorge	2010-2012	200	327	62.05%
White Salmon	2010-2014	829	246	22.88%
Cascade Stratum – Late fall run				
North Fork Lewis	2010-2014	12,330	0	0.00%
Cascade Stratum – Spring run				
Upper Cowlitz/Cispus	2010-2014	279	3,614	92.83%
Kalama	2011-2014	115	-	-
North Fork Lewis	2010-2014	217	0	0.00%
Sandy	2010-2014	1,731	1,470	45.92%
Gorge Stratum – Spring run				
White Salmon	2013-2014	13	140	91.50%
ESU Average		29,469	38,594	56.70%

Both the long- and short-term trend, and lambda for the natural origin (late-run) portion of the Clackamas River Coho salmon are negative but with large confidence intervals (Good et al.

2005). The short-term trend for the Sandy River population is close to 1, indicating a relatively stable population during the years 1990 to 2002 (Good et al. 2005). The long-term trend (1977 to 2002) for this same population shows that the population has been decreasing (trend=0.54); there is a 43 percent probability that the median population growth rate (lambda) was less than one. Long-term abundances in the Coast Range Cascade MPG were generally stable. Scappoose Creek is exhibiting a positive abundance trend. Clatskanie River Coho salmon population maintains moderate numbers of naturally produced spawners.

The spatial structure of some populations is constrained by migration barriers (such as tributary dams) and development in lowland areas. Low abundance, past stock transfers, other legacy hatchery effects, and ongoing hatchery straying may have reduced genetic diversity within and among Coho salmon populations (NWFSC 2015b). It is likely that hatchery effects have also decreased population productivity.

This ESU includes all naturally spawned populations of Coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia River up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River to Willamette Falls, Oregon, as well as multiple artificial propagation programs. Most of the populations in the ESU contain a substantial number of hatchery-origin spawners. Myers et al (Myers et al. 2006) identified three MPGs (Coastal, Cascade, and Gorge), containing a total of 24 demographically independent populations (DIPs) in the Lower Columbia River Coho salmon ESU (NWFSC 2015b).

8.35.3 Status

Recovery efforts have likely improved the status of a number of Coho salmon DIPs, abundances are still at low levels and the majority of the DIPs remain at moderate or high risk. For the lower Columbia River region, land development and increasing human population pressures will likely continue to degrade habitat, especially in lowland areas. Although populations in this ESU have generally improved, especially in the 2013/14 and 2014/15 return years, recent poor ocean conditions suggest that population declines might occur in the upcoming return years. Regardless, this ESU is still considered to be at moderate risk (NWFSC 2015b).

8.35.4 Critical Habitat

Critical habitat for the Lower Columbia River Coho salmon ESU was designated on February 24, 2016 (81 FR 9252).

8.35.5 Recovery Goals

This species is included in the Lower Columbia River Recovery Plan (NMFS 2013b). Specific recovery goals are to improve all four viability parameters to the point that the Coast, Cascade, and Gorge strata achieve high probability of persistence. Protection of existing high functioning habitat and restoration of tributary habitat are noted needs, along with the reduction of hatchery and harvest impacts. Large improvements are needed in the persistence probability of most populations of this ESU.

8.36 Coho Salmon – Oregon Coast ESU

This ESU includes naturally spawned Coho salmon originating from coastal rivers south of the Columbia River and north of Cape Blanco, and also Coho salmon from one artificial propagation program: Cow Creek Hatchery Program (Figure 40). The Oregon Coast ESU of Coho salmon was listed as threatened under the ESA on August 10, 1998 (63 FR 42587). The listing was revisited and confirmed as threatened on June 20, 2011 (76 FR 35755).

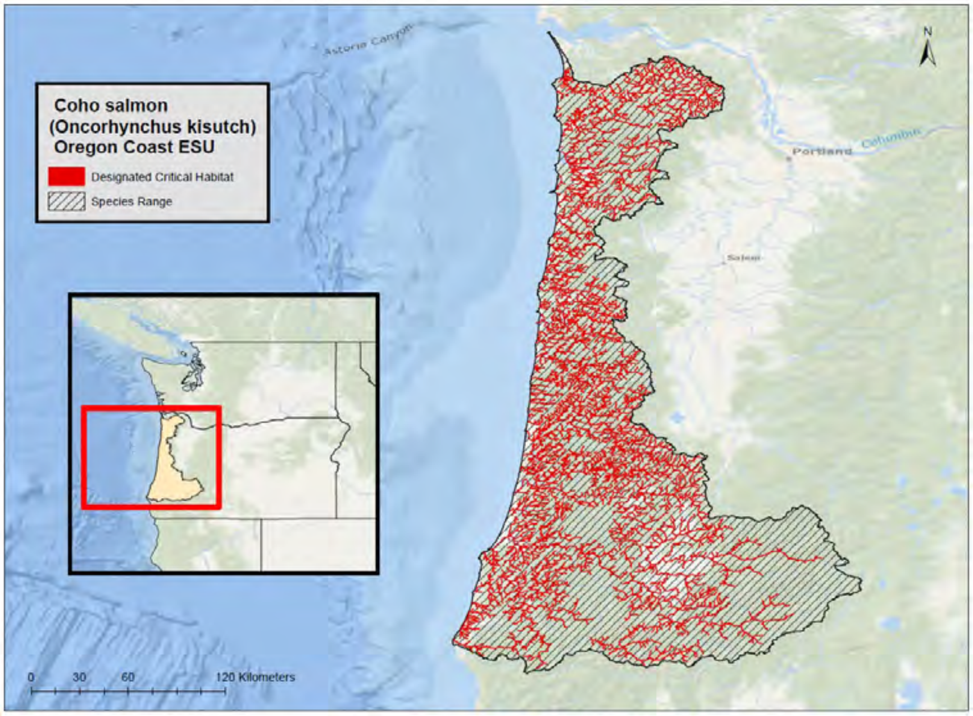

Figure 39. Geographic range and designated critical habitat of Coho salmon, Oregon coast ESU.

8.36.1 Life History

The anadromous life cycle of Coho salmon begins in their home stream where they emerge from eggs as alevins (a larval life stage dependent on food stored in a yolk sac). These very small fish require cool, slow moving freshwater streams with quiet areas such as backwater pools, beaver ponds, and side channels (Reeves et al. 1989) to survive and grow through summer and winter seasons. Current production of Coho salmon smolts in the Oregon Coast Coho salmon ESU is particularly limited by the availability of complex stream habitat that provides the shelter for overwintering juveniles during periods when flows are high, water temperatures are low, and food availability is limited (ODFW 2007).

The Oregon Coast Coho salmon follow a yearling-type life history strategy, with most juvenile Coho salmon migrating to the ocean as smolts in the spring, typically from as late as March into

June. Coho salmon smolts outmigrating from freshwater reaches may feed and grow in lower mainstem and estuarine habitats for a period of days or weeks before entering the nearshore ocean environment. The areas can serve as acclimation areas, allowing Coho salmon juveniles to adapt to saltwater. Research shows that substantial numbers of Coho fry may also emigrate downstream from natal streams into tidally influenced lower river wetlands and estuarine habitat (Chapman 1962; Koski 2009; Bass 2010).

Oregon Coast Coho salmon tend to make relatively short ocean migrations. Coho from this ESU are present in the ocean from northern California to southern British Columbia, and even fish from a given population can be widely dispersed in the coastal ocean, but the bulk of the ocean harvest of Coho salmon from this ESU are found off the Oregon coast. The majority of Coho salmon adults return to spawn as 3–year-old fish, having spent about 18 months in freshwater and 18 months in salt water (Sandercock 1991). The primary exceptions to this pattern are jacks, sexually mature males that return to freshwater to spawn after only five to seven months in the ocean.

8.36.2 Population Dynamics

Results from the most recent NWFSC review show that while Oregon Coast Coho salmon spawner abundance varies by time and population, the total abundance of spawners within the ESU has been generally increasing since 1999, with total abundance exceeding 280,000 spawners in three years between 2010 to 2015 (NWFSC 2015b).

Most independent populations in the ESU showed an overall increasing trend in abundance with synchronously high abundances in 2002 to 2003, 2009 to 2011, and 2014, and low abundances in 2007, 2009, and 2015. This synchrony suggests the overriding importance of marine survival to recruitment and escapement of Oregon Coast Coho salmon (NWFSC 2015b). When future conditions are taken into account, the Oregon Coast Coho salmon ESU, as a whole, is at moderate risk of extinction, but the recent risk trend is stable and improving (NWFSC 2015b). Current abundance estimates for natural and hatchery spawners as well as the expected number of outmigrants for the Oregon Coast ESU of Coho salmon are presented in Table 38 below. The hatchery production goal is 60,000 adipose-fin-clipped yearling Oregon Coast ESU Coho salmon (NMFS 2020).

Table 37. Average abundance estimates for the Oregon Coast ESU Coho salmon natural- and hatchery-origin spawners (NMFS 2020).

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
North Coast Stratum				
Necanicum River	1,139	5	0.42%	80,063

Population Name	**Natural-origin Spawners[a]**	**Hatchery-origin Spawners[a]**	**% Hatchery Origin**	**Expected Number of Outmigrants[b]**
Nehalem River	7,073	11	0.16%	495,889
Tillamook Bay	4,771	19	0.39%	335,290
Nestucca River	2,320	2	0.09%	162,547
North Coast Dependents	602	3	0.49%	42,350
Mid-Coast Stratum				
Salmon River	924	9	0.98%	65,352
Siletz River	5,534	2	0.04%	387,545
Yaquina River	4,585	2	0.05%	321,141
Beaver Creek	1,634	1	0.09%	114,493
Alsea River	8,627	0	0.00%	603,904
Siuslaw River	12,994	0	0.00%	909,584
Mid Coast Dependents	1,190	7	0.56%	83,747
Lakes Stratum				
Siltcoos Lake	2,362	0	0.00%	165,333
Tahkenitch Lake	1,356	2	0.13%	95,077
Tenmile Lake	2,909	0	0.00%	203,660
Umpqua Stratum				
Lower Umpqua River	8,755	2	0.02%	612,987
Middle Umpqua River	3,080	0	0.00%	215,578
North Umpqua River	2,320	191	7.59%	175,760
South Umpqua River	3,683	299	7.52%	278,743
Mid-South Coast Stratum				
Coos River	6,320	0	0.00%	442,407
Coquille River	10,781	3	0.03%	754,870
Floras Creek	1,154	0	0.00%	80,785
Sixes River	200	0	0.00%	14,029

Population Name	Natural-origin Spawners[a]	Hatchery-origin Spawners[a]	% Hatchery Origin	Expected Number of Outmigrants[b]
Mid-South Coast Dependents	5	1	16.36%	428
ESU Average	94,320	559	0.59%	6,641,564

a Five-year geometric mean of post-fishery spawners (2013 to 2017).

b Expected number of outmigrants=Total spawners*50% proportion of females*2,000 eggs per female*7% survival rate from egg to outmigrant.

While the 2008 biological review team status review concluded that there was low certainty that ESU-level genetic diversity was sufficient for long-term sustainability in the ESU (Wainwright et al. 2008), a 2015 NWFSC review suggests this is an unlikely outcome. The observed upward trends in abundance and productivity and downward trends in hatchery influence make decreases in genetic or life history diversity or loss of dependent populations in recent years unlikely (NWFSC 2015b).

The geographic setting for the Oregon Coast Coho salmon ESU includes the Pacific Ocean and the freshwater habitat (rivers, streams, and lakes) along the Oregon Coast from the Necanicum River near Seaside on the north to the Sixes River near Port Orford on the south. The Oregon/Northern California Coasts Technical Recovery Team identified 56 historical populations that function collectively to form the Oregon Coast Coho salmon ESU. The team classified 21 of the populations as independent because they occur in basins with sufficient historical habitat to have persisted through several hundred years of normal variations in marine and freshwater conditions (NMFS 2016f).

8.36.3 Status

Findings by the NWFSC (2015b) and ODFW (2016) show many positive improvements to Oregon Coast Coho salmon in recent years, including positive long-term abundance trends and escapement. Results from the NWFSC's recent review show that while Oregon Coast Coho salmon spawner abundance varies by time and population, the total abundance of spawners within the ESU has generally increased since 1999, with total abundance exceeding 280,000 spawners in recent years. Overall, the NWFSC (2015b) found that increases in Oregon Coast Coho salmon ESU scores for persistence and sustainability clearly indicate that the biological status of the ESU is improving, due in large part to management decisions (reduced harvest and hatchery releases). It determined, however, that Oregon Coast Coho salmon abundance remains strongly correlated with marine survival rates.

8.36.4 Critical Habitat

NMFS published a final rule designating critical habitat for Oregon Coast Coho salmon on February 11, 2008 (70 FR 52488).

8.36.5 Recovery Goals

See the 2016 Recovery Plan for detailed descriptions of the recovery goals and delisting criteria (NMFS 2016f). In the simplest terms, NMFS will remove the Oregon Coast Coho salmon from federal protection under the ESA when we determine that:

- The species has achieved a biological status consistent with recovery—the best available information indicates it has sufficient abundance, population growth rate, population spatial structure, and diversity to indicate it has met the biological recovery goals.
- Factors that led to ESA listing have been reduced or eliminated to the point where federal protection under the ESA is no longer needed, and there is reasonable certainty that the relevant regulatory mechanisms are adequate to protect Oregon Coast Coho salmon sustainability.

8.37 Coho Salmon – Southern Oregon and Northern California Coasts ESU

This evolutionarily significant unit, or ESU, includes naturally spawned Coho salmon originating from coastal streams and rivers between Cape Blanco, Oregon, and Punta Gorda, California (Figure 43). Also, Coho salmon originate from three artificial propagation programs. The Southern Oregon/Northern California Coast (SONCC) ESU of Coho salmon was listed as threatened under the ESA on May 6, 1997 (62 FR 24588). The listing was revisited and confirmed as threatened on June 28, 2005.

8.37.1 Life History

Coho salmon is an anadromous fish species that generally exhibits a relatively simple three-year life cycle. Adults typically begin their freshwater spawning migration in the late summer and fall, spawn by mid-winter, and then die. The run and spawning times vary between and within populations. Depending on river temperatures, eggs incubate in redds for 1.5 to 4 months before hatching as alevins (a larval life stage dependent on food stored in a yolk sac). Once most of the yolk sac is absorbed, the 30 to 35 millimeter fish (then termed fry) begin emerging from the gravel in search of shallow stream margins for foraging and safety (Council 2004). Coho salmon fry typically transition to the juvenile stage by about mid-June when they are about 50 to 60 millimeters, and both stages are collectively referred to as young of the year. Juveniles develop vertical dark bands or parr marks, and begin partitioning available instream habitat through aggressive agonistic interactions with other juvenile fish (Quinn 2005). Juveniles rear in freshwater for up to 15 months, then migrate to the ocean as smolts in the spring. Coho salmon typically spend two growing seasons in the ocean before returning to their natal stream to spawn as 3 year-olds. Some precocious males, called jacks, return to spawn after only six months at sea (NMFS 2014a).

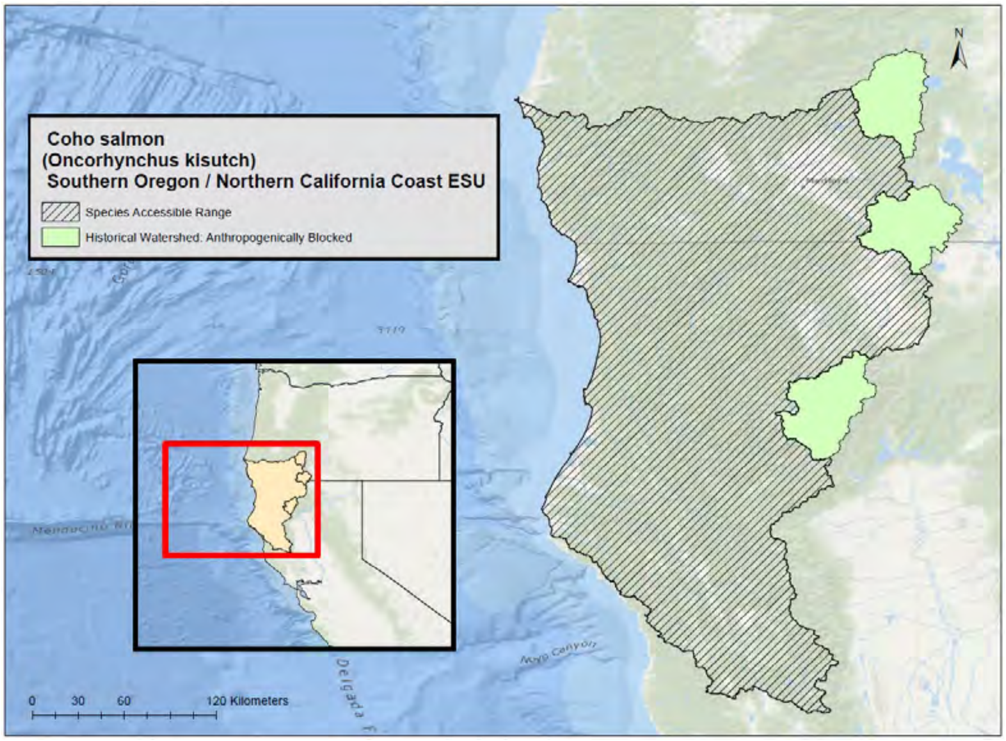

Figure 40. Geographic range of the Southern Oregon/Northern California ESU of Coho Salmon.

8.37.2 Population Dynamics

Although long-term data on abundance of SONCC Coho salmon are scarce, the best available data indicate that none of the seven diversity strata appear to support a single viable population, although all diversity strata are occupied (NMFS). Further, 24 out of 31 independent populations are at high risk of extinction and six are at moderate risk of extinction. Abundance estimates for adult SONCC ESU Coho salmon are presented in Table 39 below. Current average abundance estimates for juvenile SONCC ESU Coho salmon are 200,000 hatchery produced fish with clipped adipose fins, 575,000 hatchery produced fish with intact adipose fins, and 2,013,593 natural origin fish (NMFS 2020).

Table 38. Average abundance estimates of the natural-origin and hatchery-produced adult Southern Oregon/Northern California Coast ESU Coho salmon returning to the Rogue, Trinity, and Klamath rivers (NMFS 2020).

YEAR	Rogue River		Trinity River		Klamath River		
	Hatchery	Natural	Hatchery	Natural	Shasta River[a]	Scott River[a]	Salmon River
2008	158	414	3,851	944	30	62	
2009	518	2,566	2,439	542	9	81	
2010	753	3,073	2,863	658	44	927	

2011	1,156	3,917	9,009	1,178	62	355	
2012	1,423	5,440	8,662	1,761		201	
2013	1,999	11,210	11,177	4,097			
2014	829	2,409	8,712	917			
Average [b]	1,417	6,353	9,517	2,258	38	357	50 [c]

a Hatchery proportion unknown, but assumed to be low.

b 3-year average of most recent years of data.

c Annual returns of adults are likely less than 50 per year.

The extinction risk of an ESU depends upon the extinction risk of its constituent independent populations; because the population abundance of most independent populations are below their depensation threshold, the SONCC Coho salmon ESU is at high risk of extinction and is not viable (Williams et al. 2011). Estimates from the Rogue River with its four independent populations indicate a small but significant positive trend ($p = 0.01$) over the past 35 years and a non-significant negative trend ($p > 0.05$) over the past 12 years or four generations (NMFS 2016d). The decline in abundance from historical levels and the poor status of population viability criteria are the main factors behind the extinction risk of the ESU.

Williams et al. (2006b) designated 45 populations of Coho salmon in the SONCC Coho salmon ESU as dependent or independent based on their historical population size. Two populations are both small enough and isolated enough that they are only intermittently present (McElhany et al. 2000; Williams et al. 2006b; NMFS 2014a). These populations were further grouped into seven diversity strata based on the geographical arrangement of the populations and basin-scale genetic, environmental, and ecological characteristics.

8.37.3 Status

Though population-level estimates of abundance for most independent populations are lacking, the best available data indicate that none of the seven diversity strata appears to support a single viable population as defined by the SONCC Coho salmon technical recovery team's viability criteria (low extinction risk; Williams et al. (2008)). Further, 24 out of 31 independent populations are at high risk of extinction and six are at moderate risk of extinction. Based on the above discussion of the population viability parameters, and qualitative viability criteria presented in Williams et al. (2008), NMFS concludes that the SONCC Coho salmon ESU is currently not viable and is at high risk of extinction. The primary causes of the decline are likely long-standing human-caused conditions (e.g., harvest and habitat degradation), which exacerbated the impacts of adverse environmental conditions (e.g., drought and poor ocean conditions) (60 FR 38011; July 25, 1995).

8.37.4 Critical Habitat

NMFS designated critical habitat for the SONCC ESU of Coho salmon on May 5, 1999 (64 FR 24049).

8.37.5 Recovery Goals

A recovery plan is available for this species (NMFS 2014a). For recovery goals to be met at the ESU level, SONCC Coho salmon must demonstrate representation (genetic and life history diversity), redundancy (a sufficient number of populations to withstand catastrophic events), and connectivity (the dispersal capacity of populations to maintain long-term demographic and genetic processes).

9 ENVIRONMENTAL BASELINE

The "environmental baseline" refers to the condition of the listed species or its designated critical habitat in the action area, without the consequences to the listed species or designated critical habitat caused by the proposed action. The environmental baseline includes the past and present impacts of all Federal, state, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of state or private actions which are contemporaneous with the consultation in process. The consequences to listed species or designated critical habitat from ongoing agency activities or existing agency facilities that are not within the agency's discretion to modify are part of the environmental baseline (50 C.F.R. §402.02).

The environmental baseline for this opinion includes the effects of several human activities that affect the survival and recovery of populations of ESA-listed marine mammals, sea turtles, and fish in the action area. Some human activities are ongoing and appear to continue to affect marine mammal, sea turtle, and fish populations in the action area for this consultation. Some of these activities, most notably commercial whaling, occurred extensively in the past and continue at low levels that no longer appear to significantly affect marine mammal populations, although the effects of past reductions in numbers persist today. The following discussion summarizes the impacts, which include climate change, oceanic temperature regimes, unusual mortality events, vessel activity, whale watching, fisheries (fisheries interactions, hatcheries, and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, seismic surveys, and marine construction), military activities, and scientific research activities.

9.1 Climate Change

There is a large and growing body of literature on past, present, and future impacts of global climate change, exacerbated and accelerated by human activities. Effects of climate change include sea level rise, increased frequency and magnitude of severe weather events, changes in air and water temperatures, and changes in precipitation patterns, all of which are likely to impact ESA resources. NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov). This section provides some examples of impacts to ESA-listed species and their habitats that have occurred or may occur as the result of climate change. We address climate change as it has affected ESA-listed species and continues to affect species, and we look to the foreseeable future to consider effects that we anticipate will occur as a result of ongoing activities. While the consideration of future impacts may also be suited to our cumulative effects analysis (Section 11), it is discussed here to provide a comprehensive analysis of the effects of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats both within and outside of the action area.

In order to evaluate the implications of different climate outcomes and associated impacts throughout the 21st century, many factors have to be considered. The amount of future greenhouse gas emissions is a key variable. Developments in technology, changes in energy generation and land use, global and regional economic circumstances, and population growth must also be considered.

A set of four scenarios was developed by the Intergovernmental Panel on Climate Change (IPCC) to ensure that starting conditions, historical data, and projections are employed consistently across the various branches of climate science. The scenarios are referred to as representative concentration pathways (RCPs), which capture a range of potential greenhouse gas emissions pathways and associated atmospheric concentration levels through 2100 (IPCC 2014a). The RCP scenarios drive climate model projections for temperature, precipitation, sea level, and other variables: RCP2.6 is a stringent mitigation scenario; RCP2.5 and RCP6.0 are intermediate scenarios; and RCP8.5 is a scenario with no mitigation or reduction in the use of fossil fuels. The IPCC future global climate predictions (2014 and 2018) and national and regional climate predictions included in the Fourth National Climate Assessment for U.S. states and territories (2018) use the RCP scenarios.

The increase of global mean surface temperature change by 2100 is projected to be 0.3 to 1.7 degrees Celsius under RCP2.6, 1.1 to 2.6 degrees Celsius under RCP4.5, 1.4 to 3.1 degrees Celsius under RCP6.0, and 2.6 to 4.8 degrees Celsius under RCP8.5 with the Arctic region warming more rapidly than the global mean under all scenarios (IPCC 2014a). The Paris Agreement (an agreement within the United Nations Framework Convention on Climate Change, dealing with greenhouse-gas-emissions mitigation, adaptation, and finance, signed in 2016) aims to limit the future rise in global average temperature to 2 degrees Celsius, but the observed acceleration in carbon emissions over the last 15 to 20 years, even with a lower trend in 2016, has been consistent with higher future scenarios such as RCP8.5 (Hayhoe et al. 2018).

The globally-averaged combined land and ocean surface temperature data, as calculated by a linear trend, show a warming of approximately 1 degrees Celsius from 1901 through 2016 (Hayhoe et al. 2018). The *IPCC Special Report on the Impacts of Global Warming* (2018) (IPCC

2018) noted that human-induced warming reached temperatures between 0.8 and 1.2 degrees Celsius above pre-industrial levels in 2017, likely increasing between 0.1 and 0.3 degrees Celsius per decade. Warming greater than the global average has already been experienced in many regions and seasons, with most land regions experiencing greater warming than over the ocean (Allen et al. 2018). Annual average temperatures have increased by 1.8 degrees Celsius across the contiguous U.S. since the beginning of the 20th century with Alaska warming faster than any other state and twice as fast as the global average since the mid-20th century (Jay et al. 2018). Global warming has led to more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). Average global warming up to 1.5 degrees Celsius as compared to pre-industrial levels is expected to lead to regional changes in extreme temperatures, and increases in the frequency and intensity of precipitation and drought (IPCC 2018).

Consequences of climate change include increased ocean stratification, decreased sea-ice extent, altered patterns of ocean circulation, and decreased ocean oxygen levels (Doney et al. 2012). Since the early 1980s, the annual minimum sea ice extent (observed in September each year) in the Arctic Ocean has decreased at a rate of 11 to 16 percent per decade (Jay et al. 2018). Further, ocean acidity has increased by 26 percent since the beginning of the industrial era (IPCC 2014a) and this rise has been linked to climate change. Climate change is also expected to increase the frequency of extreme weather and climate events including, but not limited to, cyclones, tropical storms, heat waves, and droughts (IPCC 2014a).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, dissolved oxygen levels, nutrient distribution) could influence the distribution and abundance of lower trophic levels (e.g., phytoplankton, zooplankton, submerged aquatic vegetation, crustaceans, mollusks, forage fish), ultimately affecting primary foraging areas of ESA-listed species including cetaceans, sea turtles, and fish – regardless of the ocean basin. Marine species ranges are expected to shift as they align their distributions to match their physiological tolerances under changing environmental conditions (Doney et al. 2012). We expect the same changes to occur with ESA-listed species within the action area.

Climate change has the potential to impact species abundance, geographic distribution, migration patterns, and susceptibility to disease and contaminants, as well as the timing of seasonal activities and community composition and structure (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006a; McMahon and Hays 2006; Evans and Bjørge 2013; IPCC 2014a). Hazen et al. (2012) examined top predator distribution and diversity in the Pacific Ocean in light of rising sea surface temperatures using a database of electronic tags and output from a global climate model. They predicted up to a 35 percent change in core habitat area for some key marine predators in the Pacific Ocean, with some species predicted to experience gains in available core habitat and some predicted to experience losses. Notably, leatherback turtles were predicted to gain core habitat area, whereas blue whales were predicted to experience losses in available core habitat. (McMahon and Hays 2006) predicted increased ocean temperatures will expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. (Macleod 2009) estimated, based upon expected shifts in water temperature, 88 percent of cetaceans will be affected by climate change; with 47 percent predicted to experience unfavorable conditions (e.g., range contraction). (Willis-Norton et al. 2015) acknowledged there will be both habitat loss and gain, but overall climate change could result in a 15 percent loss of core pelagic habitat for leatherback turtles in the eastern South Pacific Ocean.

Though predicting the precise consequences of climate change on highly mobile marine species is difficult (Simmonds and Isaac 2007a), research has indicated that the foraging habits of Guadalupe fur seals change during warming events in El Niño years, probably linked to a decline in primary productivity is coastal areas, associated with increased sea surface temperatures, causing them to forage further offshore. Observed individuals exhibited diminished body condition, especially pups (Elorriaga-Verplancken et al. 2016). The circumstances in this example are related to El Niño Southern Oscillation event, and not climate change precisely, but it does provide insight into how Guadalupe fur seals may be affected as oceans warm under various climate change scenarios.

Similarly, climate-related changes in important prey species populations are likely to affect predator populations. Climate-mediated changes in the distribution and abundance of keystone prey species like krill and in cephalopod populations worldwide will likely affect marine mammal populations as they re-distribute throughout the world's oceans in search of prey. Blue whales, as predators that specialize in eating krill, seem likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1990); if they did not change their distribution or could not find the biomass of krill necessary to sustain their population numbers, their populations seem likely to experience declines similar to those observed in other krill predators, which would cause dramatic declines in their population sizes or would increase the year-to-year variation in population size; either of these outcomes would dramatically increase the extinction probabilities of these whales. Pecl and Jackson (2008) predicted climate change will likely result in squid that hatch out smaller and earlier, undergo faster growth over shorter life-spans, and mature younger at a smaller size. This could have negative consequences for species such as sperm whales and Guadalupe fur seals, whose diet is primarily squid and cephalopods. Sperm whales and Guadalupe fur seals, whose diets can be dominated by cephalopods, would have to re-distribute following changes in the distribution and abundance of their prey. This statement assumes that projected changes in global climate would only affect the distribution of cephalopod populations, but would not reduce the number or density of cephalopod populations. If, however, cephalopod populations collapse or decline dramatically, sperm whale populations are likely to collapse or decline dramatically as well.

For leatherback sea turtles, Guadalupe fur seals, and ESA-listed whales which undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures, regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009). Southern Resident killer whales might shift their distribution in response to climate-related changes in their salmon prey (NMFS 2019a). Climatic conditions affect salmonid abundance, productivity, spatial structure, and diversity through direct and indirect impacts at all life stages (e.g., Independent Science Advisory Board 2007; Lindley et al. 2007; Crozier et al. 2008; Moyle et al. 2013; Wainwright and Weitkamp 2013).

Pacific salmonids could be affected by rising water temperatures in streams, impacting habitat suitability and salmon growth, development, smoltification, and egg development (Crozier et al. 2008). Green sturgeon could be subjected to physiological and cellular stresses caused by changes in water temperature and salinity, possibly leading to fitness consequences (Sardella et al. 2008; Sardella and Kültz 2014).

Studies examining the effects of long-term climate change to salmon populations have identified a number of common mechanisms by which climate variation is likely to influence salmon sustainability. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance (NMFS 2019a). Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior. Expected behavioral responses include shifts in seasonal timing of important life history events, such as the adult migration, spawn timing, fry emergence timing, and the juvenile migration. Indirect effects on salmon mortality, growth rates and movement behavior are also expected to follow from changes in the freshwater habitat structure and the invertebrate and vertebrate community, which governs food supply and predation risk (Petersen and Kitchell 2001; Independent Science Advisory Board 2007; Crozier et al. 2008).

Crozier et al. (2019) conducted an extensive analysis on ESA-listed salmonid and steelhead vulnerability to climate change. Nearly all listed populations faced high exposures to projected increases in stream temperature, sea surface temperature, and ocean acidification. The highest vulnerability scores for extrinsic effects (anthropogenic stressors) occurred in interior and southern regions where climate is expected to change the most. Populations ranked as the most vulnerable to climate change overall were California Central Valley Chinook salmon, California and southern Oregon Coho salmon, Snake River Basin sockeye salmon, and Columbia and Willamette River spring-run Chinook salmon (Crozier et al. 2019).

In the marine ecosystem, salmon may be affected by warmer water temperatures, increased stratification of the water column, intensity and timing changes of coastal upwelling, loss of coastal habitat due to sea level rise, ocean acidification, and changes in water quality and freshwater inputs (Independent Science Advisory Board 2007; Mauger et al. 2015). Salmon marine migration patterns could be affected by climate-induced contraction of thermally suitable habitat. Abdul-Aziz et al. (2011) modeled changes in summer thermal ranges in the open ocean for Pacific salmon under multiple IPCC warming scenarios. For chum salmon, pink, Coho salmon, sockeye salmon and steelhead, they predicted contractions in suitable marine habitat of 30-50% by the 2080s, with an even larger contraction (86-88%) for Chinook salmon under the medium and high emissions scenarios. Northward range shifts are a climate response expected in many marine species, including salmon (Cheung et al. 2015). However, salmon populations are strongly differentiated in the northward extent of their ocean migration, and hence will likely respond individualistically to widespread changes in sea surface temperature (NMFS 2019a). In a meta-analytical review of multiple peer-reviewed papers on green sturgeon, Rodgers et al. (2019) reported that elevated temperatures significantly reduce growth and hatching success and increase the incidence of larval deformities.

The adaptive capacity of threatened and endangered salmonid species is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation (NMFS 2019a). Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change are more likely to reduce long-term viability and sustainability of salmon populations, although the character and magnitude of these effects will likely vary within and among ESUs (NMFS 2019a). Muñoz et al. (2015) reported finding a constraint on the upper limit of thermal tolerance in the Quinsam River juvenile Chinook salmon population. Although fish in this study exhibited both physiological and genetic capacities to increase their thermal tolerance in response to rising temperatures, results suggest that Pacific salmon populations are physiologically susceptible to the projected increases in river temperatures associated with climate change. Based on the observed constraint on thermal tolerance and present-day river temperatures, Muñoz et al. (2015) predict a 17 percent chance of catastrophic loss in the studied population by 2100 based on the average warming projection, with this chance increasing to 98 percent in the maximum warming scenario.

Anthropogenic climate change is also linked to food web and salinity fluctuations in estuarine environments as a result of sea level rise and seawater intrusion coupled with smaller snowpack and lower spring freshwater flows. Larger and less stable salinity regimes coupled with altered food web dynamics may have direct physiological consequences for green sturgeon juveniles in addition to indirectly affecting the quality and quantity of their prey organisms (Haller et al. 2015). In a meta-analytical review of multiple peer-reviewed papers on green sturgeon, Rodgers et al. (2019) reported that, on average, exposure to elevated salinity levels negatively affected growth, and that plasma osmolality and muscle moisture are significantly increased in response to salinity exposure. Haller et al. (2015) studied the effect of nutritional status on the osmoregulation of green sturgeon. The largest disturbances caused by feed restriction were observed at the highest salinity treatments across all feeding regimes, and the interaction between feed restriction and acute salinity exposure at the highest salinity treatment resulted in high mortality rates during the first 72 hours of salinity exposure (Haller et al. 2015). Sardella et al. (2014) studied the physiological responses of green sturgeon to potential global climate change stressors. They found that while sturgeon can acclimate to changes in salinity, salinity fluctuations resulted in substantial cellular stress.

Effects of ocean acidification on ESA-listed fish most likely occur through ecological mechanisms mediated by changes to the food web (Busch et al. 2013; Crozier et al. 2019). Taxa directly affected by declining marine pH include invertebrates such as pteropods, crabs, and krill. Physiological effects of acidification may also impair olfaction, which could hinder salmonid homing ability, along with other developmental effects (Crozier et al. 2019). Climate change impacts on ocean conditions were classified as the most serious threat to the Southern DPS of eulachon by NOAA's Biological Review Team (Gustafson et al. 2010; NMFS 2017c).

This review provides some examples of impacts to ESA-listed species and their habitats that may occur as the result of climate change. While it is difficult to accurately predict the consequences of climate change to a particular species or habitat, a range of consequences are expected that are likely to change the status of the species and the condition of their habitats.

9.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns caused by the Southern oscillation in the Pacific Ocean, which leads to El Niño and La Niña events and the Pacific decadal oscillation. These climatic events can alter habitat conditions and prey distribution for ESA-listed species in the action areas (Beamish 1993; Mantua et al. 1997; Hare and Mantua 2001; Benson and Trites 2002; Stabeno et al. 2004; Mundy and Cooney 2005).

The Pacific decadal oscillation is the leading mode of variability in the North Pacific Ocean and operates over longer periods than either El Niño or La Niña/Southern Oscillation events and is capable of altering sea surface temperature, surface winds, and sea level pressure (Mantua and Hare 2002; Stabeno et al. 2004). During positive Pacific decadal oscillations, the northeastern Pacific experiences above average sea surface temperatures while the central and western Pacific Ocean undergoes below-normal sea surface temperatures (Royer 2005). Warm Pacific decadal oscillation regimes, as occurs in El Niño events, tends to decrease productivity along the U.S. west coast, as upwelling typically diminishes (Hare et al. 1999; Childers et al. 2005). Recent sampling of oceanographic conditions just south of Seward, Alaska has revealed anomalously cold conditions in the Gulf of Alaska from 2006 through 2009, suggesting a shift to a colder Pacific decadal oscillation phase. More research needs to be done to determine if the region is indeed shifting to a colder Pacific decadal oscillation phase in addition to what effects these phase shifts have on the dynamics of prey populations important to ESA-listed cetaceans throughout the Pacific action area. A shift to a colder decadal oscillation phase would be expected to impact prey populations, although the magnitude of this effect is uncertain.

In addition to period variation in weather and climate patterns that affect oceanographic conditions in the action area, longer-term trends in climate change and/or variability also have the potential to alter habitat conditions suitable for ESA-listed species in the action area on a much longer time scale. The average global surface temperature rose by 0.85ºC from 1880 to 2012, and it continues to rise at an accelerating pace (IPCC 2014b); the 15 warmest years on record since 1880 have occurred in the 21st century (NCEI 2016). 2016 is the warmest year on record, followed by 2020 as the second warmest. The warmest year on record for global sea surface temperature was also 2016, and 2020 as the eighth warmest[4].

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[4] https://www.ncei.noaa.gov/news/global-climate-202012 (Accessed 3/8/2021)

Possible effects of this trend in climate change and/or variability for ESA-listed marine species in the action area include the alteration of community composition and structure, changes to migration patterns or community structure, changes to species abundance, increased susceptibility to disease and contaminants, altered timing of breeding and nesting, and increased stress levels (MacLeod et al. 2005; Robinson et al. 2005; Kintisch 2006; Learmonth et al. 2006b; McMahon and Hays 2006). Climate change can influence reproductive success by altering prey availability, as evidenced by the low success of Northern elephant seals (*Mirounga angustirostris*) during El Niño periods (McMahon and Burton 2005) as well as data suggesting that sperm whale females have lower rates of conception following periods of unusually warm sear surface temperature (Whitehead et al. 1997). However, gaps in information and the complexity of climatic interactions complicate the ability to predict the effects that climate change and/or variability may have to these species from year to year in the action area (Kintisch 2006; Simmonds and Isaac 2007b).

9.3 Unusual Mortality Events

Under the MMPA, an unusual mortality event (UME) is defined as "a stranding that is unexpected; involves a significant die-off of any marine mammal population; and demands immediate response." In the past, an UME was declared for fin and humpback whales in British Columbia (including Vancouver Island) and Gulf of Alaska, from April 23, 2015 to April 16, 2016, where 52 individuals were found dead.[5] The investigation did not determine a cause for the unusual mortality event, although ecological factors like the 2015 El Nino event, the warm water blob, and the Pacific Coast Domoic Acid Bloom were contributing factors. Only one unusual mortality event[6] is active for ESA-listed marine mammals within the action area: Guadalupe fur seals. An UME was declared for Guadalupe fur seals beginning in January 2015, and continuing to the present (2015 to 2020)[7]. The UME was declared due to the increased stranding of Guadalupe fur seals in California, and was expanded to include Oregon and Washington due to the elevated number of strandings there. Strandings in Oregon and Washington have been well above typical numbers since 2015 (Figure 44).

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[5] https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2016-large-whale-unusual-mortality-event-western-gulf-alaska (Accesed 3/8/2021).

[6] There is an active UME for gray whales, but because we have concluded that gray whales are not likely to be adversely affected by the proposed action, are not discussing that UME here.

[7] https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2019-guadalupe-fur-seal-unusual-mortality-event-california (Accessed 3/8/2021).

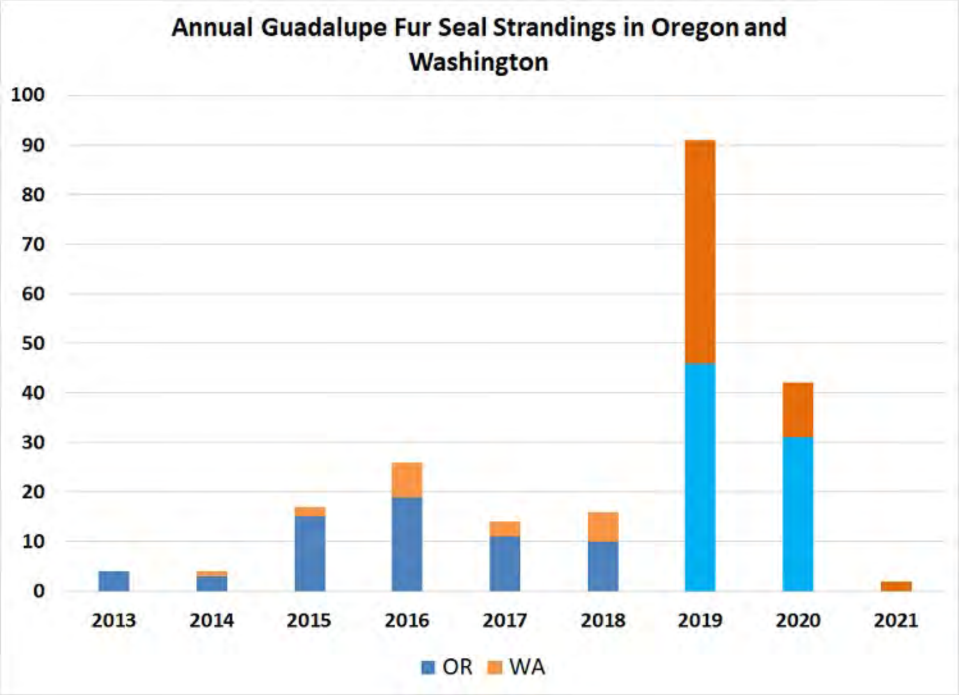

Figure 41. Guadalupe fur seal annual strandings in Oregon and Washington, 2013 to 2021 (as of 3/8/2021).

Guadalupe fur seal strandings generally peak in April through June each year. Stranded individuals were mostly weaned pups and juveniles, aged one to two years old. Most stranded individuals showed signs of malnutrition and had secondary bacterial and parasitic infections. As the UME is currently on going, we expect Guadalupe fur seals to continue to be impacted.

9.4 Vessel Activity

Vessels have the potential to affect animals through strikes, sound, and disturbance associated with their physical presence. Responses to vessel interactions include interruption of vital behaviors and social groups, separation of mothers and young, and abandonment of resting areas (Mann et al. 2000; Samuels et al. 2000; Boren et al. 2001; Constantine 2001; Nowacek 2001). Whales have been documented to exhibit avoidance behavior near vessels. A blue whale aborted its ascent when it was 57.5 meters from the vessel, and stayed underwater for three minutes beyond its projected surfacing time (Szesciorka et al. 2019). A study focusing on Southern Resident killer whales showed that individuals altered their foraging behavior when near vessels. When vessels were at an average distance of less than 400 yards (366 meters), individuals made fewer dives involving prey capture, and spent less time in these dives. The researchers found differences in response between the sexes, with female Southern Resident killer whales making fewer dives than males when vessels were less than 400 yards away (Holt et al. 2021).

Overall, the action area sees a great deal of vessel activity, from cargo and commercial shipping, to recreational vessels, cruise ships, and whale watching vessels. Washington and Oregon have several major ports in their state waters, with Seattle and Tacoma handling the most tonnage annually (Table 40).

Table 39. Major ports in Washington and Oregon with annual tonnage (NOAA 2020b; NOAA 2020a).

Port Name	Tonnage (year)
Kalama, WA	15,370,094
Coos Bay, OR	2,088,259
Tacoma, WA	25,711,848
Seattle, WA	24,204,009
Longview, WA	15,370,094
Anacortes, WA	10,682,558
Vancouver, WA	9,359,385
Grays Harbor, WA	2,307,901
Everett, WA	1,499,583
Olympia, WA	1,271,809

Ports in Canada contribute to vessel traffic within the action area. There are 135 public and private ports in British Columbia, with the Port of Vancouver, Fraser Port, and the Port of Prince Rupert accounting for more than 95 percent of the international trade moving through the British Columbian port system (Transportation 2005). The second largest port in British Columbia, the Port of Prince Rupert, is in northern British Columbia, and not within the action area. The Port of Vancouver and Fraser Port (the first and third largest ports) merged in 2008 and are overseen by the Vancouver Fraser Port Authority. Cargo from the Fraser Port is transmitted through the Port of Vancouver, and those statistics are combined. The amount of metric tons of cargo handled through the port increased every year from 2015 to 2018, the years for which complete data is available (Table 41).

Table 40. Annual summary of metric tons of cargo handled by the Port of Vancouver, 2015 to 2019 (Vancouver 2017; Vancouver 2018b; Vancouver 2019a).

Year	Metric Tons
2015	138,084,076
2016	135,537,413
2017	142,067,550

Year	Metric Tons
2018	147,093,499
2019	144, 225,630

In addition to shipping commerce, cruise ships constitute a large amount of shipping traffic in the within the action area. In 2019, 288 cruise ships entered the Port of Vancouver, with over a million passengers embarking and disembarking. This is about a 20 percent increase from 2018, which saw 241 vessels, and 889,162 passengers. Cruise ship activity was greatest in May through September (Vancouver 2019b). The number of cruise ship passengers into and out of the Port of Vancouver has steadily increased since 2015, which had around 805,415 passengers that year (Vancouver 2017). The Port of Seattle had over 1.2 million cruise ship passengers in 2019, with 213 ports of call, up from 120,000 passengers in 2000 (Seattle 2019). Although not a cruise ship hub like Seattle or Vancouver, there is still vessel traffic to and from the Port of Newport, in coastal Oregon, which supports a large commercial fishing fleet, a recreational vessel marina, and serves as the homeport for NOAA's Marine Operation Cetner, including six NOAA research and survey ships.

In addition, whale watching, which is discussed below, is a large industry affecting whales in the action area, especially Southern Resident killer whales, and resulting in vessel activity.

9.4.1 Whale Watching

Whale watching, a profitable and rapidly growing business with more than nine million participants in 80 countries and territories, may increase vessel disturbance and negatively affect whales (Hoyt 2001). Whale watching expeditions operate from the Oregon coast, primarily seeing gray whales and humpback whales.[8] Whale watching in Washington State and British Columbia are largely focused in the Salish Sea and Puget Sound, targeting killer whales, although whale-watching expeditions from Vancouver and Victoria target other species, like humpback whales. Several studies have examined the effects of whale watching on marine mammals, and investigators have observed a variety of short-term responses from animals, ranging from no apparent response to changes in vocalizations, duration of time spend at the surface, swimming speed, swimming angle or direction, respiration rate, dive time, feeding behavior, and social behavior (NMFS 2008d). Responses appear to be dependent on factors such as vessel proximity, speed, and direction, as well as the number of vessels in the vicinity (see 76 FR 20870 for a review).

Whale watching activities are particularly relevant for Southern Resident killer whales in the action area because, due to their popularity and local abundance in the area, Southern Resident killer whales are the primary target of these operations. Pods of Southern Resident killer whales

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[8] https://oregonstateparks.org/index.cfm?do=thingstodo.dsp_whalewatching (Accessed 10/22/2020).

can also attract a large number of recreational vessels. In a study, the maximum number of vessels following a single pod of Southern Resident killer whales ranged from 72 to 120 annually; the majority was recreational vessels (Lachmuth et al. 2011). The Whale Museum estimates that more than half a million people annually go whale watching in British Columbia and Washington, making up a $40 to 50 million dollar industry (Seely et al. 2017). In addition, private floatplanes, helicopters, and small aircraft regularly take advantage of whale watching opportunities (MMMP 2002); the growing number of kayakers viewing Southern Resident killer whales and closely approaching pods in the central Salish Sea is an emerging concern for managers (Seely et al. 2017).

This increase and intensity in whale watching has resulted in exposure of Southern Resident killer whales to vessel traffic and sound. Whale watching activities can affect Southern Resident killer whales by disturbing their normal activities (like feeding or swimming) or displacing them (Lusseau et al. 2009a). In 2005, a commercial whale watching vessel struck a Southern Resident killer whale, inflicting a minor injury, which subsequently healed (NMFS 2008d). Although mechanisms are in place to regulate the industry, concerns remain over persistent exposure to vessel noise, proximity to whales, which can cause behavioral changes, stress, or potentially the loss of habitat (Kruse 1991; Kriete 2002; Williams et al. 2002; Foote et al. 2004; Bain et al. 2006; NMFS 2008d; Wiley et al. 2008; Noren et al. 2009a). As Southern Resident killer whales are normally exposed to high levels of whale watching, and vessel traffic in general, engine exhaust has been assessed as a possible threat and may contribute to health effects (Lachmuth et al. 2011).Other targeted whale species can be subjected to the same stressors from whale watching.

9.4.2 Vessel Strike

Vessel strikes are considered a serious and widespread threat to ESA-listed marine mammals (especially large whales) and sea turtles. Generally, the most well documented "marine road" interaction is with large whales (Pirotta et al. 2019). This threat is increasing as commercial shipping lanes cross important breeding and feeding habitats and as whale populations recover and populate new areas or areas where they were previously extirpated (Swingle et al. 1993; Wiley et al. 1995). As vessels continue to become faster and more widespread, an increase in vessel interactions with cetaceans is to be expected. Vessel traffic within the action area can come from both private (e.g., commercial, recreational) and federal vessel (e.g., military, research), but traffic that is most likely to result in vessel strikes comes from commercial shipping. All sizes and types of vessels can hit whales, but most lethal and severe injuries are caused by vessels 80 meters (262.5 feet) or longer (Laist et al. 2001). For whales, studies show that the probability of fatal injuries from vessel strikes increases as vessels operate at speeds above 26 kilometers per hour (14 knots) (Laist et al. 2001). Evidence suggests that not all whales killed because of vessel strike are detected, particularly in offshore waters. Some detected carcasses are never recovered while those that are recovered may be in advanced stages of decomposition that preclude a definitive cause of death determination (Glass et al. 2010). The vast majority of commercial vessel strike mortalities of cetaceans are likely undetected and unreported, as most are likely never reported. Most animals killed by vessel strike likely end up sinking rather than washing up on shore (Cassoff 2011). Kraus et al. (2005) estimated that 17 percent of vessel strikes are actually detected. Therefore, it is likely that the number of documented cetacean mortalities related to vessel strikes is much lower than the actual number of moralities associated with vessel strikes, especially for less buoyant species such as blue, humpback, and fin whales (Rockwood et al. 2017). Rockwood et al. (2017) modeled vessel strike mortalities of blue, humpback, and fin whales off the U.S. West Coast (California, Oregon, and Washington including the action area) using carcass recovery rates of five and 17 percent. The authors conservatively estimated that vessel strike mortality might be as high as 7.8, 2.0, and 2.7 times the recommended human-caused mortality limit for blue, humpback, and fin whales in this area, respectively.

The potential lethal effects of vessel strikes are particularly profound on species with low abundance. However, all whale species have the potential to be affected by vessel strikes. Of 11 species of cetaceans known to be threatened by vessel strikes in the northern hemisphere, fin whales are the mostly commonly struck species, but North Atlantic right, gray, humpback, and sperm whales are also struck (Laist et al. 2001; Vanderlaan and Taggart 2007). The latest five-year average mortalities and serious injuries related to vessel strikes for the ESA-listed cetacean stocks within U.S. waters likely to be found in the action area are and experience adverse effects as a result of the proposed action are given in Table 42 below (Carretta 2019b). These data represent only known mortalities and serious injuries. It is probable that more undocumented mortalities and serious injuries within the action area have likely occurred.

Williams and O'Hara (2010) found high risk areas in British Columbia for vessel strike for humpback, fin and killer whales included narrow straits and passageways, particularly Hecate Strait, Dixon entrance, the southeastern end of the Queen Charlotte Islands, and Queen Charlotte Sound.

Table 41. Five-year annual average mortalities and serious injuries related to vessel strikes for Endangered Species Act-listed Pacific stock marine mammals within the action area.

Species	Observed	Estimated
Blue Whale	0.2	18
Fin Whale	1.6	43
Humpback Whale – Multiple ESA-listed DPSs	2.1	22
Sei Whale	0.2	N/A
Sperm Whale	0	0

Guadalupe Fur Seal	0	0

DPS=Distinct Population Segment

Due to their small population size, Southern Resident killer whales are especially vulnerable to vessel strike, and there have been cases of vessel strike in the population. J-34, a young adult male, was found dead in Georgia Strait in the fall of 2016, with blunt force trauma injuries, consistent with vessel strike. In 2005, a Southern Resident was struck by a vessel, with minor injuries. In another case in 2006, L-98, a male, was killed by a vessel interaction, after notably becoming habituated to vessel presence in Nootka Sound (Carretta et al. 2019).

There have been various measures instituted to reduce risk of vessel strike to large whales in the action area. For example, in Burrard Inlet, the pathway into the Port of Vancouver, a voluntary 15-knot speed restriction was instituted in 2018, applying to tier two vessels (e.g., recreational powerboats, fishing boats, sailboats, tugs, ferries, whale-watching boats). Deep sea vessels (e.g. boat) already adhere to a 10-knot speed restriction while transiting the First Narrows Traffic Control Zone (Vancouver 2018a). Speed restrictions also reduce the amount of sound created by the vessel. (Joy et al. 2019) showed that when commercial vessels reduced their speed to 11 knots while transiting through Georgia Strait reduced underwater noise, potentially beneficial to Southern Resident killer whales (see Section 9.9.3 for a more detailed discussion on anthropogenic sound in the action area). Voluntary vessel slowdowns in Haro Strait (to 15 knots and 12.5 knots, depending on vessel size), led to a simulated 15 percent reduction in "lost" foraging time for Southern Resident killer whales (Trounce et al. 2019).

Vessel strikes are a poorly-studied threat to sea turtles, but have the potential to be highly significant given that they can result in serious injury and mortality (Work et al. 2010a). All sea turtles must surface to breathe and several species are known to bask at the sea surface for long periods. Although sea turtles can move somewhat rapidly, they apparently are not adept at avoiding vessels that are moving at more than 4 kilometers per hour (2.6 knots); most vessels move far faster than this in open water (Hazel and Gyuris 2006; Hazel et al. 2007; Work et al. 2010a). Both live and dead sea turtles are often found with deep cuts and fractures indicative of a collision with a vessel hull or propeller (Hazel et al. 2007). Hazel et al. (2007) suggests that green turtles may use auditory clues to react to approaching vessels rather than visual cues, making them more susceptible to strike or vessel speed increases. Although it is possible to occur, data on vessel strikes of leatherback sea turtles in the action area is lacking.

Vessel strike are a less pronounced threat to fishes in the action area, as fish are mostly expected to be able to sense and maneuver away from vessels. However, sturgeon have been known to be struck and killed by vessels. Demetras et al. (2020) documented an adult male white sturgeon mortality from vessel strike in the San Francisco Bay; the location of this event is notable in that the threatened southern DPS green sturgeon uses the same area, and is thus likely facing similar threats from vessels. We are not aware of reports of vessel strike for Southern DPS green sturgeon in the action area. Vessel strike was identified as a low-risk threat for Southern DPS green sturgeon (NMFS 2018).

9.5 Aquaculture

Aquaculture has the potential to impact protected species via entanglement and/or other interaction with aquaculture gear (i.e., buoys, nets, and lines), introduction or transfer of pathogens, impacts to habitat and benthic organisms, and water quality (Lloyd 2003; Clement 2013; Price and Morris 2013; Price et al. 2017).

In 2010, aquaculture operations in British Columbia amounted to a total harvested value of almost $534 million dollars, the majority ($511.5 million) being from salmon and other finfish. Salmon farming is British Columbia's largest agricultural export.[9] Currently in British Columbia, there are about 50 salmon aquaculture operations, mostly found near northern Vancouver Island.[10] Atlantic salmon aquaculture nets pens currently operate in Washington. There is no commercial salmon production in Oregon.

Salmon aquaculture in sea pens brings with it several concerns, chief among them being impacts from the accidental release of a nonnative species. An introduced species could outcompete native species for resources, or carry pathogens or parasites, causing native species' populations to decline or suffer. Since Southern Resident killer whales rely on salmon as prey, adverse impacts to native salmon populations from aquaculture could have detrimental effects to Southern Resident killer whales. Owing to recent incidents of escape, and to the large industry for salmon aquaculture in British Columbia in particular, much of this discussion will focus on Atlantic salmon.

There have been documented cases of accidentally released Atlantic salmon successfully reproducing in British Columbia, raising concerns about the possible establishment of the species, which could cause harm to native Pacific salmon (Volpe et al. 2000). There is evidence to suggest that salmon aquaculture is detrimental to wild native salmon populations, causing reductions in survival or abundance in wild populations (Ford and Myers 2008).

The parasite salmon lice (*Lepeophtheirus salmonis*) occurs naturally in salmon. Sea pens can create advantageous conditions for salmon lice to grow and be transmitted more expansively than they could under natural conditions. In severe cases of infection, salmon lice can cause erosion of the epidermis and exposure of the dermis, although mortality in wild salmon from salmon lice infection is rare. Sub-lethal effects include stress, changes in blood glucose or electrolytes, reduced hemocrits, and reduced swimming ability (Torrissen et al. 2013). Different species of Pacific salmon respond differently to salmon lice; Coho and pink salmon appear to more rapidly reject salmon lice than Chinook and chum (Johnson and Albright 1992; Jones et al. 2007).

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[9] https://www.dfo-mpo.gc.ca/aquaculture/pacific-pacifique/index-eng.html (Accessed 3/8/2021).
[10] https://www.cbc.ca/news/canada/british-columbia/fish-farming-bc-leases-1.4704626 (Accessed 3/8/2021).

The abundance of salmon lice has increased in years with abnormally warm water temperatures, possibly indicating that more frequent and stronger outbreaks can be expected as climate change persists (Torrissen et al. 2013). Aquaculture facilities regularly apply parasite treatments to manage salmon lice, giving rise to concerns about selection pressure and treatment resistance (Torrissen et al. 2013). There are some concerns about the indirect effects of common chemical treatments for salmon lice to other species like echinoderms, kelp, and spot prawns (*Pandalus platyceros*) (Strachan 2018).

There has been one major recent incident of sea pens failing and releasing nonnative Atlantic salmon into the action area. In August 2017, hundreds of thousands of Atlantic salmon escaped a fish farm operated by Cooke Aquaculture in Puget Sound near Anacortes, when a net pen failed. Subsequent investigation revealed that insufficient cleaning of the nets resulted in excessive biofouling on the net pen array. This caused increased drag on the mooring system, which led the weakening of attachment points between the moorings and the net pen to fail (Clark 2018). Initially, there were 305,000 Atlantic salmon in the net pen. After the collapse, Cooke Aquaculture was able to harvest or extract fish from the failed net pen. Still, there were between 242,959 and 262,659 Atlantic salmon released into Puget Sound. Subsequent efforts to extract escaped Atlantic salmon by beach seine, harvesting by tribes, the public, and Cooke Aquaculture recovered 56,810 Atlantic salmon, with between 186,149 to 205,849 fish not recovered. Veterinary assessment of recovered individuals shortly following the release showed no signs of bacterial, viral, or parasitic pathogens; subsequent examinations of post-released fish showed that the Atlantic salmon were contracting bacterial and viral pathogens endemic to Puget Sound (Clark 2018).

Later analysis did show that nearly 100 percent of the escaped Atlantic salmon sampled from the Cooke Aquaculture incident tested positive for piscine orthoreovirus, a virus in salmon aquaculture that causes pathological conditions like heart and skeletal inflammation. Atlantic salmon captured by anglers a few months later also tested positive for the virus (Kibenge et al. 2019). The strain of piscine orthoreovirus found in that study was very similar to another strain of the virus originating in Icelandic salmon farms. This lends support to the theory that the virus spread from fish egg transport because the eggs from the Iceland Atlantic fish farms was used to stock fish farms in Washington (Kibenge et al. 2019).

The chief concern is that the virus could cause fitness consequences for the native Pacific salmon populations, which are already facing difficulties. The British Columbia Ministry of Agriculture reported that about 80 percent of farmed Atlantic salmon were infected with piscine orthoreovirus. A study of farmed Atlantic salmon in British Columbia found that piscine orthoreovirus was detected in 95 percent of Atlantic salmon, and 35 to 47 percent of wild Pacific salmon, with the proportion of wild fish infected with the virus related to exposure to the fish farms (Morton et al. 2017).

Eight months after the net pen failure incident, Washington Governor Jay Inslee signed legislation placing restrictions on nonnative fish farms and banning Atlantic salmon farming in the state by 2025. Cooke Aquaculture, who operates the only remaining Atlantic salmon fish farms in the state, could be gone by 2022 when their lease expires.[11]

On December 20, 2019, damage caused to a sea pen by an electrical fire at a fish farm at Robertson Island north of Vancouver Island caused an estimated 20,000 Atlantic salmon to escape into Queen Charlotte Strait.[12] Canadian Prime Minister Justin Trudeau has pledged to move British Columbia's sea-based fish farms onto land by 2025.[13]

Current data suggest that interactions and entanglements of ESA-listed marine mammals and sea turtles with aquaculture gear are rare (Price et al. 2017). This may be because worldwide the number and density of aquaculture farms are low, and thus there is a low probability of interactions, or because they pose little risk of ESA-listed marine mammals and sea turtles. Nonetheless, given that in some aquaculture gear, such as that used in longline mussel farming, is similar to gear used in commercial fisheries, aquaculture may result in impacts similar to fisheries, including bycatch. There are very few reports of marine mammal interactions with aquaculture gear in the U.S. Pacific Ocean, although it is not always possible to determine if the gear animals become entangled in is from aquaculture or commercial fisheries (Price et al. 2017).

9.5.1 Hatcheries

There are several hundred public facilities (Federal, tribal, and state-operated) producing Pacific salmonids for release into fresh and sea water salmon habitat (Hatchery Scientific Review Group 2015). Salmon hatcheries contribute to the abundance of salmon populations and to the prey base of marine mammals that feed on salmon. However, there are several concerns with how artificial propagation of salmonids may impact natural salmon populations or the habitats essential to their survival. Concerns include a decrease in water quality due to fish waste or chemical disposal, increase in predation of natural fish stocks by hatchery-raised fish, and accidental introduction of non-native species that lead to predation or increased competition with natural salmon populations. Adverse effects to native salmon populations from hatchery fish could have subsequent effects to ESA-listed species that prey upon salmon (e.g., Southern Resident killer whale).

After completing the ocean stage, hatchery-origin fish generally return to tributaries concurrently with natural-origin salmon. Unless they are harvested or collected for broodstock or removal, hatchery-origin fish spawn in natural habitat. While hatcheries can provide a temporary demographic buffer for catastrophic declines in abundance, hatchery populations could eventually be more susceptible to large-scale climate forcing than natural populations due to the absence of behavioral, physiological, and genetic adaptation in the wild (Crozier et al. 2019).

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[11] https://www.npr.org/sections/thesalt/2018/03/26/597019406/after-three-decades-washington-state-bans-atlantic-salmon-farms (Accessed 3/8/2021).

[12] https://mowi.com/caw/blog/2019/12/21/news-release-incident-at-robertson-island-causes-potential-fish-escape/ (Accessed 3/8/2021).

[13] https://www.alaskapublic.org/2019/12/27/fire-at-b-c-fish-farm-releases-thousands-of-atlantic-salmon/ (Accessed 3/8/2021).

9.6 Fisheries

Fisheries constitute an important and widespread use of the ocean resources throughout the action area. Fisheries can adversely affect fish populations, other species, and habitats. Direct effects of fisheries interactions on marine mammals and sea turtles include entanglement and entrapment, which can lead to fitness consequences or mortality because of injury or drowning. Non-target species are captured in fisheries (i.e., bycatch), and can represent a significant threat to non-target populations. Indirect effects include reduced prey availability, including overfishing of targeted species, and destruction of habitat.

9.6.1 Marine Mammals

Entrapment and entanglement in fishing gear is a frequently documented source of human-caused mortality in cetaceans (see Dietrich et al. 2007). Materials entangled tightly around a body part may cut into tissues, enable infection, and severely compromise an individual's health (Derraik 2002). Entanglements also make animals more vulnerable to additional threats (e.g., predation and vessel strikes) by restricting agility and swimming speed. The majority of marine mammals that die from entanglement in fishing gear likely sink at sea rather than strand ashore, making it difficult to accurately determine the extent of such mortalities. In excess of 97 percent of entanglement in cetaceans is caused by derelict fishing gear (Baulch and Perry 2014b). Figure 43 shows the number of confirmed whale entanglements per year detected off the U.S. west coast from 2001 to 2016 (Santora et al. 2020). The number of confirmed whale entanglements, most notably humpback whales, increased markedly throughout the 2014 to 2016 Pacific marine heat wave event.

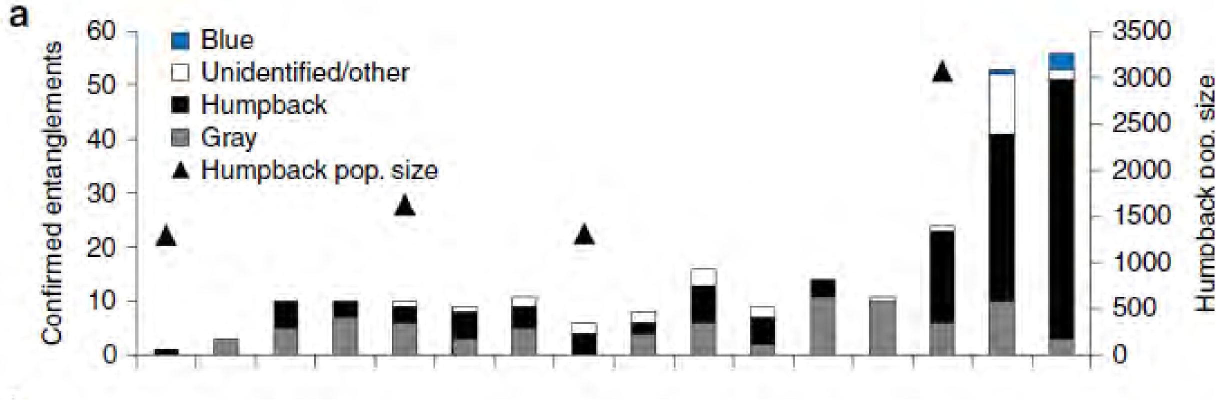

Figure 42. Trend in total confirmed whale entanglements per year detected off the U.S. west coast from 2001 to 2016, and estimated humpback whale population size (Santora et al. 2020).

The latest five-year average mortalities and serious injuries related to fisheries interactions for the ESA-listed marine mammal likely to be found in the action area within U.S. waters are given in Table 43 below (Carretta 2019b). Data represent only known mortalities and serious injuries; more, undocumented moralities and serious injuries for these and other marine mammals found within the action area have likely occurred.

Table 42. Five-year average mortalities and serious injuries related to fisheries interactions for Endangered Species Act-listed marine mammals within the action area.

Species	Mortality
Blue Whale	0.9
Fin Whale	≥0.5
Humpback Whale – Multiple ESA-listed DPSs	15.7
Sei Whale	0
Sperm Whale	N/A
Guadalupe Fur Seal	≥3.2

DPS=Distinct Population Segment

There have been reports of Guadalupe fur seals stranding with evidence of entanglement in fishing gear or other marine debris (Hanni et al. 1997). Previous bycatch data do not report any Guadalupe fur seal bycatch in fisheries in the U.S., including observed fisheries such as the driftnet and gillnet fisheries in California, and the groundfish trawl fishery in California, Washington and Oregon (NMFS 2000; NMFS 2013e). From the period of 2009 to 2013, there were 20 Guadalupe fur seals reported as injured or killed as a result of human-related injury; 13 dead, three seriously injured, and four non-seriously injured (Carretta et al. 2015). Several of these individuals were entangled in pieces of gillnet, trawl nets, or gear from an unidentified net fishery.

In addition to direct impacts like entanglement, marine mammals may also be subject to indirect impacts from fisheries. In a study of retrospective data, Jackson et al. (2001) concluded that ecological extinction caused by overfishing precedes all other pervasive human disturbance of coastal ecosystems, including pollution and anthropogenic climatic change.

Fisheries can have a profound influence on fish populations. Marine mammals probably consume at least as much fish as is harvested by humans (Kenney et al. 1985). Many cetacean species (particularly fin and humpback whales) are known to feed on species of fish that are harvested by humans (Carretta et al. 2016). Thus, competition with humans for prey is a potential concern. Reductions in fish populations, whether natural or human-caused, may affect the survival and recovery of ESA-listed marine mammal populations. Even species that do not directly compete with human fisheries could be indirectly affected by fishing activities through changes in ecosystem dynamics. However, in general the effects of fisheries on marine mammals through changes in prey abundance remain unknown in the action area.

9.6.2 Sea Turtles

Fishery interaction remains a major factor in sea turtle recovery and, frequently, the lack thereof. Wallace et al. (2010) estimated that worldwide, 447,000 sea turtles are killed each year from bycatch in commercial fisheries. Although sea turtle excluder devices and other bycatch reduction devices have significantly reduced the level of bycatch to sea turtles and other marine species in U.S. waters, mortality still occurs.

Leatherback turtles in the Pacific Ocean migrate about 11,265.4 kilometers (6,082.9 nautical miles) from nesting beaches in the tropical Pacific Ocean (e.g., Indonesia, Papua New Guinea, Costa Rica, Mexico) to foraging grounds off the U.S. West Coast. This migration puts leatherback turtles in proximity of numerous fisheries, especially longlines, increasing bycatch risk. Roe (2014) found areas of high bycatch risk in the North and Central Pacific Ocean. By far, however, the greatest areas of bycatch risk were in the jurisdictional waters of several Indo-Pacific nations, largely affecting nesting individuals. The authors pointed to the difficultly in coordinating management efforts between several countries as a barrier to reducing risk of bycatch and supporting leatherback turtle recovery.

9.6.3 Fish

ESA-listed salmon are incidentally caught in several fisheries that operate in the action area targeting non-listed salmon or other species. These include:

- Groundfish fisheries off the coasts of Washington, Oregon and California that operate under the Pacific Coast Groundfish Fishery Management Plan;
- Coastal pelagic species (i.e., northern anchovy, squid, Pacific sardine, Pacific mackerel, and jack mackerel) managed by the Pacific Fisheries Management Council under the Coastal Pelagic Species Fisheries Management Plan;
- Commercial salmon fisheries that operate under the Pacific Salmon Treaty;
- Salmon fisheries that are managed by the U.S. Pacific Fisheries Management Council under the Pacific Coast Management Plan;
- Salmon fisheries managed by the U.S. Fraser River Panel;
- Recreational fisheries that operate in the ocean and inland portions of the action area
- Tribal ceremonial and subsistence (gillnet, dip net and hook and line) fisheries in Puget Sound

Fisheries management plans developed for federally regulated fisheries with ESA-listed species bycatch are required to undergo section 7 consultation, including a NMFS' issued opinion and an ITS for those activities in the plan that are likely to adversely affect listed species. The ITS includes the anticipated amount of take (lethal and nonlethal) and reasonable and prudent measures with specific terms and conditions for mitigating and minimizing the adverse effects of the proposed action on ESA-listed species and designated critical habitat. Section 7 consultations also evaluate the secondary effects of fisheries removals on ESA-listed species that prey on fish (e.g., Southern Resident killer whales).

Pacific salmon fisheries provide for commercial, recreational, and tribal harvest in ocean and inland waters. Commercial ocean fisheries targeting Pacific salmon primarily use troll or hook-and-line gear, but gill nets are also used in commercial and tribal freshwater fisheries in inland waters. The broad geographic range and migration routes of salmon, from the inland tributaries to offshore areas, require comprehensive management by several stakeholder groups representing federal, state, tribal, and Canadian interests (NMFS 2019a).

While management of fishing activities have largely been focused on sustainability and protecting ESA-listed salmonids, management of salmon fisheries with respect to endangered Southern Resident killer whales is also part of the consultation process to evaluate impacts to fish stocks (listed or non-listed) that affect prey available for the Southern Residents (NMFS 2019a). A growing body of evidence documents how Southern Resident killer whales are affected by limitations of their primary prey, Chinook salmon (Matkin et al. 2017). Availability of Chinook for Southern Residents is likely affected by multiple factors including sound, competition from other salmon predators (e.g., other resident killer whales and pinnipeds), and fisheries harvest (Chasco et al. 2017). Both directed and incidental fishing activities may reduce the biomass available to Southern Resident killer whales by removing prey or by selecting for the larger salmon that are preferred by Southern Resident killer whales (NMFS 2008d). Reductions in Chinook salmon prey available due to fishery removals vary from year to year and by season and location. In years prior to ESA listings for salmon, fishery reductions were as high as 20-30 percent in some seasons and locations (NMFS 2019a). More recently, with ESA considerations for salmon and whales, seasonal reductions in inland and coastal waters have ranged from zero to 15 percent reductions. NMFS is currently working on a comprehensive analysis that assesses the effects of fisheries on Chinook salmon availability throughout the Southern Resident killer whales' geographic range, using a retrospective Fishery Regulation Assessment Model (FRAM)-based analysis similar to those used in previous fisheries consultations (NMFS 2008b; NMFS 2008c; NMFS 2011d; NMFS 2018a).

The whiting fishery (including at-sea, shore-based, and Tribal fisheries), which is a sector of the Pacific Coast groundfish fisheries, is estimated to have caught an average of 7,718 chinook each year from 2011 through 2015 (NMFS 2017b). Incidental capture of Chinook salmon in the bottom trawl sector of the groundfish fishery has sharply declined in recent years from an annual average over 15,000 from 2002-2003 to around 557 per year from 2011-2015 (NMFS 2017b). ESA section 7 consultations aim to limit the impact of ocean salmon fisheries on ESA-listed populations. For example, the maximum age-3 impact rate for 2015 ocean salmon fisheries on Sacramento River winter Chinook is 19 percent (PFMC 2015).

Coastal pelagic fisheries also have the potential to impact Pacific salmon through incidental capture or by removing prey biomass from the ecological system (Pacific Fishery Management Council 2014). Pelagic fisheries primarily operate off southern and central California, but there is a large sardine fishery off Oregon and Washington. Pacific sardine is an important source of forage for a large number of birds, marine mammals, and fish. The directed Pacific sardine fishery has been closed since July 1, 2015 because of low biomass, but small-scale directed fishing can still take place (NMFS 2019a).

Take of Southern DPS green sturgeon in federal fisheries was prohibited as a result of the ESA 4(d) protective regulations issued in June of 2010 (75 FR 30714). Green sturgeon are occasionally encountered as bycatch in Pacific Coast groundfish fisheries (Al-Humaidhi 2011). The estimated number of Southern DPS green sturgeon encountered in the federally-managed sectors of the groundfish fishery for 2013 to 2017 ranged from 1 to 16 per year (Richerson et al. 2019). Among state managed fisheries, bycatch was highest in the California halibut bottom trawl fishery, which encountered an estimated 118 to 641 Southern DPS green sturgeon annually from 2013 to 2017 (Richerson et al. 2019).The California nearshore groundfish sector caught an estimated 16 Southern DPS individuals in 2017, although from 2002-2016 none were caught in this fishery.

Approximately 50 to 250 green sturgeon are encountered annually by recreational anglers in the lower Columbia River (NMFS 2015f), of which 86 percent are expected to be Southern DPS green sturgeon based on the higher range estimate of Israel et al. (2009). Green sturgeon are also caught incidentally by recreational anglers fishing in Washington outside of the Columbia River (NMFS 2015f). Southern DPS green sturgeon are also captured and released by California recreational anglers. Based on self-reported catch card data, an average of 193 green sturgeon were caught and released annually by California anglers from 2007 to 2013 (NMFS 2015f). Recreational catch and release can potentially result in indirect effects on green sturgeon, including reduced fitness and increased vulnerability to predation. However, the magnitude and impact of these effects on Southern DPS green sturgeon are not well studied.

The main source of eulachon bycatch are the west coast shrimp fisheries (NMFS 2017e). Offshore trawl fisheries for ocean shrimp (*Pandalus jordani*) occur off the west coast of North America from the west coast of Vancouver Island to Cape Mendocino, California (Hannah and Jones 2007) and in British Columbia, Canada. *Pandalus jordani* is known as the smooth pink shrimp in British Columbia, ocean pink shrimp or smooth pink shrimp in Washington, pink shrimp in Oregon, and Pacific Ocean shrimp in California. The ocean shrimp season is open April 1 through October 31 in California, Oregon and Washington and ships deliver catch to shore-based processors. Total coast-wide ocean shrimp landings have ranged from a low of 1,888 metric tons in 1957 to a high of 46,494 metric tons in 2015 (NMFS 2017e).

Prior to 2000, eulachon bycatch in the ocean shrimp fishery ranged from 32 to 61 percent of the total catch (Hannah and Jones 2007). Eulachon occur as bycatch in shrimp trawl fisheries off the coasts of Washington, Oregon, California, and British Columbia (Gustafson et al. 2010). Ward et al. (2015) found that the coastal areas just south of Coos Bay, Oregon; between the Columbia River and Grays Harbor, Washington; and just south of La Push, Washington were consistent hotspots of eulachon bycatch across years. The previously depressed and currently increasing abundance of the Southern DPS of eulachon (James et al. 2014) are likely contributing to the increased levels of eulachon bycatch reported for 2012 to 2014. The dramatic increases in the level of eulachon bycatch in both the Washington and Oregon ocean shrimp trawl fisheries in 2012 and 2013 occurred in spite of regulations requiring the use of bycatch reduction devices. It is unclear why bycatch ratios were highest in the Washington, intermediate in the Oregon, and lowest in the California sectors of the ocean shrimp trawl fishery in 2012 and 2013. However, the bycatch ratio increased in Oregon and decreased in Washington in 2014 compared to the previous two-year period. Use of bycatch reduction devices in offshore shrimp trawl fisheries, which was mandated beginning in 2003 in Washington and Oregon has substantially reduced bycatch of fin fish in these fisheries (Hannah and Jones 2007; Frinodig et al. 2009).

9.7 Pollution

Within the action area, pollution poses a threat to ESA-listed marine mammals and sea turtles. Pollution can come in the form of marine debris, pesticides, contaminants, and hydrocarbons.

9.7.1 Marine Debris

Data on marine debris in some locations of the action area is largely lacking; therefore, it is difficult to draw conclusions as to the extent of the problem and its impacts on populations of ESA-listed species in the Northeast Pacific Ocean, but we assume similar effects from marine debris documented within other ocean basins could also occur to species from marine debris.

Cetaceans are impacted by marine debris, which includes plastics, glass, metal, polystyrene foam, rubber, and derelict fishing gear (Baulch and Perry 2014a; Li et al. 2016). Over half of cetacean species (including blue, fin, humpback, sei, and sperm whales) are known to ingest marine debris (mostly plastic), with up to 31 percent of individuals in some populations containing marine debris in their guts and being the cause of death for up to 22 percent of individuals found stranded on shorelines (Baulch and Perry 2014b). A recent study showed that microplastics were present in nearly all fecal samples from Southern Resident killer whales (Harlacher 2020).

Plastic waste in the ocean can leach chemical additives into the water or these additives, such as brominated flame retardants, stabilizers, phthalate esters, biphenyl A, and nonylphenols (Panti et al. 2019). Additionally, plastic waste chemically attracts hydrocarbon pollutants such as polychlorinated biphenyl and dichlorodiphenyltrichloroethane. Individuals can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. Once consumed, plastics can act as nutritional diluents in the gut, making the animal feel satiated before it has acquired the necessary amount of nutrients required for general fitness (reviewed in (Machovsky-Capuska et al. 2019)). Plastics may therefore influence the nutritional niches of animals in higher trophic levels, such as Guadalupe fur seals and other pinnipeds (Machovsky-Capuska et al. 2019).

Given the limited knowledge about the impacts of marine debris on marine mammals, it is difficult to determine the extent of the threats that marine debris poses to marine mammals. However, marine debris is consistently present and has been found in marine mammals in and near the action area. In 2008, two sperm whales stranded along the California coast, with an assortment of fishing related debris (e.g., net scraps, rope) and other plastics inside their stomachs (Jacobsen et al. 2010). One whale was emaciated, and the other had a ruptured stomach. It was suspected that gastric impactions was the cause of both deaths. Jacobsen et al.

(2010) speculated the debris likely accumulated over many years, possibly in the North Pacific gyre that will carry derelict Asian fishing gear into eastern Pacific Ocean waters.

Ingestion of marine debris can be a serious threat to sea turtles. When feeding, sea turtles (e.g., leatherback turtles) can mistake debris (e.g., tar and plastic) for natural food items, especially jellyfish, which are a primary prey. Some types of marine debris may be directly or indirectly toxic, such as oil. One study found plastic in 37 percent of dead leatherback turtles and determined that nine percent of those deaths were a direct result of plastic ingestion (Mrosovsky et al. 2009). Plastic ingestion is very common in leatherback turtles and can block gastrointestinal tracts leading to death (Mrosovsky et al. 2009). Other types of marine debris, such as discarded or derelict fishing gear and cargo nets, may entangle and drown sea turtles of all life stages.

Plastic debris is a major concern because it degrades slowly and many plastics float. The floating debris is transported by currents throughout the oceans and has been discovered accumulating in oceanic gyres (Law et al. 2010). Additionally, plastic waste in the ocean chemically attracts hydrocarbon pollutants. Marine mammals, sea turtles, and fish can mistakenly consume these wastes containing elevated levels of toxins instead of their prey. It is expected that marine mammals, sea turtles, and fish may be exposed to marine debris over the course of the action although the risk of ingestion or entanglement and the resulting impacts are uncertain at the time of this consultation.

9.7.2 Pollutants and Contaminants

Exposure to pollution and contaminants have the potential to cause adverse health effects in marine species. Marine ecosystems receive pollutants from a variety of local, regional, and international sources, and their levels and sources are therefore difficult to identify and monitor (Grant and Ross 2002). Marine pollutants come from multiple municipal, industrial, and household as well as from atmospheric transport (Iwata 1993; Grant and Ross 2002; Garrett 2004; Hartwell 2004). Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation (Grant and Ross 2002; Garrett 2004; Hartwell 2004).

The accumulation of persistent organic pollutants, including polychlorinated-biphenyls, dibenzo-p-dioxins, dibenzofurans and related compounds, through trophic transfer may cause mortality and sub-lethal effects in long-lived higher trophic level animals (Waring et al. 2016), including immune system abnormalities, endocrine disruption, and reproductive effects (Krahn et al. 2007a). Persistent organic pollutants may also facilitate disease emergence and lead to the creation of susceptible "reservoirs" for new pathogens in contaminated marine mammal populations (Ross 2002). Recent efforts have led to improvements in regional water quality and monitored pesticide levels have declined, although the more persistent chemicals are still detected and are expected to endure for years (Mearns 2001; Grant and Ross 2002).

In a small and imperiled population, these pollutant effects can be especially deleterious, as they could work in concert along with other stressors (e.g., reductions in prey), leading to reduced fitness for an individual. For example, in Southern Resident killer whales, contamination from pollutants could lead to endocrine disruption (delayed development, changes to metabolism, reduced perinatal survival), and compromised immune systems (Mongillo et al. 2016).

Numerous factors can affect concentrations of persistent pollutants in marine mammals, such as age, sex and birth order, diet, and habitat use (Mongillo et al. 2012). In marine mammals, pollutant contaminant load for males increases with age, whereas females pass on contaminants to offspring during pregnancy and lactation (Addison and Brodie 1987; Borrell et al. 1995). Pollutants can be transferred from mothers to juveniles at a time when their bodies are undergoing rapid development, putting juveniles at risk of immune and endocrine system dysfunction later in life (Krahn et al. 2009).

Pollutants and contaminants cause adverse health effects in pinnipeds. Acute toxicity events may result in mass mortalities; repeated exposure to lower levels of contaminants may also result in immune suppression and/or endocrine disruption (Atkinson et al. 2008). In addition to hydrocarbons and other persistent chemicals, pinnipeds may become exposed to infectious diseases (e.g., Chlamydia and leptospirosis) through polluted waterways(Aguirre et al. 2007).

In sea turtles, a variety of heavy metals (e.g., arsenic, barium, cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, selenium, silver and zinc) have been found in tissues in levels that increase with sea turtle size (Godley et al. 1999; Saeki et al. 2000; Anan et al. 2001; Fujihara et al. 2003; Gardner et al. 2006; Storelli et al. 2008; Barbieri 2009; Garcia-Fernandez et al. 2009). Cadmium has been found in leatherback turtles at the highest concentration compared to any other marine vertebrate (Gordon et al. 1998; Caurant et al. 1999). Newly emerged hatchlings have higher concentrations than are present when laid, suggesting that metals may be accumulated during incubation from surrounding sands (Sahoo et al. 1996).

Sea turtle tissues have been found to contain organochlorines and many other persistent organic pollutants. Polychlorinated biphenyl (better known as PCB, found in engine coolants) concentrations in sea turtles are reportedly equivalent to those in some marine mammals, with liver and adipose levels of at least one congener being exceptionally high (PCB 209: 500-530 ng/g wet weight; Davenport 1990; Oros 2009). PCBs have been found in leatherback turtles at concentrations lower than expected to cause acute toxic effects, but might cause sub-lethal effects on hatchlings (Stewart 2011). Further study has shown that PBDEs in leatherback eggs show a negative correlation to hatching success (De Andrés et al. 2016).

Green sturgeon are vulnerable to pollutants and pesticides, with such contaminants posing a risk to eggs, larvae, and juveniles, potentially causing reduced growth, injury, or mortality (NMFS 2018b). Accumulation of PCBs has been shown in Chinook and Coho salmon in Puget Sound, and PCBs have been found in all species of Pacific salmon in Alaska and the Columbia River. The effects of accumulation of PCBs to salmon are unknown, though it is thought possible that if the PCBs are passed to the eggs, it could affect reproductive success, or inhibit immune response in juveniles (O'Neill et al. 1998).

Because POPs are both ubiquitous and persistent in the environment, marine mammals, sea turtles, and other forms of marine life will continue to be exposed to POPs for all of their lives. The effects of POPs to ESA-listed species are unknown and not directly studied, but it is possible that the effects could be sub-lethal and long-term in nature, and include impacting reproduction, immune function, and endocrine activity. These are effects that would become more apparent as time goes on. At present, however, the effects of POPs in ESA-listed species are not currently well known.

9.7.3 Oil Spills

There has never been a large-scale oil spill in the action area, but numerous small-scale vessel spills likely occur. A nationwide study examining vessel oil spills from 2002 through 2006 found that over 1.8 million gallons of oil were spilled from vessels in all U.S. waters (Dalton and Jin 2010). In this study, "vessel" included numerous types of vessels, including barges, tankers, tugboats, and recreational and commercial vessels, demonstrating that the threat of an oil spill can come from a variety of boat types. In addition to vessels, oil spills can come from other sources like pipelines and rail cars, but in this discussion, we focus on spills to water.

The substantial volume of shipping traffic and the presence of refineries in the action area create the risk of a catastrophic oil spill that could affect listed species and their prey. Due to its proximity to Alaska's crude oil supply, Puget Sound is one of the leading petroleum refining centers in the United States. In the state of Washington alone, 20 billion gallons of oil move through the state annually, with most of it transported via vessel (i.e., 50 percent or more over the years 2007 to 2018) (Ecology 2019). The Trans Mountain pipeline expansion in British Columbia would increase the amount of oil transported, from 300,000 barrels currently to 890,000 once it comes online in 2022. Once completed, the pipeline is expected to result in an increase in oil tanker traffic in the region; currently, the Port of Vancouver has between 30 and 50 crude oil tankers annually. This is predicted to increase to up to 400 crude oil tankers per year once the Trans Mountain pipeline expansion is complete (NEB 2019).

In keeping with the national scale study discussed earlier, most spill incidents in the action area are small scale in nature, but the increasing oil production, processing, and transport in the action area mean there is the possibility of a large-scale event. For example, in Washington from 2015 to 2019, there were 2,225 reported oil spills to water incidents, with the majority (95.3 percent) of the incidents spilling less than 100 gallons, and 32 percent of total spills coming from incidents where only one gallon was released[14]. In Oregon in 2018, around 500 oil spills occurred, with most classified as "small spill" (less than 42 gallons) (PSBC 2019). Between 2017 and 2019, Vancouver Island reported a total of 1,446 spill incidents, with most (1,429) classified

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[14] From the Washington State Department of Ecology - Spills Program Integrated Information System (SPIIS) Database

as "Code 1" spills, described as generally smaller spills that are easy to clean up, in contrast to Code 2 spills, which are classified as substantial spills not easily confined (EPP 2019). Although the individual spills reported are small or minor, it is important to point out the fact that oil spills occur frequently, there are thousands of them overall, and that there could be cumulative effects to exposed species as a result.

Although these spills occurred many years ago outside the action area for this consultation, given the long life spans and broad distribution of several of the species considered in this consultation, it is possible that those populations could be impacted by long-term, sub-lethal effects from those spills. The long-term effects of repeated ingestion of sub-lethal quantities of petroleum hydrocarbons on marine mammals are not well understood, either. As a result, the magnitude of the risks posed by oil discharges in the proposed action area is difficult to precisely quantify or estimate.

9.8 Aquatic Nuisance Species

Aquatic nuisance species are aquatic and terrestrial organisms, introduced into new habitats throughout the U.S. and other areas of the world that produce harmful impacts on aquatic ecosystems and native species (http://www.anstaskforce.gov). They are also referred to as invasive, alien, or non-indigenous species. Invasive species have been referred to as one of the top four threats to the world's oceans (Raaymakers and Hilliard 2002; Raaymakers 2003; Terdalkar et al. 2005; Pughiuc 2010). Introduction of these species is cited as a major threat to biodiversity, second only to habitat loss (Wilcove et al. 1998). A variety of vectors are thought to have introduced non-native species including, but not limited to aquarium and pet trades, recreation, and ballast water discharges from ocean-going vessels. Common impacts of invasive species are alteration of habitat and nutrient availability, as well as altering species composition and diversity within an ecosystem (Strayer 2010). Shifts in the base of food webs, a common result of the introduction of invasive species, can fundamentally alter predator-prey dynamics up and across food chains (Moncheva and Kamburska 2002), potentially affecting prey availability and habitat suitability for ESA-listed species. They have been implicated in the endangerment of 48 percent of ESA-listed species (Czech and Krausman 1997). Currently, there is little information on the level of aquatic nuisance species and the impacts of these invasive species may have on marine mammals, fish, and sea turtles in the action area through the duration of the project. Therefore, the level of risk and degree of impact to ESA-listed marine mammals, sea turtles, and fish is unknown.

In the action area, there are several aquatic nuisance and introduced species that have the potential to impact ESA-listed species. Non-native species like striped bass (*Morone saxatillis*) may prey upon young green sturgeon, while non-native Japanese eelgrass (*Zostera japonica*) binds sediments that can reduce unvegetated sand feeding habitat for green sturgeon (Moser et al. 2016).

9.9 Anthropogenic Sound

The ESA-listed species that occur in the action area are regularly exposed to several sources of natural and anthropogenic sounds. A wide variety of anthropogenic and natural sources contribute to ocean noise throughout the world's oceans. Anthropogenic sources of noise that are most likely to contribute to increases in ocean noise are vessel noise from commercial shipping and general vessel traffic, oceanographic research, oil, gas and mineral exploration, underwater construction, geophysical (seismic) surveys, Naval and other sources of sonar, and underwater explosions (Richardson et al. 1995f; Hatch and Wright 2007b).

Noise is of particular concern to marine mammals because many species use sound as a primary sense for navigating, finding prey, avoiding predators, and communicating with other individuals.

Noise in the marine environment has received a lot of attention in recent years and is likely to continue to receive attention in the foreseeable future. There is a large and variable natural component to the ambient noise level as a result of events such as earthquakes, rainfall, waves breaking, and lightning hitting the ocean as well as biological noises such as those from snapping shrimp, other crustaceans, fishes, and the vocalizations of marine mammals (Crawford and Huang 1999; Patek 2002; Hildebrand 2004b). However, several studies have shown that anthropogenic sources of noise have increased ambient noise levels in the ocean over the last 50 years (NRC 1994; Richardson et al. 1995f; NRC 2000; NRC 2003a; Jasny et al. 2005; NRC 2005b). Much of this increase is due to increased shipping as ships become more numerous and of larger tonnage (NRC 2003a). Commercial fishing vessels, cruise ships, transport boats, airplanes, helicopters and recreational boats all contribute sound into the ocean (NRC 2003a). The military uses sound to test the systems of Navy vessels as well as for naval operations. In some areas where oil and gas production takes place, noise originates from the drilling and production platforms, tankers, vessel and aircraft support, seismic surveys, and the explosive removal of platforms (NRC 2003a).

Andrew et al. (2002) compared ocean ambient sound from the 1960s to the 1990s from a receiver off the California coast. The data showed an increase in ambient noise of approximately 10 dB in the frequency ranges of 20 to 80 Hertz and 200 to 300 hertz, and about 3 dB at 100 hertz over a 33-year period. Each 3 dB increase is noticeable to the human ear as a doubling in sound level. A possible explanation for the rise in ambient noise is the increase in shipping noise. There are approximately 11,000 supertankers worldwide, each operating approximately 300 days per year, each producing constant broadband noise at typical source levels of 198 dB (Hildebrand 2004b). Generally the most energetic regularly operated sound sources are seismic airgun arrays from approximately 90 vessels with typically 12 to 48 individual guns per array, firing about every 10 seconds (Hildebrand 2004b).

9.9.1 Seismic Surveys

Similar to the proposed action, offshore seismic surveys involve the use of high-energy sound sources operated in the water column to probe below the seafloor. Numerous seismic surveys have been conducted off the west coast over the past several decades. Unlike other regions (e.g., Gulf of Mexico) where the large majority of seismic activity is associated with oil and gas development, seismic surveys conducted in the action area are primarily for scientific research, to identify possible seafloor or shallow-depth geologic hazards, and to locate potential archaeological resources and benthic habitats that should be avoided.

For past scientific research seismic surveys in the action area, NMFS issued permits for seismic activity conducted near marine mammals and ESA-listed sea turtles. MMPA and ESA permits specify the conditions under which researchers can operate seismic sound sources, such as airguns, including mitigation measure to minimize adverse effects to protected species. In the action area, other past seismic surveys include one in 2012 (over the Cascadia Thrust Zone), which resulted in a no jeopardy or adverse modification determination.

9.9.2 Active Sonar

Active sonar emits high-intensity acoustic energy and receives reflected and/or scattered energy. A wide range of sonar systems are in use for both civilian and military applications. The primary sonar characteristics that vary with application are the frequency band, signal type (pulsed or continuous), rate of repetition, and source level. Sonar systems can be divided into categories, depending on their primary frequency of operation; low frequency for one kilohertz and less, mid frequency for one to 10 kilohertz; high frequency for 10 to 100 kilohertz; and very high frequency for greater than 100 kilohertz (Hildebrand 2004a). Low frequency systems are designed for long-range detection (Popper et al. 2014a). The effective source level of an low-frequency active array, when viewed in the horizontal direction, can be 235 dB re 1μPa-m or higher (Hildebrand 2004a). Signal transmissions are emitted in patterned sequences that may last for days or weeks. An example of a low-frequency active sonar system is the U.S. Navy Surveillance Underwater Towed Array Sensor System (SURTASS), discussed in more detail below (See Section 8.10). Mid-frequency military sonars include tactical anti-submarine warfare sonars, designed to detect submarines over several tens of kilometers, depth sounders and communication sonars. High-frequency military sonars includes those incorporated into weapons (torpedoes and mines) or weapon countermeasures (mine countermeasures or anti-torpedo devices), as well as side-scan sonar for seafloor mapping. Commercial sonars are designed for fish finding, depth sounding, and sub-bottom profiling. They typically generate sound at frequencies of 3 to 200 kilohertz, with source levels ranging from 150 to 235 dB re 1μPa-m (Hildebrand 2004a). Depth sounders and sub-bottom profilers are operated primarily in nearshore and shallow environments, however, fish finders are operated in both deep and shallow areas.

9.9.3 Vessel Sound and Commercial Shipping

Individual vessels produce unique acoustic signatures, although these signatures may change with vessel speed, vessel load, and activities that may be taking place on the vessel. Sound levels are typically higher for the larger and faster vessels. Peak spectral levels for individual commercial vessels are in the frequency band of ten to 50 hertz and range from 195 dB re: μPa^2-s at 1 m for fast-moving (greater than 20 knots) supertankers to 140 dB re: μPa^2-s at 1 m for smaller vessels (NRC 2003a). Although large vessels emit predominantly low frequency sound, studies report broadband sound from large cargo vessels above two kilohertz, which may interfere with important biological functions of cetaceans (Holt 2008). At frequencies below 300 hertz, ambient sound levels are elevated by 15 to 20 dB when exposed to sounds from vessels at a distance (McKenna et al. 2013b).

Much of the increase in sound in the ocean environment over the past several decades is due to increased shipping, as vessels become more numerous and of larger tonnage (NRC 2003a; Hildebrand 2009; McKenna et al. 2012). Shipping constitutes a major source of low-frequency (five to 500 hertz) sound in the ocean (Hildebrand 2004a), particularly in the Northern Hemisphere where the majority of vessel traffic occurs. While commercial shipping contributes a large portion of oceanic anthropogenic noise, other sources of maritime traffic can also impact the marine environment. These include recreational boats, whale-watching boats, research vessels, and ships associated with oil and gas activities. See Section 9.4 for a detailed discussion of the amount of vessel traffic from ports within the action area.

Vessel noise can result from several sources including propeller cavitation, vibration of machinery, flow noise, structural radiation, and auxiliary sources such as pumps, fans and other mechanical power sources. Kipple and Gabriele (2007) measured sounds emitted from 38 vessels ranging in size from 14 to 962 feet at speeds of 10 knots and at a distance of 500 yards from the hydrophone. Sound levels ranged from a minimum of 157 to a maximum of 182 dB re 1 μPa-m, with sound levels showing an increasing trend with both increasing vessel size and with increasing vessel speed. Vessel sound levels also showed dependence on propulsion type and horsepower. McKenna et al. (2012) measured radiated noise from several types of commercial ships, combining acoustic measurements with ship passage information from Automatic Identification System (AIS). On average, container ships and bulk carriers had the highest estimated broadband source levels (186 dB re 1 lPa2 20 to 1000 hertz), despite major differences in size and speed. Differences in the dominant frequency of radiated noise were found to be related to ship type, with bulk carrier noise predominantly near 100 hertz while container ship and tanker noise was predominantly below 40 hertz. The tanker had less acoustic energy in frequencies above 300 hertz, unlike the container and bulk carrier.

Sound emitted from large vessels, such as shipping and cruise ships, is the principal source of low frequency noise in the ocean today, and marine mammals are known to react to or be affected by that noise (Richardson et al. 1995d; Foote et al. 2004; Hildebrand 2005; Hatch and Wright 2007a; Holt et al. 2008; Melcon et al. 2012; Anderwald et al. 2013; Kerosky et al. 2013; Erbe et al. 2014; Guerra et al. 2014; May-Collado and Quinones-Lebron 2014; Williams et al. 2014b). Several studies have demonstrated short-term effects of disturbance on humpback whale behavior (Hall 1982; Baker et al. 1983; Krieger and Wing 1984; Bauer and Herman 1986), but the long-term effects, if any, are unclear or not detectable. Carretta et al. (2001) and Jasny et al. (2005) identified the increasing levels of anthropogenic noise as a habitat concern for whales and other cetaceans because of its potential effect on their ability to communicate. Significant changes in odontocete behavior attributed to vessel noise have been documented up to at least 5.2 kilometers away from the vessel (Pirotta et al. 2012).

Erbé (2002c) recorded underwater noise of whale-watching boats in the popular killer whale-watching region of southern British Columbia and northwestern Washington State. Source levels ranged from 145 to 169 dB re 1 Pa-m and increased as the vessel's speed increased. Based on sound propagation models, Erbé (2002c) concluded that the noise of fast boats would be audible to killer whales over 16 kilometers, would mask killer whale calls over 14 kilometers, would elicit behavioral response over 200 meters, and would cause a temporary threshold shifts of 5 dB within 450 meters after 30 to 50 minutes of exposure. Erbé (2002c) concluded that boats cruising at slow speeds would be audible and would cause masking at 1 kilometers, would elicit behavioral responses at 50 meters, and would result in temporary threshold shifts at 20 meters.

Galli et al. (2003) measured ambient noise levels and source levels of whale-watch boats in Haro Strait. They measured ambient noise levels of 91 dB (at frequencies between 50 and 20,000 hertz) on extremely calm days (corresponding to sea states of zero) and 116 dB on the roughest day on which they took measures (corresponding to a sea state of ~5). Mean sound spectra from acoustic moorings set off Cape Flattery, Washington, showed that close ships dominated the sound field below 10 kilohertz while rain and drizzle were the dominant sound sources above 20 kilohertz. At these sites, shipping noise dominated the sound field about 10 to 30 percent of the time but the amount of shipping noise declined as weather conditions deteriorated. The large ships they measured produced source levels that averaged 184 dB-m ± 4 dB, which was similar to the 187 dB at 1 meter reported by Greene (1995). The engines associated with the boats in their study produced sounds in the 0.5 to 8.0 kilohertz range at source levels comparable to those of killer whale vocalizations. They concluded that those boats in their study that travelled at their highest speeds proximate to killer whales could make enough noise to make hearing difficult for the whales.

In addition to the disturbance associated with the presence of vessel, the vessel traffic affects the acoustic ecology of Southern Resident killer whales, which would affect their social ecology. Foote et al. (2004) compared recordings of Southern Resident killer whales that were made in the presence or absence of boat noise in Puget Sound during three time periods between 1977 and 2003. They concluded that the duration of primary calls in the presence of boats increased by about 15 percent during the last of the three time periods (2001 to 2003). At the same time, Holt et al. (2009) reported that Southern Resident killer whales in Haro Strait off the San Juan Islands in Puget Sound, Washington, increased the amplitude of their social calls in the face of increased sounds levels of background noise. Although the costs of these vocal adjustments remains unknown, Foote et al. (2004) suggested that the amount of boat noise may have reached a threshold above which the killer whales needs to increase the duration of their vocalization to avoid masking by the boat noise.

Commercial shipping traffic is a major source of low frequency (5 to 500 hertz) human generated sound in the world's oceans (Simmonds and Hutchinson 1996; NRC 2003a). The radiated noise spectrum of merchant ships ranges from 20 to 500 hertz and peaks at approximately 60 hertz. Ross (Ross 1976) estimated that between 1950 and 1975 shipping had caused a rise in ambient ocean noise levels of 10 dB; based on his estimates, Ross predicted a continuously increasing trend in ocean ambient noise of 0.55 dB per year. Chapman and Price

(2011) recorded low frequency deep ocean ambient noise in the Northeast Pacific Ocean from 1976 to 1986 and reported that the trend of 0.55 dB per year predicted by Ross (1976) persisted until at least around 1980; afterward, the increase per year was significantly less, about 0.2 dB per year. Within the action area identified in this opinion, the vessel sound inside the western half of the Strait of Juan de Fuca and off the Washington coast comes from cargo ships (86 percent), tankers (6 percent), and tugs (5 percent) (NMFS 2008d citing Mintz and Filadelfo 2004a, 2004b)). Williams et al. (2014a) measured ocean noise levels at 12 sites in the Canadian Pacific Ocean, including Haro Strait, and reported that noise levels were high enough to reduce the communication spaces for fin, humpback and killer whales under typical (median) conditions by 1, 52 and 62 percent, respectively, and 30, 94 and 97 percent under noisy conditions.

Bassett et al. (2012) paired one year of AIS data with hydrophone recordings in Puget Sound's Admiralty Inlet to assess ambient noise levels and the contribution of vessel noise to these levels. Results suggested ambient noise levels between 20 hertz and 30 kilohertz were largely driven by vessel activity and that the increases associated with vessel traffic were biologically significant. Throughout the year, at least one AIS-transmitting vessel was within the study area 90 percent of the time and multiple vessels were present 68 percent of the time. A vessel noise budget showed cargo vessels accounted for 79 percent of acoustic energy, while passenger ferries and tugs had lower source levels but spent substantially more time in the study site and contributed 18 percent of the energy in the budget. All vessels generated acoustic energy at frequencies relevant to all marine mammal functional hearing groups.

9.10 Military Activities

Many researchers have described behavioral responses of marine mammals to the sounds produced by helicopters and fixed-wing aircraft, boats and ships, as well as dredging, construction, geological explorations, etc. (Richardson et al. 1995f). Most observations have been limited to short-term behavioral responses, which included cessation of feeding, resting, or social interactions. Smultea et al. (2008b) documented a recognized "stress behavioral reaction" by a group of sperm whales in response to small aircraft fly-bys. The group ceased forward movement, moved closer together in a parallel flank-to-flank formation, and formed a fan-shaped semi-circle with the lone calf remaining near the middle of the group. In-air noise levels from aircraft can be problematic for marine life, and that sound can also extend into water. Kuehne et al. (2020) found that sounds from military aircraft at Whidbey Island, Washington, were detectable 30 meters below the water surface at levels of 134 dB re 1 μPa rms.

The U.S. Navy conducts training, testing, and other military readiness activities on range complexes throughout coastal and offshore areas in the United States and on the high seas. The U.S. Navy's Northwest Training and Testing range complex overlaps with the action area for the National Science Foundation's seismic survey. During training, existing and established weapon systems and tactics are used in realistic situations to simulate and prepare for combat. Activities include: routine gunnery, missile, surface fire support, amphibious assault and landing, bombing, sinking, torpedo, tracking, and mine exercises. Testing activities are conducted for different purposes and include at-sea research, development, evaluation, and experimentation. The U.S.

Navy performs testing activities to ensure that its military forces have the latest technologies and techniques available to them. The majority of the training and testing activities the U.S. Navy conducts in the action area are similar, if not identical to activities that have been occurring in the same locations for decades, therefore the ESA-listed species located within the action area have been exposed to these military activities often and repeatedly.

The U.S. Navy's activities produce sound and visual disturbance to marine mammals and sea turtles throughout the action area. Anticipated impacts from harassment due to the U.S. Navy's activities include changes from foraging, resting, milling, and other behavioral states that require low energy expenditures to traveling, avoidance, and behavioral states that require higher energy expenditures. Based on the currently available scientific information, behavioral responses that result from stressors associated with these training and testing activities are expected to be temporary and will not affect the reproduction, survival, or recovery of these species. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals and sea turtles. Sound produced during U.S. Navy activities is also expected to result in instances of TTS and PTS to marine mammals and sea turtles. The U.S. Navy's activities constitute a federal action and take of ESA-listed marine mammals and sea turtles considered for these activities have previously undergone separate ESA section 7 consultations. Through these consultations with NMFS, the U.S. Navy has implemented monitoring and conservation measures to reduce the potential effects of underwater sound from activities on ESA-listed resources in the Pacific Ocean. Conservation measures include employing visual observers and implementing mitigation zones during activities using active sonar and explosives.

The Air Force conducts training and testing activities on range complexes on land and in U.S. waters. Aircraft operations and air-to-surface activities may occur in the action area). Air Force activities generally involve the firing or dropping of munitions (e.g., bombs, missiles, rockets, and gunnery rounds) from aircraft towards targets located on the surface, though Air Force training exercises may also involve boats. These activities have the potential to impact ESA-listed species by physical disturbance, boat strikes, debris, ingestion, and effects from noise and pressure produced by detonations. Air Force training and testing activities constitute a federal action and take of ESA-listed species considered for these Air Force activities have previously undergone separate section 7 consultations.

9.11 Scientific Research Activities

Regulations for section 10(a)(1)(A) of the ESA allow issuance of permits authorizing take of certain ESA-listed species for the purposes of scientific research. Prior to the issuance of such a permit, the proposal must be reviewed for compliance with section 7 of the ESA. Scientific research permits issued by NMFS currently authorize studies of ESA-listed species in the Northeast Pacific Ocean, some of which extend into portions of the action area for the proposed action. Marine mammals and sea turtles have been the subject of field studies for decades. The primary objective of most of these field studies has generally been monitoring populations or gathering data for behavioral and ecological studies. Over time, NMFS has issued dozens of permits on an annual basis for various forms of "take" of marine mammals, sea turtles and fish in the action area from a variety of research activities. There have been numerous research permits issued since 2009 under the provisions of both the MMPA and ESA authorizing scientific research on marine mammals and sea turtles, including for research in the action area.

Authorized research on ESA-listed marine mammals includes aerial and vessel surveys, close approaches, photography, videography, behavioral observations, active acoustics, remote ultrasound, passive acoustic monitoring, biological sampling (i.e., biopsy, breath, fecal, sloughed skin), and tagging. Research activities involve non-lethal "takes" of these marine mammals.

Authorized research on sea turtles includes close approach, capture, handling and restraint, tagging, blood and tissue collection, lavage, ultrasound, imaging, antibiotic (tetracycline) injections, captive experiments, laparoscopy, and mortality. Most research activities involve authorized sub-lethal "takes," with some resulting mortality.

Authorized research on fish includes capture, handling and restraint, tagging, blood and tissue sampling, and mortality. Most research activities involve authorized sub-lethal "takes", with some resulting in mortality.

Research permits for ESA-listed fish are authorized under section 10(a)(1)(A) and issued at the West Coast Region, or the research is authorized under section 4(d) rules, for threatened fish. The consultations that took place on the issuance of these ESA scientific research permits each found that the authorized research activities will have no more than short-term effects and were not determined to result in jeopardy to the species or adverse modification of designated critical habitat.

Additional "take" is likely to be authorized in the future as additional permits are issued as additional permits are issued, along with corresponding ESA consultations for any ESA-listed species affected by the issuance of those permits.

9.12 Impact of the Baseline on Endangered Species Act-Listed Species

Collectively, the stressors described above have had, and likely continue to have, lasting impacts on the ESA-listed marine mammals, sea turtles, and fish in the action area likely to be adversely affected by the proposed action. Some of these stressors result in mortality or serious injury to individual animals (e.g., vessel strikes, incidental bycatch, entanglement), whereas others result in more indirect (e.g., fishing that impacts prey availability) or non-lethal (e.g., whale watching) impacts.

We consider the best indicator of the environmental baseline on ESA-listed resources to be the status and trends of those species. As noted in Section 8, some of the species considered in this consultation are experiencing increases in population abundance, some are declining, and for others, their status remains unknown. Taken together, this indicates that the environmental baseline is impacting species in different ways. The species experiencing increasing population abundances are doing so despite the potential negative impacts of the activities described of the environmental baseline. Therefore, while the environmental baseline may slow their recovery, recovery is not being prevented. For the species that may be declining in abundance, it is possible that the suite of conditions described in this *Environmental Baseline* section is limiting their recovery. However, it is also possible that their populations are at such low levels (e.g., due to historical commercial whaling) that even when the species' primary threats are removed, the species may not be able to achieve recovery. At small population sizes, species may experience phenomena such as demographic stochasticity, inbreeding depression, and Allee effects, among others, that cause their limited population size to become a threat in and of itself. A thorough review of the status and trends of each species for which NMFS has found the action is likely to cause adverse effects is discussed in the *Status of Species Likely to be Adversely Affected* section of this opinion.

10 EFFECTS OF THE ACTION

Section 7 regulations define "effects of the action" as all consequences to listed species or critical habitat that are caused by the proposed action, including the consequences of other activities that are caused by the proposed action. A consequence is caused by the proposed action if it would not occur but for the proposed action and it is reasonably certain to occur (50 C.F.R. §402.02). Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action (see 50 C.F.R. §402.17).

This effects analyses section is organized following the stressor, exposure, response, risk assessment framework.

10.1 Definition of Take, Harm, and Harass

Section 3 of the ESA defines take as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct. We categorize two forms of take, lethal and sublethal take. Lethal take is expected to result in immediate, imminent, or delayed but likely mortality. Sublethal take is when effects of the action are below the level expected to cause death, but are still expected to cause injury, harm, or harassment. Harm, as defined by regulation (50 C.F.R. §222.102), includes acts that actually kill or injure wildlife and acts that may cause significant habitat modification or degradation that actually kill or injure fish or wildlife by significantly impairing essential behavioral patterns, including, breeding, spawning, rearing, migrating, feeding, or sheltering. Thus, for sublethal take we are concerned with harm that does not result in mortality but is still likely to injure an animal.

NMFS has not defined "harass" under the ESA by regulation. However, on October 21, 2016, NMFS issued interim guidance on the term "harass," defining it as to "create the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering." For this consultation, we rely on this definition of harass when assessing effects to all ESA-listed species except marine mammals.

Our October 21, 2016, guidance states that our "interim ESA harass interpretation does not specifically equate to MMPA Level A or Level B harassment, but shares some similarities with both levels in the use of the terms 'injury/injure' and a focus on a disruption of behavior patterns. NMFS has not defined 'injure' for purposes of interpreting Level A and Level B harassment but in practice has applied a physical test for Level A harassment." Under the MMPA, harassment is defined as any act of pursuit, torment, or annoyance which:

- Has the potential to injure a marine mammal or marine mammal stock in the wild (Level A Harassment); or
- Has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering (Level B Harassment).

In the following sections, we consider the exposures that could cause an effect on ESA-listed species that are likely to co-occur with the acoustic stressors we have determined are likely to adversely affect these species in space and time, and identify the nature of that co-occurrence. We consider the frequency and intensity of exposures that could cause an effect on ESA-listed species and, as possible, the number, age or life stage, and gender of the individuals likely to be exposed to the action's effects and the population(s) or subpopulation(s) those individuals represent. We also consider the responses of ESA-listed species to exposures and the potential reduction in fitness associated with these responses.

10.2 L-DEO Exposure Analysis

The L-DEO exposure analysis relies on two basic components: (1) information on species distribution (i.e., density within the action area), and (2) information on the level of exposure to sound at which species are likely to be affected (i.e., exhibit some response). In many cases, estimating the potential exposure of animals to anthropogenic stressors is difficult due to limited information on animal density estimates in the action area and overall abundance, the temporal and spatial location of animals; and proximity to and duration of exposure to the sound source. For these reasons, we evaluate the best available data and information in order to reduce the level of uncertainty in making our final exposure estimates.

10.2.1.1 Ensonified Area

In 2003, empirical data concerning 190, 180, and 160 dB re: 1 μPa (rms) distances were acquired during the acoustic calibration study of the R/V *Maurice Ewing*'s airgun array in a variety of configurations in the northern Gulf of Mexico (Tolstoy 2004). At the time, these sound levels represented Level A harassment threshold for pinnipeds and cetaceans, and Level B harassment threshold for marine mammals. In addition, propagation measurements of pulses from the R/V *Marcus G. Langseth*'s 36 airgun array at a tow depth of 6 meters (19.7 feet) have been reported in deep water (approximately 1,600 meters [5,249.3 feet]), intermediate water depth on the slope (approximately 600 to 1,100 meters [1,968.5 to 3,608.9 feet]), and shallow water (approximately 50 meters [164 feet]) in the Gulf of Mexico in 2007 through 2008 (Tolstoy et al. 2009; Diebold et al. 2010). Results of the propagation measurements (Tolstoy et al. 2009) showed that radii around the airguns for various received levels varied with water depth. However, the depth of the airgun array was different in the Gulf of Mexico calibration study 6 meters [19.7 feet]) from in the proposed seismic survey activities (10 to 12 meters [32.8 to 39.4 feet]). Because propagation varies with airgun array depth, correction factors have been applied to the distances reported by Tolstoy et al. (2009).

For deep and intermediate water depth cases, the field measurements in the Gulf of Mexico cannot be used readily to derive MMPA Level A and Level B harassment isopleths, as at those sites the calibration hydrophone was located at a roughly constant depth of 350 to 500 meters (1,148.3 to 1,640.4 feet), which may not intersect all the sound pressure level isopleths at their widest point from the sea surface down to the maximum relevant water depth for marine mammals of approximately 2,000 meters (6,561.7 feet). At short ranges, where the direct arrivals dominate and the effects of seafloor interactions are minimal, the data recorded at the deep and slope sites are suitable for comparison with modeled levels at the depth of the calibration hydrophone. At longer ranges, the comparison with the model, constructed from the maximum sound pressure level through the entire water column at varying distances from the airgun array, is the most relevant.

In deep and intermediate water depths, comparisons at short ranges between sound levels for direct arrivals recorded by the calibration hydrophone and model results from the same airgun array tow depth are in good agreement. Consequently, isopleths falling within this domain can be predicted reliably by the L-DEO model, although they may be imperfectly sampled by measurements recorded at a single depth. At greater distances, the calibration data show that seafloor-reflected and sub-seafloor-refracted arrivals dominate, whereas the direct arrivals become weak and/or incoherent. Aside from local topography effects, the region around the critical distance is where the observed levels rise closest to the model curve. However, the observed sound levels are found to fall almost entirely below the model curve. Thus, analysis of the Gulf of Mexico calibration measurements demonstrates that although simple, the L-DEO model is a robust tool for conservatively estimating isopleths. For deep water depths (greater than 1,000 meters [3,280.8 feet]), L-DEO used the deep water radii obtained from model results down to a maximum water depth of 2,000 meters (6,561.7 feet).

For shallow and intermediate depth waters, L-DEO was able to use site-specific data to calculate the 160 dB and 175 dB re: 1 μPa (rms) isopleths, based on Crone et al. (2014) Crone et al. (2014), empirical data collected on the Cascadia Margin in 2012.

To estimate 160 dB and 175 dB radii in shallow and intermediate water depths, L-DEO used the received levels from multichannel seismic data collected by the research vessel *Marcus G. Langseth* during the 2012 Cascadia Margin survey (Crone et al. 2014), which occurred in the same general area as the proposed 2021 Cascadia Survey. Streamer data in shallow water collected in 2012 have the advantage of including the effects of local and complex subsurface geology, seafloor topography and water column properties and thus allow us to establish mitigation radii more confidently than by using the data from calibration experiments in the Gulf of Mexico (Tolstoy 2004; Tolstoy et al. 2009; Diebold et al. 2010).

10.2.1.2 Exposure Estimates of Endangered Species Act-Listed Marine Mammals

As discussed in the *Status of Species Likely to be Adversely Affected* section, there are eight ESA-listed marine mammal species that are likely to be adversely affected by the proposed action: blue, fin, Central America DPS of humpback, Mexico DPS of humpback, sei, sperm, Southern Resident killer whales and Guadalupe fur seals.

During the proposed action, ESA-listed marine mammals may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder.

Where available, the appropriate seasonal density estimate from the U.S. Navy Marine Species Density Database or CetSound was used in the exposure estimates (i.e., summer). For species with a quantitative density range within or around the action area, the maximum presented density was conservatively used. The approach used here is based on the best available data.

Table 43. Densities used for calculating exposure of ESA-listed cetaceans.

Species	Density (#/km^2) in Shallow Water (< 100 meters)	Density (#/km^2) in Intermediate Water (100 to 1,000 meters)	Density (#/km^2) in Deep Water (> 1,000 meters)	Source
Humpback Whale	0.005420	0.004020	0.000483	(Becker et al. 2016)
Blue Whale	0.002023	0.001052	0.000358	(Becker et al. 2016)
Fin Whale	0.000202	0.000931	0.001381	(Becker et al. 2016)
Sei Whale	0.000400	0.000400	0.000400	(Navy 2019)
Sperm Whale	0.0000586	0.0001560	0.0013023	(Becker et al. 2016)

Densities for Guadalupe fur seals were available within the 200-meter isobath (0.015300 #/km^2) and from the 200-meter isobath to 300 kilometers offshore (0.017100 #/km^2) in summer (Navy 2019). The Permits Division used habitat-based density model data obtained from the Navy (Navy 2019) to calculate the exposure estimates for Southern Resident killer whales using GIS. Density estimates for Southern Resident killer whales from the U.S. Navy's Marine Species Density Database (Navy 2019) were overlaid with GIS layers of the Level B harassment zones in each depth category to determine the areas expected to be ensonified in each density category and to calculate exposure numbers (Figure 44; see Table 46 for the key and colors depicting the densities and the amount of ensonified area in each density area).

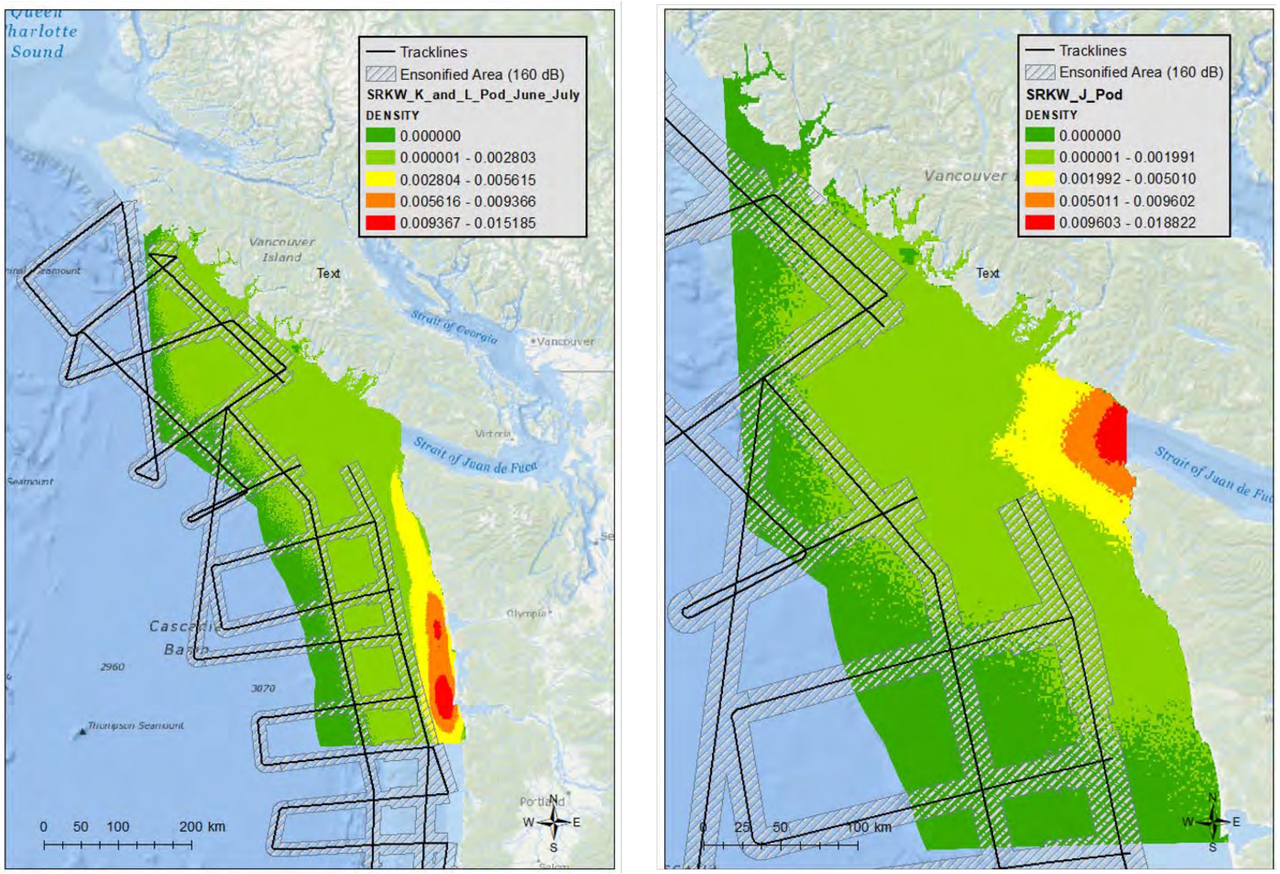

Figure 43. Map of expected densities of Southern Resident killer whales overlaid with the survey tracklines and ensonified area.

Table 44. Southern Resident killer whale densities key.

Pod	Density (animals/km^2)	Ensonified Area (km^2)	Color Key
K/L	0.000000	5,888	Dark Green
	0.000001 - 0.002803	15,470	Light Green
	0.002804 - 0.005615	342	Yellow
	0.005616 - 0.009366	0	Orange
	0.009367 - 0.015185	0	Red
J	0.000000	6,427	Dark Green

Pod	Density (animals/km^2)	Ensonified Area (km^2)	Color Key
	0.000001 - 0.001991	5,556	Light Green
	0.001992 - 0.005010	0	Yellow
	0.005011 - 0.009602	0	Orange
	0.009603 - 0.018822	0	Red

In addition to the density information in this section, we also present information on ESA-listed marine mammals in the action area to describe additional details on the nature of the exposure.

Fin, Sei, Blue and Sperm Whales

Blue, fin, and sei whale habitat in Canadian Pacific waters typically includes the continental shelf break, continental slope, and oceanic waters beyond the shelf break (Canada 2017). According to an analysis of historic whaling records, fin, sei, and male sperm whales occurred in summer along the shelf break of the coastal waters of British Columbia, extending over a large area 75 to 100 kilometers beyond the shelf at the north end of Vancouver. When the action takes place in these areas, we consider it more likely that fin, sei, and male sperm whales would be exposed at that time than they would in other areas. Male sperm whales were more closely associated with the shelf break than females, who appear to distribute much more diffusely throughout the area. (Gregr and Trites 2001). In June and July, we would expect blue whales in the area to be foraging or traveling, likely following the phytoplankton bloom (e.g., for foraging opportunities) (Abrahms et al. 2019). The waters off Vancouver are highly productive and serve as a secondary foraging area for blue whales; blue whales generally move north through Oregon and Washington waters to forage off Vancouver (Burtenshaw et al. 2004b). Blue whales that are exposed to the proposed action off Washington or Oregon would likely be traveling to foraging areas, while those that are exposed off Vancouver would likely be foraging.

Humpback Whales

Individual humpback whales from the Central America, Mexico, and Hawaii DPSs could be present in the action area during the seismic survey. There are two feeding areas in the action area—California/Oregon, and Washington/Southern British Columbia—where we expect humpback whales to be exposed. Individuals from Hawaii are thought to mostly feed in feeding areas from the Aleutian Islands, Alaska, to British Columbia (Ford 2009). There are more individuals from the Mexico and Central America DPSs on the California/Oregon and Washington/Southern British Columbia feeding areas (Wade 2017). The humpback whales we expect to be exposed in the action area are comprised of multiple distinct population segments: Hawaii, Central America, and Mexico. We do not expect individual humpbacks from the ESA-endangered Western North Pacific DPS to be present in the action area, and it will not be considered.

Based on Wade (2017) and the NMFS guidance, we expect that there will be different proportions of the three DPSs present in each of the summer feeding areas. As such, we need to evaluate the proportion of the action area that will occur in each of the summer feeding areas.

Since the proposed action will take place over two feeding areas, we need to determine how humpback whales we expect to occur throughout each of the feeding areas in the action area.

The total survey will cover about 6,540 kilometers of tracklines. The number of tracklines off the coast of Oregon, and presumably those that would occur in the Oregon and California feeding area is 3,207.4 kilometers (49 percent). The number of tracklines in the Southern British Columbia/Washington feeding area is approximately 3,346.9 kilometers (51 percent). By applying these percentages to the total amount of expected number of humpback exposure, we estimated that 72 individual humpbacks would be in British Columbia/Washington feeding area, and 68 individuals in the Oregon area (140 individuals total due to rounding). We then applied the percentages presented in Table 47 to determine the number of individuals from each distinct population segment exposed to the proposed action.

Table 45. Probability of encountering humpback whales from each distinct population segment in the North Pacific Ocean in various summer feeding areas. Adapted from Wade (2017).

Summer Feeding Areas	Western North Pacific Distinct Population Segment	Hawaii Distinct Population Segment	Mexico Distinct Population Segment	Central America Distinct Population Segment
Kamchatka	100%	0%	0%	0%
Aleutian Islands, Bering Sea, Chukchi Sea, Beaufort Sea	2.1%	86.8%	11%	0%
Gulf of Alaska	0.4%	87.2%	12%	0%
Southeast Alaska, Northern British Columbia	0%	96.1%	3.8%	0%
Southern British Columbia, Washington	0%	63.5%	27.9%	8.7%
Oregon, California	0%	0%	32.7%	67.2%

For the Oregon/California feeding area, we estimate that 68 humpback whales would be exposed. By applying the Wade (2017) proportions (Mexico DPS 32.7 percent; Central America DPS 67.2 percent; Hawaii 0 percent), we estimate that the number of individuals from each DPS exposed would be:

- 23 Mexico DPS individuals and
- 47 Central America DPS individuals.

For the British Columbia/Washington feeding area, we estimate that 72 humpback whales would be exposed. By applying the Wade (2017) proportions (Mexico DPS 27.9 percent; Central America DPS 8.7 percent; Hawaii 63.5 percent), we estimate that the number of individuals from each DPS exposed would be:

- 45 Hawaii DPS individuals,
- 20 Mexico DPS individuals, and
- 6 Central America DPS individuals.

The total number of humpback whales exposed for the survey would be:

- Hawaii DPS: 45
- Mexico DPS: 43
- Central America DPS: 53

Only the Mexico and Central America DPSs are listed under the ESA, so we expect 96 total exposures for ESA-listed humpback whales (excluding the 45 exposures for the non-listed Hawaii DPS). We expect all life stages and both sexes to be exposed to the proposed action, and that individuals would be exposed while foraging or traveling to or from feeding areas.

Southern Resident Killer Whales

Based on the available information, we do believe that Southern Resident killer whales will be exposed. The proposed seismic activities will take place starting on June 1, 2021, and last for 37 days, ending on or about July 7, 2021. It is difficult to predict with any degree of certainty where precisely Southern Resident killer whales will be during the seismic survey. Southern Resident killer whale occurrence is believed to be largely driven by prey availability, particularly Chinook salmon.

In summer, Southern Resident killer whales have traditionally occurred with regularity in the inland waters of Washington and British Columbia (e.g., the Strait of Juan de Fuca, Haro Strait, Boundary Pass, Georgia Strait; (Hauser et al. 2007). Because the proposed seismic activities take place in June and into July, one might expect the Southern Resident killer whales to be in the inland waters of Washington and British Columbia, and thus away from the survey and not exposed to the action. Indeed, reports from whale-watching networks regularly document killer whales in the Salish Sea in June and July each year[15], and numerous scientific publications support this area as making up the summertime range of Southern Residents. These observations and studies were the basis for designating the inland waters of Washington as critical habitat for the distinct population segment in 2006.

However, these data, observations, and studies only account for less than half the days of the year, and until relatively recently, there was little known about the population's distribution throughout the year outside of these inland water areas. In the Southern Resident Killer Whale Recovery Plan, there was an emphasis placed on filling this data gap (NMFS 2008d). In order to better understand Southern Residents' outer coastal range, passive acoustic monitoring stations were established off the outer coasts of Washington, Oregon, and California, as well as increased satellite-tagging efforts for Southern Resident killer whales.

For this consultation, we cannot rely on a generalization about Southern Resident killer whale summer range as outside the action area. An examination of Southern Resident killer whale occurrence in spring (April 1 to June 30) over the years 1994 to 2016 showed a decline in habitat use in the Salish Sea in spring (Shields et al. 2018). The Fraser River spring run Chinook experienced a decline in 2005, and Shields et al. (2018) observed that Southern Resident killer whales spent fewer days in the Salish Sea after that time (62.2 days on average from 1994 to 2004, versus 47.75 days from 2005 to 2016). The shift in habitat use is thought to be related to the presence (or absence) of Chinook salmon in the Salish Sea, namely Fraser River Chinook salmon. In the past (2004 to 2008), Southern Resident killer whales preyed mostly upon Chinook salmon from the Fraser River while in the Strait of Juan de Fuca and around the San Juan Islands in summer months (Hanson et al. 2010a). It is possible that the Southern Resident killer whales are changing their habitat use in order to find adequate prey. In addition to the information presented above, reports from local media and killer whale sighting networks indicate that Southern Resident killer whales are much less prevalent or even conspicuously absent from their expected summer range in the Salish Sea in the last few years.[16] [17]

Acoustic monitoring efforts have indicated that waters outside the inland waters of the Salish Sea are used by the Southern Resident killer whales to a significant degree. Acoustic monitoring stations at Swiftsure Bank, off the southern coast of Vancouver Island, detected Southern Resident killer whales every month of the year between 2009 and 2011, with a peak in summer months (June, July, and August) (Riera et al. 2019). All three pods were detected at least once in every month with a few exceptions. J pod was not detected in January or November, and L pod was not detected in March (Riera et al. 2019). K and L pods were frequently detected together,

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[15] http://www.orcanetwork.org/Archives/index.php?categories_file=Sightings%20Archives%20Home (Accessed 2/17/2021).

[16] https://www.seattletimes.com/seattle-news/environment/where-are-the-southern-resident-orcas-researchers-see-longest-absence-ever-from-summer-waters/ (Accessed 2/17/2021)

[17] http://www.orcanetwork.org/Archives/index.php?categories_file=Sightings%20Archive%20-%20Jul%2019 (Accessed 2/17/2021)

with the longest encounter durations occurring in May through September. At an acoustic monitoring station at Cape Elizabeth, Washington, on the edge of the continental shelf, Southern Resident killer whales were detected in January through June, and in October (Rice et al. 2017).

Through passive acoustic monitoring, Southern Resident killer whales were detected in every month from January to June off the outer coast of Cape Flattery, Washington. Detection rates of Southern Resident killer whales in coastal waters from Cape Flattery, Washington, to Point Reyes, California, were greater in 2009 to 2011 than in 2006 to 2008 (Hanson et al. 2013). J pod individuals were only detected on the northern-most recorders (near Cape Flattery), and then only infrequently. K and L pods were also detected off California in January, February, May, and December (Hanson et al. 2013; NMFS 2019c).

We cannot say with certainty where precisely we expect Southern Resident killer whales to be at the time of the proposed survey, but based on the available studies and acoustic data, Navy density data, and sightings reports, we cannot assume that the Southern Residents will definitely be in the inland waters of Washington and British Columbia during the proposed action. It is possible that the Southern Resident killer whales could be exposed to the proposed action if they are foraging in the coastal waters within the action area (see Figure 44).

Based on satellite tagging, acoustic recording data, and opportunistic sightings, Southern Resident killer whales spend most (96.5 percent) of their time on the continental shelf, within 34 kilometers of shore in waters less than 200 meters deep (NMFS 2019c). Five percent of locations were within two kilometers of shore, and five percent beyond 34 kilometers. 77.7 percent of satellite tag locations occurred in waters less than 100 meters deep, and only 5.3 percent were in waters less than 18 meters deep (NMFS 2019c). High-use areas included the Washington outer coast, (53.1 percent of their time spent there), and about 19 percent between Grays Harbor (southern Washington) and the Columbia River (i.e., the Oregon/Washington border) (NMFS 2019c). When the seismic survey is occurring in these areas, we expect the likelihood of exposure to be greater.

We would expect individuals of all age classes and both sexes to be exposed, from each of the three pods.

The Permits and Conservation Division used Navy density data (Navy 2019) and GIS to calculate the number of Southern Resident killer whale exposure during the proposed action. The Navy density data is depicted in Figure 44 and Table 46. Because individuals from K and L pods tend to travel together, with J pod traveling as a group, this led the Navy to calculate densities for J pod separately, and K and L pods together (Riera et al. 2019). The total number of exposures and exposures by pod are presented in Table 48 below.

Table 46. Modelled exposures for Southern Resident killer whales.

Southern Resident Killer Whale Pod	Number of Exposures
K and L Pod	9
J Pod	2
Total for the DPS	**11**

The modelled exposures are for Southern Resident killer whales throughout the entire action area, in the U.S. EEZ and the territorial waters of Canada.

Guadalupe Fur Seals

Guadalupe fur seals strand almost annually in California, and are observed in increasing numbers in Oregon and Washington (Carretta 2019a). The current Unusual Mortality Event for Guadalupe fur seals is ongoing; in 2019, over 90 Guadalupe fur seal pups and juveniles have stranded in Oregon and Washington.[18] In June, adult males and females arrive at their colonies to breed and pup; breeding colonies for the species are on Guadalupe Island and San Benito Island, Mexico, with a purported breeding colony on San Miguel Island, of the Channel Islands, California, all far outside the action area.

With the population increasing, the broad range of the species at sea, and strandings in the area, we do expect Guadalupe fur seals to be in the action area and be exposed to the proposed action. Because the seismic activities take place in June and July, during breeding and pupping season, we do not think adult Guadalupe fur seals would be exposed to the proposed action. Based on strandings in the area, we expect that juveniles and pups of both sexes would be exposed to the proposed action. These stranded animals are showing signs of malnutrition with secondary bacterial and parasitic infections, so it is possible that exposed Guadalupe fur seals would already be compromised when exposed to the seismic activities.

Exposure Summary

To summarize, the number of ESA-listed marine mammals exposed to the proposed seismic activities are presented in Table 49.

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[18] https://www.fisheries.noaa.gov/national/marine-life-distress/2015-2019-guadalupe-fur-seal-unusual-mortality-event-california (Accessed 3/8/2021)

Table 47. Number of total exposures of ESA-listed marine mammals in the entire action area during National Science Foundation's seismic survey in the Northeast Pacific Ocean.

Species	Total Number of Exposures
Blue Whale	59
Fin Whale	97
Humpback Whale – Central America DPS	53
Humpback Whale – Mexico DPS	43
Sei Whale	33
Sperm Whale	73
Killer whale—Southern Resident DPS	11
Guadalupe Fur Seal	2,161

As discussed in Section 4.1, parts of the action area take place in the territorial waters of Canada, and we are not able to authorize take in those waters. However, we must estimate the amount of ESA-listed species that could be exposed throughout the entire action area in making our jeopardy determination; in this case, that means the entire ensonified area for the proposed action.

The NSF and the L-DEO provided exposure estimates both inside and outside Canadian territorial waters, representing all potential exposures no matter where they might occur. Those estimates are presented in Table 49.

10.2.1.3 Exposure Estimates of Endangered Species Act-Listed Sea Turtles

As discussed in the *Status of Species Likely to be Adversely Affected* section, there is one ESA-listed sea turtle species that is likely to be affected by the proposed action: leatherback turtles.

During the proposed action, ESA-listed sea turtles may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder.

Density Estimates and Modeled Exposure

The L-DEO used a similar method to calculate exposure for leatherback sea turtles as that for marine mammals. In the case of leatherback sea turtles, the L-DEO used the 175 dB threshold to create a buffer in GIS representing the ensonified area within each of the three water depth categories (< 100 meters, 100 to 1000 meters, and >1000 meters). The L-DEO used density estimates from (Navy 2019) (0.000114 #/km^2) to obtain an estimated 3 leatherback sea turtles exposed. The modeled exposures are all expected to occur outside Canadian territorial waters (and elsewhere throughout the action area) because leatherback sea turtles forage in deeper waters (200 meters deep or more), and these waters are beyond the 12 nautical mile line of Canadian territorial waters.

In U.S. Pacific waters, leatherbacks forage in shelf waters between the 200-meter and 2,000-meter isobaths (77 FR 4169). An examination of 122 opportunistic sightings of leatherback sea turtles in Canadian Pacific waters, most of them were in waters from the continental shelf to 200 meters deep, with fewer in waters 1,500 meters deep and offshore waters (Gregr 2015). There is considerable bias associated with these sightings as they were not part of a systemic survey, but they do allow us to reasonably believe that leatherback sea turtles are likely to be exposed to seismic activities during the proposed action. Depth is considered a factor in leatherback sea turtle occurrence in the Canadian Pacific, as there is evidence that indicates they preferentially forage in on-shelf areas; sea surface temperature is also an important factor in predicting occurrence (with a potential thermal limit of 13 degrees Celsius) (Benson et al. 2011a; Gregr 2015).

Leatherback sea turtles arrive on foraging grounds off the U.S. West Coast primarily in April through July (Benson et al. 2011a). The majority of sightings in the Canadian Pacific are between July and September (Gregr 2015). Because of the timing and location of the action, we expect that the three exposed leatherback sea turtles would be foraging or transiting to foraging areas at the time of the action. Adults of both sexes could be exposed to the proposed action.

10.2.1.4 Exposure Estimates of Endangered Species Act-Listed Fishes

As discussed in the *Status of Species Likely to be Adversely Affected* section, there are seven ESA-listed fish species that are likely to be adversely affected by the proposed action: Southern DPS green sturgeon, southern DPS eulachon, ESA-listed ESUs or DPSs of Chinook, Coho, chum, sockeye, and steelhead (Table 5).

During the proposed action, ESA-listed fishes may be exposed to sound from five sound sources: the airgun array, multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder. The National Science Foundation, L-DEO, and NMFS Permits and Conservation Division did not provide estimates of the expected number of ESA-listed fishes in the area of these sound sources.

Salmonid Presence in the Marine Environment

The seismic survey will take place over a broad range of ocean habitats, from the nearshore, shallow waters off the coasts of Oregon, Washington, and Vancouver, the continental shelf, the continental slope, and the offshore oceanic area beyond the slope. This action area will encompass a variety of habitats for ESA-listed species, and different habitats are more likely to host one species or another based its habitat requirements. For the ESA-listed fish species considered in this consultation, the continental shelf is a very important habitat. The continental shelf off the U.S. West Coast is the area from the intertidal zone to the 200 meter depth contour

(656 feet), which is typically 8 to 60 kilometers from shore (NMFS 2015d). The survey tracklines come close to shore, as close as about 14 kilometers in some places, and the furthest tracklines are over 300 kilometers from shore.

The total number of tracklines proposed for the survey is about 6,540 kilometers. About 1,964 kilometers will take place in waters less than 200 meters deep in the waters of the continental shelf (30 percent of the total survey).

The survey will take place starting in June, and last for 37 days. The timing and location of the survey means that ESA-listed fishes of different life stages will be exposed. The overall amount of tracklines over the continental shelf (less than 200 meters deep) is 1,964 kilometers, and it would take the R/V *Marcus G. Langseth* approximately 252 hours, or about 10.5 days, to complete seismic activities on those lines. This is a relatively short amount of time over which ESA-listed Chinook (and other salmonids) could be exposed. The survey would collect data on the tracklines in those areas, and then move on to other parts of the action area, meaning that the duration of exposure would be limited. In total, there will be about 11,150 km^2 of ensonified area (to the TTS threshold for fish) occurring in continental shelf waters. This amounts to approximately 11.8 percent of the entire survey. The tracklines in waters less than 200 meters deep are spread out over the entire survey area, with more occurring off of northern Vancouver and Oregon than Washington (due to the revisions to lines in those areas, see Figure 3).

The tracklines were revised to avoid areas off Washington and Vancouver due to concerns over exposure of Southern Resident killer whales, where they could be foraging primarily on Chinook salmon, if they were in coastal areas during the time of the proposed action. Coastal Washington waters and the La Perouse and Swiftsure banks off Vancouver are relatively shallow, and considered very productive for Chinook and other salmonids (Healey et al. 1990; Peterson et al. 2010). By avoiding these areas to reduce exposure of Southern Resident killer whales that may be foraging there, the proposed action would also avoid these areas where Chinook and other salmonids occur, reducing exposure of those species. In the places where the tracklines will be in continental shelf waters less than 200 meters deep, like northern Vancouver and coastal Oregon, we do not expect high densities of Southern Resident killer whales (see Figure 44) (Navy 2019).

Salmonids

There are several ESA-listed DPSs or ESUs of Pacific salmonids that could occur in the action area during their oceanic life phase, including:

- Snake River Spring/Summer Run ESU of Chinook salmon,
- Snake River Fall Run ESU of Chinook salmon,
- California Coastal ESU of Chinook salmon,
- Central Valley Spring Run ESU of Chinook salmon,
- Sacramento River Winter Run ESU of Chinook salmon,
- Lower Columbia River ESU of Chinook salmon,
- Puget Sound ESU of Chinook salmon,
- Upper Willamette River ESU of Chinook salmon,

- Upper Columbia River Spring Run ESU of Chinook salmon,
- Columbia River ESU of chum salmon,
- Hood Canal Summer Run of chum salmon,
- Central California Coast ESU of Coho salmon,
- Lower Columbia River ESU of Coho salmon,
- Oregon Coast ESU of Coho salmon,
- Southern Oregon Coast ESU of Coho salmon,
- Ozette Lake ESU of sockeye salmon,
- Snake River ESU of sockeye salmon,
- Lower Columbia River DPS of steelhead trout,
- Middle Columbia River DPS of steelhead trout,
- Puget Sound DPS of steelhead trout,
- Snake River DPS of steelhead trout,
- Snake River Basin DPS of steelhead trout,
- Northern California DPS of steelhead trout,
- California Central Valley DPS of steelhead trout,
- Central California Coast DPS of steelhead trout,
- South-Central California Coast DPS of steelhead trout,
- Upper Columbia River DPS of steelhead trout, and
- Upper Willamette River DPS of steelhead trout

There is some uncertainty about precisely where in the Pacific Ocean these (or any) salmonids go (Meyers 1998); based on what we do understand, however, the DPSs or ESUs noted above are likely to be present, because salmon form mixed stock aggregations during their time in the ocean (Bellinger et al. 2015). The following sections will discuss the life stages likely to be exposed and the distributions of the Pacific salmon and steelhead DPSs or ESUs in relation to the proposed action area.

Salmon Life Stages Present

Due to the timing and location of the proposed seismic survey, we expect both juvenile and adult salmon and steelhead to be exposed to the action. The marine environment represents very important habitat for salmon and steelhead during critical phases of their life cycle. This includes:

- Juveniles when they are entering the marine environment from their natal rivers,
- Juveniles already in the marine environment for their growth phase, and
- Pre-spawning adults that are returning to their natal rivers to spawn.

While not every population of Pacific salmon and steelhead may be exposed during their entry into the ocean or during their spawning run due to the location and timing of the proposed action, we still expect them to be exposed while in the marine environment. Pacific salmonids spend a few years in the ocean during their growth phase, and could be exposed to the proposed seismic activities then.

Estuaries represent important habitat for both juvenile and adult salmon. Adults use coastal areas near their natal rivers as staging areas before moving into freshwater to spawn. Residence times for adults in staging areas can vary from one to six weeks. Juveniles can remain in the estuaries for four days (chum) to up to six months (Chinook) before entering the marine environment (Simenstad et al. 1982), likely using the areas to adjust to higher salinity water. Where the action area overlaps with the staging areas for various salmon populations, both juveniles and adults could be exposed. In some areas, especially at the southern end of the survey near Oregon where the tracklines are close to shore, sound from the seismic airguns could enter estuaries and coastal areas where salmon are staging.

In order to be exposed to the proposed action when entering the marine environment, the juvenile salmon or steelhead must be exiting from a river that is in the action area (or drains into a river system in the action area, i.e., the Snake River). For this action, that would include rivers in Oregon and Washington. Juveniles entering the ocean from rivers in California would not be exposed at that time of entry. However, juveniles from rivers south of the action area may still be exposed to the proposed seismic activities in the marine environment since juvenile salmon and steelhead form mixed stock aggregations there. In addition, juvenile salmon and steelhead may also be exposed after they enter the marine environment during their migration to their preferred marine growth location. For example, juvenile sockeye enter the ocean and use coastal waters to migrate northward to southeast Alaska, and juvenile chum move northward to the Gulf of Alaska.

The specific spawning migration and entry timing varies by species and distinct population segment or evolutionarily significant unit. See the tables below for information on migration timing by species. Here, we refer to adult salmonids present in their natal rivers and moving upriver to spawn as "adult spawning migration timing" and juveniles leaving their natal rivers to enter the ocean for their growth phase as "juvenile entry into marine environment".

As discussed earlier, Pacific salmonids form mixed stock aggregations in the marine environment. In the case of Chinook salmon, individuals from a broad area are found in the coastal waters of the action area.

In a fishery-dependent study from May to September in the coastal waters of Oregon and northern California, Bellinger et al. (2015) identified Chinook salmon from numerous river systems from Alaska to the Central Valley, California. Stock richness was highest in the northern part of the sampling area than in the south. In a study of killer whale prey collection from off the coasts of Oregon and Washington, Chinook from a broad area were found in fecal samples, including fish from the Middle Fraser River, Canada, Puget Sound, Washington, the Columbia River, Oregon and Washington, the Snake River, Washington and Idaho, the Klamath River, California, the Central Valley (Sacramento and San Joaquin Rivers), California, and the Taku River in southeast Alaska (NMFS 2019c).

Based on this information, we are examining Chinook salmon distinct population segments or evolutionarily significant units from a broad area. The timing of their spawning runs and entry into the ocean are shown in Table 52.

Table 48. Spawning Migration and Entry Timing for Chinook Salmon Distinct Population Segments/Evolutionarily Significant Units

Chinook Distinct Population Segment/Evolutionarily Significant Unit	Chinook Adult Spawning Migration Timing	Chinook Juvenile Entry into Marine Environment
Puget Sound	April to May: Spring-run June to July: Summer-run Fall-run: August to September (Myers 1998)	Spring-run: May to June Summer and fall-run: April to July (Myers 1998)

Chinook Distinct Population Segment/Evolutionarily Significant Unit	**Chinook Adult Spawning Migration Timing**	**Chinook Juvenile Entry into Marine Environment**
Upper Columbia River Spring Run	Late March to May, peak in mid-May.	April to June; Peak numbers in May. All enter Canadian waters by end of June. (Myers 1998; Fisher et al. 2014a)
Lower Columbia River	March to June: Spring-run August to October: Fall-run	March to September (Peak numbers April to June): Spring-run March to September (Peak numbers in September): Fall-run (Fisher et al. 2014a)
Upper Willamette River	February to August, peak from April to late May. (Myers 1998)	March to September, peak numbers in June. (Myers 1998; Fisher et al. 2014a)
Snake River Spring-Summer	March to May. Spawning adults present along the Washington Coast and Columbia River plume. Peak numbers in May. (DART 2013)	April to June, peak numbers in May. All entering Canadian waters by June. (Myers 1998; Fisher et al. 2014a)
Snake River Fall Run	August to October: Spawning adults present along the Washington Coast and Columbia River plume (Peak numbers in September).	June to November: No significant peak. All entering Canadian waters by end of November. (Myers 1998; Fisher et al. 2014a)

Chinook Distinct Population Segment/Evolutionarily Significant Unit	Chinook Adult Spawning Migration Timing	Chinook Juvenile Entry into Marine Environment
	(DART 2013)	
California Coastal	September to early November (Moyle et al. 2017)	February to June (Moyle et al. 2017)
Central Valley Spring-Run	March to July (Myers 1998)	February to June, peaks April to May (Cordoleani et al. 2018)
Sacramento River Winter-Run	November to June (Myers 1998; Moyle et al. 2017)	January through May, peaking in mid-March (Moyle et al. 2017)

Adult individuals from DPSs or ESUs that migrate to spawn after July and August would likely be moving to or already in coastal staging areas, in estuaries or in the mouths of rivers within the action area, preparing to move upstream later in the season. These individuals could be exposed to the seismic survey and include:

- Puget Sound ESU, fall run
- Lower Columbia River ESU, fall run
- Snake River Fall Run ESU

The survey would occur in June and into July. The information presented in Table 52 for adult spawning migration timing refers the periods when adults are in their natal rivers, moving upstream to the spawning sites. This information comes from tagging studies recording tagged salmon as they pass upstream. We do not expect individuals from the other adult Chinook salmon distinct population segments or evolutionarily significant units listed in Table 52 to be exposed to seismic activities during their upstream migration.

The seismic survey does not take place in California waters, so it would not expose adult individuals from ESUs originating in California while they were staging in coastal waters. However, since Pacific salmon form mixed stock aggregations in the marine environment, it is possible that adults from the following populations could be exposed while moving through the action area to their natal rivers:

- California Coastal ESU

- Sacramento River Winter-run ESU

We expect individuals from the following juvenile Chinook salmon distinct population segments or evolutionarily significant units to be exposed to seismic activities during their entry into the marine environment in the action area:

- Puget Sound ESU: Summer and fall runs
- Lower Columbia River ESU: Spring and fall runs
- Upper Willamette River ESU
- Snake River Fall-Run ESU

Coho

Coho salmon enter the ocean in spring of their second year, and spend the next few years in the ocean, as they grow from smolts to adults, before the adults return to freshwater to spawn, usually in fall or early winter of their third year (Cole 2000). Spawning migration times and marine entry times for Coho salmon are shown in Table 53.

Table 49. Spawning Migration and Entry Timing for Coho Salmon Distinct Population Segments/Evolutionarily Significant Units

Coho Distinct Population Segment/Evolutionarily Significant Unit	Coho Adult Spawning Migration Timing	Coho Juvenile Entry into Marine Environment
Lower Columbia River ESU	Mid-September to mid-November (Fulton 1970)	March to July (Bell 1990)
Oregon Coast ESU	October to December (Weitkamp et al. 1995)	March to July Bell 1990
Southern Oregon/Northern California ESU	September to October (Weitkamp et al. 1995; Moyle et al. 2017)	March to May (Moyle 2002a)
Central California Coast DPS	November to January (Weitkamp et al. 1995; Moyle et al. 2017)	March to May Moyle 2002

Adult Coho from the Central California distinct population segment or the Southern Oregon/Northern California evolutionarily significant units may be exposed to the proposed action while in the marine environment or while transiting to their natal streams. Adult Lower

Columbia River and Oregon Coast Coho may be exposed while in the marine environment. We do expect the following juvenile Coho to be exposed as they enter the marine environment from their natal rivers:

- Lower Columbia River ESU
- Oregon Coast ESU

Juvenile Coho from any distinct population segment or evolutionarily significant unit may be exposed to the proposed action while in the marine environment.

Chum

Upstream spawning migration times and marine entry times for chum salmon are shown in Table 54.

Table 50. Spawning Migration and Entry Timing for Chum Salmon Evolutionarily Significant Units

Chum Distinct Population Segment/Evolutionarily Significant Unit	Chum Adult Spawning Migration Timing	Chum Juvenile Entry into Marine Environment
Hood Canal Summer-Run ESU	Mid-August to mid-October, peak in September (Johnson et al. 1997b)	February to early April (Tynan 1997)
Columbia River ESU	Early October to mid-November (Johnson et al. 1997b)	March to May Washington Department of Fish and Wildlife, 2019

Adult chum salmon that are in coastal staging areas before entering their natal rivers to spawn. Hood Canal is in Puget Sound, and not in the action area, so adults from the Hood Canal Summer-Run ESU will not be exposed at that time, but could be exposed while in the marine environment transiting into that area. Due to the timing of the entry into the marine environment, we do not expect any juvenile chum salmon to be exposed during those times. Immature and maturing chum salmon are distributed widely throughout the offshore waters of the Gulf of Alaska, outside the action area (Salo 1991a). After entering the ocean, juvenile chum migrate northward from the Columbia River and Hood Canal along the coast until reaching Alaska (Johnson et al. 1997b). Because they enter the marine environment as late as May, juvenile chum could be exposed to the proposed action in June and July while they are traveling north, especially those from the Columbia River, which is within the action area.

Sockeye

Spawning migration times and marine entry times for sockeye salmon are shown in Table 55.

Table 51. Spawning Migration and Entry Timing for Sockeye Salmon Evolutionarily Significant Units

Sockeye Distinct Population Segment/Evolutionarily Significant Unit	Sockeye Adult Spawning Migration Timing	Sockeye Juvenile Entry into Marine Environment
Ozette Lake ESU	Mid-April to mid-August (Peak: May and June) (NMFS 2009c)	March to June (Peak: April and May) (NMFS 2009c)
Snake River ESU	June to July (NMFS 2015c)	May to mid-June (Tucker et al. 2015)

Due to the timing of their spawning runs, we do not expect the adult sockeye Snake River ESU to be exposed to the proposed seismic activities since they are expected to be in the river at the time of the proposed action. Ozette Lake ESU adult sockeye salmon return from the ocean to Lake Ozette from mid-April to mid-August, and thus could be exposed to the proposed action.

Upon leaving the Ozette River and entering the ocean, juveniles undergo a rapid northward migration along the coast to southeast Alaska, arriving by mid-June to July (Tucker et al. 2015). Juveniles from the Columbia River plume undergo a northward similar migration (the Snake River feeds into the Columbia River), but enter the ocean a little later than Ozette Lake sockeye juveniles. By fall, both ESUs are absent from the continental shelf (Gustafson et al. 1997; Tucker et al. 2015). Because the proposed seismic activities will take place in June and July, and the survey will extend all the way to Vancouver Island in the north, we expect migrating juvenile sockeye salmon to be exposed to the proposed action.

Steelhead

Spawning migration times and marine entry times for steelhead are shown in Table 56.

Table 52. Spawning Migration and Entry Timing for Steelhead Evolutionarily Significant Units

Steelhead Distinct Population Segment/Evolutionarily Significant Unit	Steelhead Adult Spawning Migration Timing	Steelhead Juvenile Entry into Marine Environment
Puget Sound DPS	November to Mid-June: Winter-run	March to June Bell 1990

Steelhead Distinct Population Segment/Evolutionarily Significant Unit	Steelhead Adult Spawning Migration Timing	Steelhead Juvenile Entry into Marine Environment
	April to November: Summer-run Bell 1990 (Busby et al. 1996b)	
Upper Columbia River DPS	November to May June to Early August: "A-run" Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Middle Columbia River DPS	November to May June to Early August: "A-run" Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Lower Columbia River DPS	Late February to Early June: Spring-run November to May: Winter-run Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Upper Willamette River DPS	February to March: Late winter-run (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)
Snake River Basin DPS	June to Early August: "A-run" August to October: "B-run" Bell 1990 (Busby et al. 1996b)	Mid-April to Early June (Daly et al. 2014)

Steelhead Distinct Population Segment/Evolutionarily Significant Unit	Steelhead Adult Spawning Migration Timing	Steelhead Juvenile Entry into Marine Environment
Northern California Coast DPS	March to August: Summer-run September to November: Winter-run (Busby et al. 1996b; Moyle et al. 2017)	March to June (Moyle et al. 2017)
California Central Valley DPS	August to October (Busby et al. 1996b; Moyle et al. 2017)	March to May Busby et al. 1996; Moyle et al. 2017 (Moyle et al. 2017)
Central California Coast DPS	October to November (Busby et al. 1996b; Moyle et al. 2017)	January to June Busby et al. 1996; Moyle et al. 2017 (Moyle et al. 2017)
South-Central California DPS	January to May (Moyle et al. 2017)	January to May (Moyle et al. 2017)

For adult steelhead populations originating in California (California Central Valley DPS, Central California Coast DPS, South Central California DPS), we do not expect these individuals to be exposed to the proposed action while in their staging areas, because California rivers are outside the action area. Adult steelhead of other populations could be exposed to the proposed seismic activities while in the marine environment, possibly while transiting to staging areas near their natal rivers.

Due to the timing of the action, we do not expect juvenile steelhead distinct population segments while entering the ocean. All juvenile steelhead could potentially be exposed to the proposed action while in the marine environment.

Salmonid Exposure: Water Depth

The seismic survey tracklines will be in water depths from 60 to 4,400 meters, and will overlap in areas where we expect Chinook, Coho, chum, sockeye, and steelhead to be exposed. In order to assess exposure for Pacific salmon in this consultation, we need to establish where the species will be in relation to the seismic survey. This means considering two spatial factors: where the Pacific salmon and steelhead occur in relation to shore (e.g., in what water depths, along what oceanographic feature), and examining where in the water column they occur.

Chinook salmon are commonly found in the California Current, in nearshore environments. Thermal conditions are likely an important factor in their habitat use. In late summer and autumn (late July to November), tagged Chinook occupied cool areas (9 to 12 degrees Celsius), (Hinke et al. 2005). It is thought that the cool, upwelled water in the coastal shelf serves as a migratory corridor and feeding ground for Chinook and Coho (Bellinger et al. 2015).

Adult Coho salmon are found on the continental shelf from southeast Alaska to Monterey Bay, California (Weitkamp and Neely 2002a; Beacham et al. 2016). Some adults migrate to the offshore waters of the North Pacific (Quinn et al. 2005). Juveniles are initially found in the nearshore environment before moving to the continental shelf area with the adults (Beacham et al. 2016).

In June, in the continental shelf and oceanic waters off the coast of Washington, the average depth at capture for Coho was 85.6 meters, and 55 meters for Chinook, with Coho ranging further offshore. In June, 80 percent of yearling Coho and Chinook were found in the nearshore zone (about 30 meters water depth) to water depths of 124 and 83 meters, respectively (Peterson et al. 2010). In another sturdy, juvenile Chinook salmon were most frequently captured in waters less than 37 meters deep (Fisher 1995) near the Columbia River off Oregon and Washington between May and September.

Immature and maturing chum salmon are distributed widely throughout the offshore waters of the Gulf of Alaska, outside the action area (Salo 1991a). After entering the ocean, juvenile chum migrate northward from the Columbia River and Hood Canal along the coast until reaching Alaska (Johnson et al. 1997b).

Juvenile sockeye salmon use a narrow band along the coast to rapidly move northward from their natal river, leaving it in mid-May to mid-June, and arriving in the Gulf of Alaska by mid-June to mid-July. Adult sockeye salmon distribute widely in the offshore waters of the Gulf of Alaska (Gustafson et al. 1997; Tucker et al. 2015).

Adult steelhead occur in the north Pacific in the oceanic waters off the continental shelf. When they reach maturity, they migrate east back over the continental shelf to their natal rivers (Quinn 2005). In contrast to other juvenile salmon that use a north-south coastal migration route, juvenile steelhead quickly migrate west after leaving their natal rivers to the oceanic waters past the continental shelf. These movements can take as little as one to three days, with an average of ten days (Daly et al. 2014).

As described earlier, the airgun array will be towed at a depth of 12 meters. In a study conducted in fall (September and October) and winter (January to February) in the eastern Bering Sea, salmon most often occupy the upper level of the water column, with some variation by species and life stage (Walker et al. 2007). Some immature Chinook, sockeye, and chum were captured at depths between 30 and 60 meters, in addition to being caught in waters above 30 meters deep. Chinook and chum have the deepest vertical distributions, with Chinook having an average depth of 42 meters (average daily maxima of 130 meters deep), and chum occupying an average depth of 16 meters (average daily maxima of 58 meters) (Walker et al. 2007). Coho were found at an average depth of 11 meters, with an average daily maxima of 46 meters, and sockeye found at an average depth of 3 meters (average daily maxima of 19 meters) (Walker et al. 2007).

Both juvenile and adult steelhead are regarded as being surface-oriented, occupying the upper 10 meters of the water column (Light et al. 1989). Adult sockeye salmon occupy the upper 30 meters of the water column, with most occupying in the upper 10 meters (Quinn et al. 1989; Ogura and Ishida 1995). Juvenile sockeye are mostly found in the upper 15 meters of the column (Beamish et al. 2007).

Because steelhead occupy off shelf waters, we expect juvenile and adult steelhead to be exposed further offshore during the proposed action (in contrast to other Pacific salmon that mostly occupy continental shelf waters). Juvenile steelhead could be exposed to seismic activities during their off shelf movements.

Salmonid Density

For each ESA-listed salmon ESU, eulachon ESU and steelhead DPS, we estimated a density of animals in the action area based on information regarding the species' distribution and abundance. For abundance data, we used the 2020 biological opinion analyzing the effects of sixteen ESA Section 10(a)(1)(A) Scientific Research Permits in Oregon, Washington, Idaho and California affecting Salmon, Steelhead, Eulachon, Green Sturgeon and Rockfish in the West Coast Region (NMFS 2020). This information is presented in Table 57 by life stage and origin (i.e., natural, hatchery intact adipose fin, and hatchery adipose clip). ESA take prohibitions do not apply to hatchery fish with clipped adipose fins from threatened ESUs/DPSs.

Table 53. Summary of estimated annual abundance of ESA-listed salmonids. Abundance estimates for each ESU and DPS are divided into natural, listed hatchery intact adipose, and listed hatchery adipose clip (NMFS 2020)[19].

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
Sacramento River winter-run Chinook	Adult	210	-	2232
	Smolt	195,354	-	200,000
Central Valley spring-run Chinook	Adult	3,727	-	2,273
	Smolt	775,474	-	2,169,329
California Coastal Chinook	Adult	7,034	-	-

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[19] Adult abundance numbers represent the total number of spawners. These do not factor in adults in the ocean environment.

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
	Smolt	1,278,078	-	-
Snake River fall Chinook	Adult	10,337	13,551	15,508
	Smolt	692,819	2862418	2483713
Snake River spring/summer Chinook	Adult	12,798	421	2,387
	Smolt	1,007,526	775,305	4,453,663
Lower Columbia River Chinook	Adult	29,469	38,594[1]	-
	Smolt	11,745,027	962,458	31,353,395
Upper Willamette River Chinook	Adult	10,203	31,476[1]	-
	Smolt	1,211,863	157	4,709,045
Upper Columbia River spring Chinook	Adult	2,872	3364	6,226
	Smolt	468,820	368,642	621,759
Puget Sound Chinook	Adult	22,398	15,543[1]	-
	Smolt	3,035,288	7,271,130	36,297,500
Hood Canal summer run chum	Adult	25,146	1,452	-
	Smolt	3,889,955	150,000	-
Columbia River chum	Adult	10,644	426	-
	Smolt	662,6218	601,503	200,000
Central California Coast Coho	Adult	1,932	327	559
	Smolt	158,130	165,880	60,000
Southern Oregon/Northern California Coast Coho	Adult	9,065	10,934	-
	Parr	2,013,593	575,000	7,287,647
Oregon Coast Coho	Adult	94,320	0	-
	Parr	6,641,564	0	-
Lower Columbia River Coho	Adult	29,866	8,791	-
	Smolt	661,468	249,784	-
Ozette Lake sockeye	Adult	5,036[2]	0	0
	Smolt	1,037,787	259,250	45,750
Snake River sockeye	Adult	546	-	4,004
	Smolt	19,181	-	242,610
South-Central California steelhead	Adult	695	-	0
	Smolt	79,057	-	0
Central California Coast steelhead	Adult	2,187	-	3,866
	Smolt	248,771	-	648,891
California Central Valley steelhead	Adult	1,686	-	3,856
	Smolt	630,403	-	1,600,653

Species	Life Stage	Natural	Listed Hatchery Intact Adipose	Listed Hatchery Adipose Clip
Northern California steelhead	Adult	7,221	-	-
	Smolt	821,389	-	-
Upper Columbia River steelhead	Adult	1,931	1,163	5,309
	Smolt	199,380	138,601	687,567
Snake River Basin steelhead	Adult	10,547	16,137	79,510
	Smolt	798,341	705,490	3,300,152
Lower Columbia River steelhead	Adult	12,920	22297[1]	-
	Smolt	352,146	9138	1,197,156
Upper Willamette River steelhead	Adult	2,912	-	-
	Smolt	140,396	-	-
Middle Columbia River steelhead	Adult	5,052	112	448
	Smolt	407,697	110,469	444,973
Puget Sound steelhead	Adult	19,313[2]	-	-
	Smolt	2,196,901	112,500	110,000

[1] We do not have separate estimates for fin-clipped and intact adipose fin hatchery fish for the life stage of this DPS/ESU.

[2] Includes estimates for natural and hatchery fish (intact and clipped numbers)

NMFS (2020) only presented run-size estimates for fish returning to their natal rivers to spawn as a quantification of adults. The number of returning adults is an underestimate of the number of post-juvenile fish that will occur in the oceanic environment since most Chinook, chum, sockeye salmon and steelhead spend two to four years foraging and maturing in the ocean environment before returning to spawn. Coho salmon typically return to spawn at age three and thus spend approximately two years at sea, and eulachon typically spend three to five years at sea before returning to freshwater to spawn. Information is not available for all ESA-listed salmon and eulachon ESUs and steelhead DPSs to estimate the total oceanic abundance of these species (PFMC 2015). Therefore, we multiplied the number of returning adults for each ESU or DPS by the average number of years the species spends at sea before returning to spawn, in order to account for all age classes of fish that would be expected in the oceanic environment (i.e., three years for Chinook, chum, sockeye, and steelhead; two years for Coho; four years for eulachon). We recognize that since this methodology is based on the number of returning adults, it does not account for individuals that die before returning to spawn. However, this does not inhibit our ability to accurately assess jeopardy and determine whether or not to expect any population level effects from this action because we are assessing jeopardy and the potential for any population level effects by comparing effects from this action to the number of returning adults (which is generally how salmon, steelhead, and eulachon abundance and trends are tracked).

Once we estimated the ocean abundance of maturing/adult and juvenile fish from each ESU/DPS, we estimated a density based on the expected habitat area (distribution) in the marine environment for each species. This habitat area (distribution) data used for our density calculations is presented in Table 58 below, and a description of the data inputs used to calculate the offshore habitat of ESA-listed Chinook, chum, Coho, steelhead, and sockeye is discussed below.

We derived expected distribution data from NMFS (2015a) which calculated[20] the area (square kilometers) of offshore habitat for ESA-listed Chinook, chum, Coho, steelhead, and sockeye. The north-south oceanic distribution for Chinook was based on the results presented in Weitkamp (2010), which used coded-wire-tags to estimate the distribution of Chinook salmon from various recovery areas along the west coast of North America (See Figure 45 and Figure 46). Chinook distribution data from Shelton et al. (2019) was assessed, however it was determined that Weitkamp (2010) provided more comprehensive distribution data for all run types (spring, summer, fall, and winter) whereas Shelton et al. (2019) only provided data for fall run Chinook. For Coho, the north-south oceanic distribution was based on Weitkamp and Neely (2002b) which used a similar methodology.

Since Chinook and Coho primarily reside on the continental shelf, NMFS (2015a) used the shelf break as the westward boundary of these species' distribution (the shelf break was defined as the 200 meter depth contour; (Landry and Hickey 1989)). Similar studies were not available for chum, sockeye, and steelhead. Chum geographic distribution was based on the ocean migration of the species from British Columbia, Washington, and Oregon, as determined from tagging data and presented in Neave et al. (1976). The migration pattern described in Neave et al. (1976) did not include information on individuals found immediately offshore of their river of origin in Oregon and Washington. Chum migrate north and west once they leave their river of origin (Quinn 2005; Byron and Burke 2014) and are generally found on the continental shelf, inshore of 37 kilometers from the coast (Pearcy and Fisher 1990). Therefore, NMFS (2015a) added the area of the continental shelf from each ESU's river of origin north to the mouth of Puget Sound (the area southernmost point where Neave et al. (1976) presented tagging data). NMFS (2015a) used the same geographic distribution for sockeye as it did for chum because in general, it is thought that sockeye follow a similar migration pattern once they enter the ocean, moving north and west along the coast, and having moved offshore by the end of their first ocean year (Quinn 2005; Byron and Burke 2014). For steelhead, NMFS (2015a) relied on the geographic ocean distribution of the species during summer described in Light et al. (1989).

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[20] Area of offshore habitat was calculated using ArcMap version 10.2.1 (ESRI, Redlands, CA)

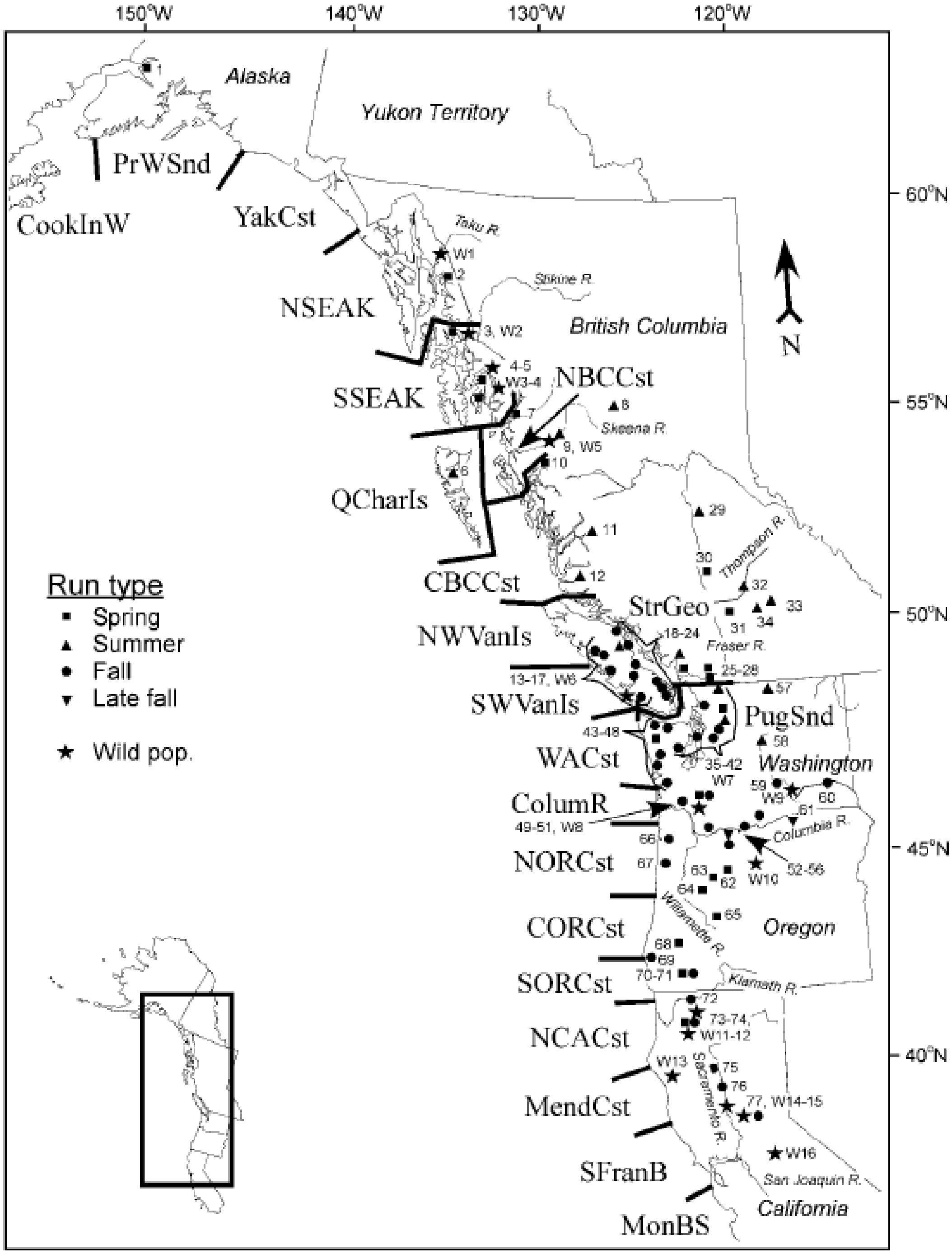

Figure 44. Locations of the 21 marine recovery areas (indicated by dark lines) used to estimate distributions (Weitkamp 2010).

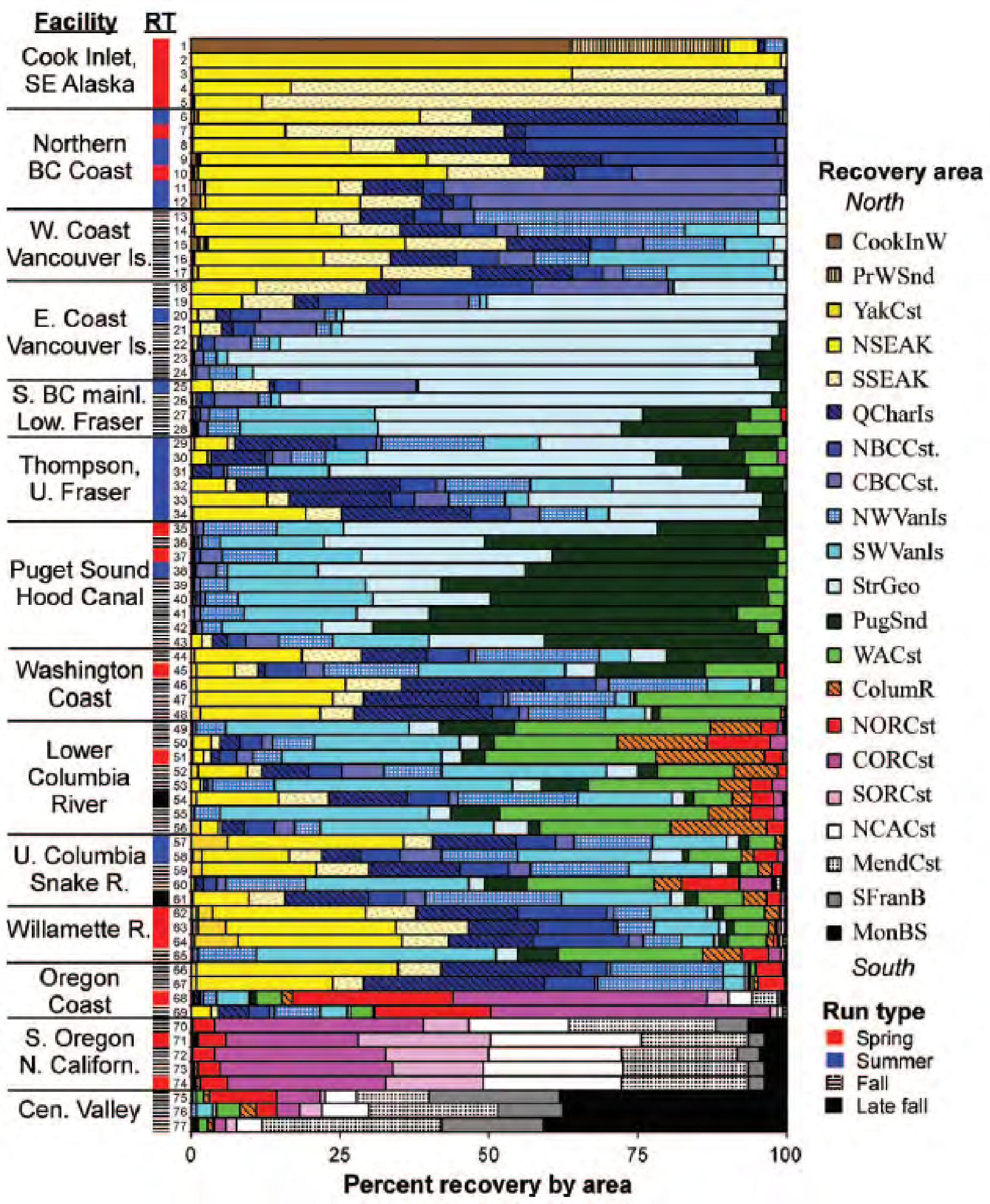

Figure 45. Recovery patterns for coded-wire-tagged Chinook salmon. Each horizontal bar represents the percentages of recoveries in the 21 marine recovery areas for a single hatchery run type group (Weitkamp 2010).

Table 54. Habitat area (distribution) used for each salmonid ESU/DPS (km^2) in the offshore marine environment.[21]

DPS/ESU	Marine Habitat Area (km^2)
Sacramento River winter-run Chinook	123,717
Central Valley spring-run Chinook	123,717
California Coastal Chinook	64,316
Snake River fall Chinook	657,628
Snake River spring/summer Chinook	657,628
Lower Columbia River Chinook	562,179
Upper Willamette River Chinook	634,343
Upper Columbia River spring Chinook	657,628
Puget Sound Chinook	241,626
Chum (all ESUs)	4,414,073
Central California Coast Coho	49,908
Southern Oregon/Northern California Coast Coho	181,607
Oregon Coast Coho	131,699
Lower Columbia River Coho	106,339
Sockeye (all ESUs)	4,414,073
Steelhead (all DPSs)	13,339,020

Offshore densities used for ESA-listed salmonids are presented in Table 59. These densities were developed using the abundance data in Table 57 and the marine habitat distribution area information in Table 58.

Table 55. Offshore density estimates for ESA-listed salmonids in the action area.

Species	Life stage	ESU/DPS	Density (# fish/km^2)
Chinook	Adult	Sac River winter run	0.059216
	Juvenile		3.195632
	Adult	Central valley spring run	0.145493
	Juvenile		23.80274
	Adult	California coastal	0.328099
	Juvenile		19.87185
	Adult	Snake River fall	0.179719
	Juvenile		9.182927
	Adult	Snake River spring/summer	0.071192

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[21] It is important to note that these distributions are representative of the majority of area a specific ESU/DPS may be found, not inclusive of everywhere where an ESU/DPS has been caught.

Species	Life stage	ESU/DPS	Density (# fish/km^2)
	Juvenile		9.483316
	Adult	Lower Columbia River	0.36321
	Juvenile		78.37518
	Adult	Upper Willamette River	0.197113
	Juvenile		9.334169
	Adult	Upper Columbia River spring	0.05685
	Juvenile		2.218916
	Adult	Puget Sound	0.471071
	Juvenile		192.8763
Coho	Adult	Central Calif coast	0.090527
	Juvenile		6.492146
	Adult	S. Oregon/N. Calif coast	0.220245
	Juvenile		15.3551
	Adult	Oregon coast	1.440846
	Juvenile		50.88546
	Adult	Lower Columbia River	0.727052
	Juvenile		77.10152
Chum	Adult	Hood Canal summer run	0.017961
	Juvenile		0.90934
	Adult	Columbia River	0.007475
	Juvenile		1.626864
Sockeye	Adult	Ozette Lake	0.001134
	Juvenile		0.302244
	Adult	Snake River	0.003072
	Juvenile		0.058926
Steelhead	Adult	South-Central California	0.000156
	Juvenile		0.005927
	Adult	Central Calif	0.000492
	Juvenile		0.018650
	Adult	California Central Valley	0.000379
	Juvenile		0.047260
	Adult	Northern Calif	0.001624
	Juvenile		0.061578
	Adult	Upper Columbia River	0.000434
	Juvenile		0.014947
	Adult	Snake River basin	0.002372
	Juvenile		0.059850
	Adult	Lower Columbia River	0.002906
	Juvenile		0.026400
	Adult	Upper Willamette River	0.000655
	Juvenile		0.010525
	Adult	Middle Columbia River	0.001136
	Juvenile		0.030564
	Adult	Puget Sound	0.004344
	Juvenile		0.164697

Salmonid Exposure Numbers

To determine exposure, we used the acoustic thresholds and resulting isopleths and then used GIS to establish a buffer around the tracklines to calculate the amount of area ensonified throughout the action area. As discussed earlier, the continental shelf (waters less than 200 meters deep) represents important habitat for ESA-listed fishes. In order to estimate exposure for fish, we needed to focus on the areas of habitat that overlapped with the action area where we think it is most likely ESA-listed salmonids will occur. Although steelhead can exhibit a more offshore distribution, the 200 meter depth line was used as a conservative measure to illustrate where they are mainly located. About 2,184 kilometers will take place in waters less than 200 meters deep in the waters of the continental shelf (33.4 percent of the tracklines for the total survey). The amount of ensonified area in waters less than 200 meters deep to the 187 dB level is 14,218 km^2. The amount of ensonified areas in waters less than 200 meters deep to the 206 dB level is 911 km^2. These levels correspond to the thresholds for the onset of injury and TTS in fish with swim bladders; see Section 10.2.2.3 for more discussion. We used these ensonified areas and multiplied them by the density of each ESA-listed salmonid population to calculate the number of Pacific salmonids exposed to the proposed action.

Results from these calculations of the estimated number of ESA-listed salmonids that would experience TTS or be injured are presented in Table 60, Table 61, and Table 62.

Oceanographic conditions like coastal upwellings are possibly related to the distribution of salmonids. Peterson et al. (2010) observed greater abundance of juvenile salmonids in Washington shelf waters than Oregon, and proposed that there are features in Washington waters that may make that habitat more conducive for juveniles. These features included strong stratification in shelf waters, more productive shelf waters due to nutrients being resupplied from the Strait of Juan de Fuca, less upwelling in Washington than in Oregon, and reduced salinity in Washington shelf waters because of input from the Strait of Juan de Fuca, the Columbia River plume, and upwelled, subarctic waters. Thus, we have some reason to believe that juvenile salmonids are not evenly distributed throughout the action area, and may be more prevalent in Washington shelf waters than in Oregon, which would lead us to expect that there could be more exposure of juvenile salmonids in Washington waters. However, since we are not able to quantify to what degree juvenile salmonids are more prevalent throughout the action area, we will conservatively assume that they are evenly distributed.

Eulachon Exposure

ESA-listed Southern DPS of eulachon occur in the marine environment and may be exposed to the proposed action. Southern DPS of eulachon are found on the continental shelf off the U.S. West Coast and are most often at depth between 50 to 200 meters (164 to 656 feet) (Gustafson 2016b). Although eulachon have been documented to occur in deeper water depths (maximum of 625 meters), these instances are rare and have only been observed from Alaskan trawl data which may greatly overestimate eulachon's true maximum depth as fish may become entrained into the nets, either on deployment or recovery (Hay and McCarter 2000). Approximately 2,184 kilometers of tracklines for the proposed action will take place in waters less than 200 meters deep, overlapping with the range of eulachon.

Spawning adult eulachon enter the Lower Columbia River estuary from late December to March, while larvae drift downstream into the ocean from February to March (Gustafson 2016a). In research trawl surveys, most juvenile eulachon are taken at around 100 meters depth in British Columbia and between 137 and 147 meters off the U.S. West Coast (defined as Washington, Oregon and California) (Gustafson et al. 2012). This species typically spends three to five years in saltwater before returning to freshwater to spawn.

To determine the average density of southern DPS eulachon in the offshore environment we used a similar methodology as described for estimating salmonid densities above. NMFS (2015a) determined that the southern DPS of eulachon has a marine distribution area of 1,183,304 km^2. The latest estimate of the population abundance of the southern DPS of eulachon was 18,796,090 spawners estimated in the Columbia River and Fraser River from 2014 to 2018. Because we do not have estimates of eulachon abundance in marine waters, the number of spawners in the Columbia River and Fraser River was used as a proxy for abundance in the oceanic environment. We multiplied the number of returning adults by the average number of years the species spends at sea before returning to spawn, in order to account for all age classes of fish that would be expected in the oceanic environment (i.e., four years for eulachon). This method produced a total Southern DPS eulachon density estimate of 63.54 km^2, which resulted in 903,412 individuals exposed to sound from the proposed action.

Green Sturgeon Exposure

The proposed seismic survey activities will take place in waters that may be occupied by Southern DPS of green sturgeon. Sub-adult and adult green sturgeon spend most of their lives in the marine environment, at water depths between 20 to 70 meters (66 to 230 feet) (Erickson and Hightower 2007; Huff et al. 2011), from southern California to Alaska (NMFS 2015f). There will be about 196 kilometers of tracklines that will take place in water depths less than 100 meters (out of a total of about 6,540 kilometers overall for the entire survey). Even when the survey tracklines are not taking place directly in water depths where southern DPS green sturgeon occur, because of the size of the ensonified area, sound created by the airgun array could extend into places where they are, exposing them to the seismic activities.

The limited feeding data available for adult green sturgeon show that they consume benthic invertebrates including shrimp, clams, chironomids, copepods, mollusks, amphipods, and small fish (Houston 1988; Moyle et al. 1992b; Wilson and McKinley 2004; Dumbauld et al. 2008). Information regarding their preference for areas of high seafloor complexity and prey selection in coastal waters (benthic prey) indicate green sturgeon reside and migrate along the seafloor while in coastal waters. The airgun array is directed downward, so it is likely that the proposed action will expose green sturgeon while they are feeding at the ocean floor.

The timing of the proposed action is significant in terms of likelihood of green sturgeon exposure. In July and August, tagged green sturgeon moved into shallower water (20 meters deep or less) (Huff et al. 2011). Satellite tagging data from 2019 indicate that up until mid-July, tagged green sturgeon are using the coastal waters of Washington, moving into the shallow coastal waters near the Columbia River by late July (J. Smith, pers comm.).

The seismic survey will begin sometime around June 1st, with the vessel leaving Newport, Oregon. Due to operational considerations that will take place on the spot, the NSF does not know fine-scale details about how the survey will occur—that is, if the survey will start from the north and go south, start with the inshore tracklines, or vice versa. Thus, it is still possible that green sturgeon could be exposed before they move into shallower water later in July and into August. However, due to the timing of the survey, the overall low amount of the survey that will take place in waters less than 100 meters deep, and that we expect green sturgeon to spend a portion of the time of the proposed action in shallow waters outside of the action area, we expect an overall low amount of green sturgeon exposure.

We were unable to determine the density of Southern DPS green sturgeon in the action area. There is an array of NMFS acoustic receivers off the coast of Washington, but none within the action area. As a result, we were not able to use data from those receivers to calculate a density.

We are relying on the extent of the ensonified area as a surrogate to estimate green sturgeon exposure. If a green sturgeon is within this area during seismic operations, it would be exposed to the stressor (i.e., the sound field produced by the airguns).

10.2.2 Response Analysis

A pulse of sound from the airgun array displaces water around the airgun array and creates a wave of pressure, resulting in physical effects on the marine environment that can then affect marine organisms, such as ESA-listed marine mammals, sea turtles, and fishes considered in this opinion. Possible responses considered in this analysis consist of:

- Hearing threshold shifts;
- Auditory interference (masking);
- Behavioral responses; and
- Non-auditory physical or physiological effects.

The *Response Analysis* also considers information on the potential for stranding and the potential effects on prey of ESA-listed marine mammals and sea turtles in the action area.

As discussed in *The Assessment Framework* (Section 2) of this opinion, response analyses determine how ESA-listed resources are likely to respond after exposure to an action's effects on the environment or directly on ESA-listed species themselves. For the purposes of consultation, our assessments try to detect potential lethal, sub-lethal (or physiological), or behavioral responses that might result in reduced fitness of ESA-listed individuals. Ideally, response analyses will consider and weigh evidence of adverse consequences as well as evidence suggesting the absence of such consequences.

The National Science Foundation, L-DEO, and NMFS Permits and Conservation Division estimated the number of ESA-listed marine mammals that may be exposed to received levels greater than or equal to 160 dB re: 1 μPa (rms) for the sound sources associated with the proposed action. The exposure estimates stem from the best available information on marine mammal densities (Table 45) and a predicted radius (rms; Table 2) along seismic survey tracklines. ESA-listed marine mammals exposed to these sound sources could be harmed, exhibit changes in behavior, suffer stress, or even strand.

To determine exposures, the National Science Foundation, L-DEO, and NMFS Permits and Conservation Division calculated ESA harm and harassment by using the radial distances from the airgun array to the predicted isopleths corresponding to MMPA Level A and Level B harassment. The area estimated to be ensonified in a single day (187 kilometers [101 nautical miles] for the two-dimensional seismic survey is then calculated, based on the areas predicted to be ensonified around the airgun array and representative trackline distances traveled per day. The ensonified areas were then multiplied by the number of survey days. The product is then multiplied by 1.25 to account for the additional 25 percent contingency. This results in an estimate of the total area expected to be ensonified. The total area ensonified at 160 dB re: 1 μPa (rms) is 79,581.9 square kilometers (23,202.4 square nautical miles), which was calculated in the geographic information system mapping program by multiplying the 160 dB harassment buffer zone widths for the different airgun array configurations by the trackline distance. The number of marine mammals that can be exposed to the sounds from the airgun array on one or more occasions is estimated for the calculated marine area along with the expected density of animals in the area. Summing exposures along all of the tracklines yields the total exposures for each species for the proposed action for the 36-airgun array configuration for the seismic survey activities. The method also yields exposures for each seismic survey trackline individually, allowing examination of those exemplary tracklines that will yield the largest or smallest exposures. The approach assumes that no marine mammals will move away or toward the trackline in response to increasing sound levels before the levels reach the specific thresholds as the R/V *Marcus G. Langseth* approaches. This calculation assumes 100 percent turnover of individuals within the ensonified area on a daily basis, that is, each individual exposed to the seismic survey activities is a unique individual that may exhibit a response.

Based on information provided by the National Science Foundation and L-DEO, we have determined that marine mammals are likely to be exposed to sound levels at or above the threshold at which TTS and behavioral responses will occur. From modeling by the L-DEO, the National Science Foundation and L-DEO provided sound source levels of the airgun array (Table 4) and estimated distances for the 160 dB re: 1 μPa (rms) sound levels, as well as MMPA Level A harassment thresholds generated by the airgun array configurations (single airgun and the full 36 airgun array) and water depth. To briefly summarize, for the 36-airgun array, the predicted distances to the 160 dB re: 1 μPa (rms) sound level threshold for MMPA Level B harassment in shallow, intermediate and deep water are 12,650 meters, 9,648 meters, and 6,733 meters, respectively. The modeled radial distances for permanent threshold shift thresholds (MMPA Level A harassment) for various marine mammal hearing groups were presented in Table 4.

In developing the National Science Foundation's draft environmental analysis and L-DEO's incidental harassment authorization application, they used estimates of marine mammal densities in the action area synthesized by CetSound (https://cetsound.noaa.gov/cda-index), and its underlying data found in (Becker et al. 2016), as well as that developed by (Navy 2019) for the Northwest Testing and Training Area, which overlaps with the action area.

The L-DEO used the GIS files that are the outputs for the habitat-based density models created by CetSound. The density estimates were available in the form of a GIS grid with each cell in the grid measuring about 7 kilometers east to west by 10 kilometers north to south. The L-DEO then used this grid to intersect it with a GIS layer of the areas expected to be ensonified to 160 dB SPL threshold within the three water depth categories (< 100 meters, 100 to 1000 meters, and >1000 meters). The densities from all grid cells overlapping the ensonified areas within each water depth category were averaged to calculate a zone-specific density for each species to determine number of animals exposed (Table 45).

An estimate of the number of marine mammals that will be exposed to sounds from the airgun array is also included in the National Science Foundation's draft environmental analysis. The National Science Foundation, L-DEO, and NMFS Permits and Conservation Division did not provide any estimates from sound sources other than the airgun array, although other equipment producing sound will be used during airgun array operations (e.g., the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder).

In their *Federal Register* notice of the proposed incidental harassment authorization, the NMFS Permits and Conservation Division stated that they did not expect the sound emanating from the other equipment to exceed the levels produced by the airgun array. Therefore, the NMFS Permits and Conservation Division did not expect additional responses from sound sources other than the airgun array. We agree with this assessment and similarly focus our analysis on responses to sound from the airgun array. The multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder are also expected to affect a smaller ensonified area within the larger sound field produced by the airgun array and are not expected to be of sufficient duration that will lead to the onset of TTS or PTS for an animal.

During the development of the incidental harassment authorization, the NMFS Permits and Conservation Division conducted an independent analysis that was informed by comments received during the public comment period for the proposed incidental harassment authorization and a draft environmental analysis prepared under the National Environmental Policy Act and Executive Order 12114. The analysis also included estimates of the number of ESA-listed marine mammals likely to be exposed to received levels at MMPA Level A harassment thresholds in the absence of monitoring and mitigation measures (conservation measures) that will be required as part of the IHA.

In this section, we describe the National Science Foundation, L-DEO, and NMFS Permits and Conservation Division's analytical methods to estimate the number of ESA-listed marine mammal species that might be exposed to the sound field and experience an adverse response. We also rely on acoustic thresholds to determine sound levels at which marine mammals are expected to exhibit a response, utilize these thresholds to calculate ensonified areas, and, finally, either multiply these areas by data on marine mammal density or use the sound field in the water column as a surrogate to estimate the number of marine mammals exposed to sounds levels generated by the airgun array that are likely to result in adverse effects to the animals.

Acoustic Thresholds

Acoustic thresholds are used in the development of radii for exclusion zones around a sound source and the necessary mitigation requirements necessary to limit marine mammal exposure to harmful levels of sound (NOAA 2018) under an MMPA authorization. For Level B harassment under the MMPA and responses under the ESA, NMFS has historically relied on an acoustic threshold for 160 dB re: 1 μPa (rms). This value is based on observations of behavioral responses of mysticetes, but is used for all marine mammal species. For the proposed action, the NMFS Permits and Conservation Division continued to rely on this historic NMFS acoustic threshold to estimate the number of takes by MMPA Level B harassment, and accordingly, adverse effects to ESA-listed marine mammals that are proposed in the incidental harassment authorization.

For physiological responses to active acoustic sources, such as TTS and PTS, the NMFS Permits and Conservation Division relied on NMFS' technical guidance for auditory injury of marine mammals (NOAA 2018). Unlike NMFS' 160 dB re: 1 μPa (rms) MMPA Level B harassment threshold (which does not include TTS or PTS), these TTS and PTS auditory thresholds differ by species hearing group (Table 57). Furthermore, these acoustic thresholds are a dual metric for impulsive sounds, with one threshold based on peak sound pressure level (0 to peak SPL) that does not include the duration of exposure. The other metric, the cumulative sound exposure criteria, incorporate auditory weighting functions based upon a species group's hearing sensitivity, and thus susceptibility to TTS and PTS over the exposed frequency range and duration of exposure. The metric that results in the largest distance from the sound source (i.e., produces the largest field of exposure) is used in estimating total range to potential exposure and effect, because it is the more precautionary criteria. In recognition of the fact that the requirement to calculate ensonified areas can be more technically challenging to predict due to the duration component and the use of weighting functions in the new SEL_{cum} thresholds, NMFS developed an optional user spreadsheet that includes tools to help predict a simple isopleth that can be used in conjunction with marine mammal density or occurrence to facilitate the estimation of the numbers that may be adversely affected by sound.

In using these acoustic thresholds to estimate the number of individuals that may experience auditory injury, the NMFS Permits and Conservation Division classify any exposure equal to or above the acoustic threshold for the onset of PTS (see Table 57) as auditory injury, and thus MMPA Level A harassment, and adverse effects under the ESA. Any exposure below the threshold for the onset of PTS, but equal to or above the 160 dB re: 1 μPa (rms) acoustic threshold is classified as MMPA Level B harassment. The NMFS Permits and Conservation Division does not distinguish between those individuals that are expected to experience TTS and those that will only exhibit a behavioral response.

Table 56. Functional hearing groups, generalized hearing ranges, and acoustic thresholds identifying the onset of permanent threshold shift and temporary threshold shift for marine mammals exposed to impulsive sounds (NOAA 2018).

Hearing Group	Generalized Hearing Range*	Permanent Threshold Shift Onset	Temporary Threshold Shift Onset
Low-Frequency Cetaceans (Baleen Whales) (LE,LF,24 hour)	7 Hertz to 35 kilohertz	$L_{pk,flat}$: 219 dB $L_{E,LF,24h}$: 183 dB	213 dB peak SPL 168 dB SEL
Mid-Frequency Cetaceans (Dolphins, Toothed Whales, Beaked Whales, Bottlenose Whales) (LE,MF,24 Hour)	150 Hertz to 160 kilohertz	$L_{pk,flat}$: 230 dB $L_{E,MF,24h}$: 185 dB	224 dB peak SPL 170 dB SEL
Otariid Pinnipeds (Guadalupe Fur Seals) (LE,MF,24 Hour) – Underwater	60 Hertz to 39 kilohertz	$L_{pk,flat}$: 232 dB $L_{E,MF,24h}$: 203 dB	212 dB peak SPL 170 dB SEL

LE, X, 24 Hour=Frequency Sound Exposure Level (SEL) Cumulated over 24 Hour
LF=Low Frequency
MF=Mid-Frequency

*Represents the generalized hearing range for the entire group as a composite (i.e., all species within the group), where individual species’ hearing ranges are typically not as broad. Generalized hearing range chosen based on approximately 65 dB threshold from normalized composite audiogram, with the exception for lower limits for low frequency cetaceans (Southall et al. 2007b) (approximation).

Note: Dual metric acoustic thresholds for impulsive sounds (peak and/or SEL_{cum}): Use whichever results in the largest (most conservative for the ESA-listed species) isopleth for calculating PTS onset. If a non-impulsive sound has the potential of exceeding the peak sound pressure level thresholds associated with impulsive sounds, these thresholds should also be considered.

Note: Peak sound pressure (Lpk) has a reference value of 1 μPa, and cumulative sound exposure level (LE) has a reference value of 1 μPa^2s. In this table, thresholds are abbreviated to reflect American National Standards Institute standards (ANSI 2013). However, peak sound pressure is defined by ANSI as incorporating frequency weighting, which is not the intent for this technical guidance. Hence, the subscript “flat” is being included to indicate peak sound pressure should be flat weighted or unweighted within the generalized hearing range. The subscript associated with cumulative sound exposure level thresholds indicates the designated marine mammal auditory weighting function and that the recommended accumulation period is 24 hours. The cumulative sound exposure level thresholds could be exceeded in a multitude of ways (i.e., varying exposure levels and durations, duty cycle). When possible, it is valuable for action proponents to indicate the conditions under which these acoustic thresholds will be exceeded.

Using the above acoustic thresholds, the NMFS Permits and Conservation Division evaluated the exposure and estimates of ESA-listed marine mammals expected to measurably respond to the adverse effects of the sounds from the airgun array.

10.2.2.1 Potential Response of Marine Mammals to Acoustic Sources

Exposure of marine mammals to very strong impulsive sound sources from airgun arrays can result in auditory damage, such as changes to sensory hairs in the inner ear, which may temporarily or permanently impair hearing by decreasing the range of sound an animal can detect within its normal hearing ranges. Hearing threshold shifts depend upon the duration, frequency, sound pressure, and rise time of the sound. A TTS results in a temporary change to hearing sensitivity (Finneran 2013), and the impairment can last minutes to days, but full recovery of hearing sensitivity is expected. However, a study looking at the effects of sound on mice hearing, has shown that, although full hearing can be regained from TTS (i.e., the sensory cells actually receiving sound are normal), damage can still occur to the cochlear nerve leading to delayed but permanent hearing damage (Kujawa and Liberman 2009). At higher received levels, particularly in frequency ranges where animals are more sensitive, PTS can occur, meaning lost auditory sensitivity is unrecoverable. Either of these conditions can result from exposure to a single pulse or from the accumulated effects of multiple pulses, in which case each pulse need not be as loud as a single pulse to have the same accumulated effect. A TTS and PTS are generally specific to the frequencies over which exposure occurs but can extend to a half-octave above or below the center frequency of the source in tonal exposures (less evident in broadband noise such as the sound sources associated with the proposed action; (Schlundt 2000; Kastak 2005; Ketten 2012)).

Few data are available to precisely define each ESA-listed species hearing range, let alone its sensitivity and levels necessary to induce TTS or PTS. Baleen whales (e.g., blue, fin, humpback, and sei whales) have an estimated functional hearing frequency range of 7 Hertz to 35 kilohertz and sperm whales have an estimated functional hearing frequency range of 150 Hertz to 160 kilohertz (see Table 44) (Southall 2007). For pinnipeds in water, data are limited to measurements of TTS in harbor seals (*Phoca vitulina*), an elephant seal (*Mirounga angustirostris*), and California sea lions (*Zalophus californianus*) (Kastak et al. 1999; Kastelein et al. 2012). Otariid sea lions and fur seals, like Guadalupe fur seals, have an estimated functional hearing range of 60 Hertz to 39 kilohertz.

Based upon captive studies of odontocetes, our understanding of terrestrial mammal hearing, and extensive modeling, the best available information supports the position that sound levels at a given frequency will need to be approximately 186 dB SEL or approximately 196 to 201 dB re: 1 μPa (rms) in order to produce a low-level TTS from a single pulse (Southall et al. 2007d). PTS is expected at levels approximately 6 dB greater than TTS levels on a peak-pressure basis, or 15 dB greater on an SEL basis than TTS (Southall et al. 2007d). In terms of exposure to the R/V *Marcus G. Langseth*'s airgun array, an individual will need to be within a few meters of the largest airgun to experience a single pulse greater than 230 dB re: 1 μPa (peak) (Caldwell and Dragoset 2000). If an individual experienced exposure to several airgun pulses of approximately 219 dB for low-frequency cetaceans, 230 dB for mid-frequency cetaceans, or 202 dB for high-frequency cetaceans, PTS could occur. Marine mammals (cetaceans and pinnipeds) will have to be within certain modeled radial distances specified in Table 2 and Table 4 from the R/V *Marcus*

G. Langseth's single airgun and 36 airgun array to be within the MMPA Level A harassment to be within the threshold isopleth and risk a PTS and within the MMPA Level B harassment to be within the threshold isopleth and risk behavioral responses.

Research and observations show that pinnipeds in the water are tolerant of anthropogenic noise and activity. If Guadalupe fur seals are exposed to active acoustic sources, they may react in a number of ways depending on their experience with the sound source and what activity they are engaged in at the time of the acoustic exposure. Guadalupe fur seals may not react at all until the sound source is approaching within a few hundred meters and then may alert, approach, ignore the stimulus, change their behaviors, or avoid the immediate area by swimming away or diving (Finneran et al. 2003a; Kvadsheim et al. 2010; Götz and Janik 2011). Significant behavioral reactions would not be expected in most cases, and long-term consequences for individuals are unlikely.

Ranges to some behavioral impacts can take place at distances exceeding 100 kilometers (54 nautical miles), although significant behavioral effects are much more likely at higher received levels within a few kilometers of the sound source. Behavioral reactions will be short-term, likely lasting the duration of the exposure, and long-term consequences for individuals.

Overall, we do not expect TTS to occur to any ESA-listed marine mammals because of exposure to the airgun array. We expect that most individuals will move away from the airgun array as it approaches; however, a few individuals may be exposed to sound levels that may result in TTS or PTS, but we expect the probability to be low. As the seismic survey proceeds along each transect trackline and approaches ESA-listed individuals, the sound intensity increases and individuals will experience conditions (stress, loss of prey, discomfort, etc.) that prompt them to move away from the research vessel and sound source and thus avoid exposures that will induce TTS or PTS. Ramp-ups will also reduce the probability of TTS-inducing exposure at the start of seismic survey activities for the same reasons, as acoustic intensity increases, animals will move away and therefore unlikely to accumulate more injurious levels. Furthermore, mitigation measures will be in place to initiate a shut-down if individuals enter or are about to enter the 500 meter (1,640.4 feet) exclusion zone during full airgun array operations, which is beyond the distances believed to have the potential for PTS in any of the ESA-listed marine mammals as described above. Each individual may be exposed to 160 dB re: 1 μPa (rms) levels. We do not expect this to produce a cumulative TTS or other physical injury for several reasons. Specifically, we expect that individuals will recover from TTS between each of these exposures, we expect monitoring to produce some degree of mitigation such that exposures will be reduced, and (as stated above), we expect individuals to generally move away at least a short distance as received sound levels increase, reducing the likelihood of exposure that is biologically meaningful. In summary, we do not expect animals to be present for a sufficient duration to accumulate sound pressure levels that will lead to the onset of TTS or PTS.

Marine Mammals and Auditory Interference (Masking)

Interference, or masking, occurs when a sound is a similar frequency and similar to or louder than the sound an animal is trying to hear (Clark et al. 2009; Erbe et al. 2016). Masking can interfere with an individual's ability to gather acoustic information about its environment, such as predators, prey, conspecifics, and other environmental cues (Richardson 1995). This can result in loss of environmental cues of predatory risk, mating opportunity, or foraging options (Francis and Barber 2013). Low frequency sounds are broad and tend to have relatively constant bandwidth, whereas higher frequency bandwidths are narrower (NMFS 2006c).

There is frequency overlap between airgun array sounds and vocalizations of ESA-listed marine mammals, particularly baleen whales and to some extent sperm whales. The proposed seismic survey could mask whale calls at some of the lower frequencies for these species. This could affect communication between individuals, affect their ability to receive information from their environment, or affect sperm whale echolocation (Evans 1998; NMFS 2006c). Most of the energy of sperm whale clicks is concentrated at 2 to 4 kilohertz and 10 to 16 kilohertz and, though the findings by Madsen et al. (2006) suggest frequencies of pulses from airgun arrays can overlap this range, the strongest spectrum levels of airguns are below 200 Hertz (2 to 188 Hertz for the R/V *Marcus G. Langseth*'s airgun array). Any masking that might occur will likely be temporary because acoustic sources from the seismic surveys are not continuous and the research vessel will continue to transit through the area during the survey rather than remaining in a particular location. In addition, the proposed seismic survey activities on the R/V *Marcus G. Langseth* are planned to occur over the course of approximately 37 days, including approximately three days of equipment deployment and retrieval and approximately two days of transit, for seismic survey in the Northeast Pacific Ocean in June and July 2021.

Given the disparity between sperm whale echolocation and communication-related sounds with the dominant frequencies for seismic surveys, masking is not likely to be significant for sperm whales (NMFS 2006c). Overlap of the dominant low frequencies of airgun pulses with low-frequency baleen whale calls may pose a somewhat greater risk of masking. The R/V *Marcus G. Langseth*'s airguns will emit a 0.1-second pulse when fired approximately every 16 to 17 seconds, with sperm whale calls lasting 0.5 to 1 second. Therefore, pulses will not "cover up" the vocalizations of ESA-listed sperm whales to a significant extent (Madsen et al. 2002b). We address the response of ESA-listed marine mammals stopping vocalizations because of airgun sound in the *Marine Mammals and Behavioral Responses* section below.

Although sound pulses from airguns begin as short, discrete sounds, they interact with the marine environment and lengthen through processes such as reverberation. This means that in some cases such as in shallow water environments, airgun sound can become part of the acoustic background. Few studies of how impulsive sound in the marine environment deforms from short bursts to lengthened waveforms exist, but can apparently add significantly to acoustic background (Guerra et al. 2011), potentially interfering with the ability of animals to hear otherwise detectible sounds in their environment.

The sound localization abilities of marine mammals suggest that, if signal and sound come from different directions, masking will not be as severe as the usual types of masking studies might suggest (Richardson 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these sounds by improving the effective signal-to-sound ratio. In the cases of higher frequency hearing by the bottlenose dolphin (*Tursiops truncatus*), beluga whale (*Delphinapterus leucas*), and killer whale, empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking sound (Bain 1993; Bain 1994; Dubrovskiy 2004). Toothed whales and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background sound. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient sound toward frequencies with less noise (Au 1974; Au 1975; Moore 1990; Thomas 1990; Romanenko 1992; Lesage 1999). A few marine mammal species increase the source levels or alter the frequency of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage 1993; Lesage 1999; Terhune 1999; Foote 2004; Parks 2007; Holt 2009; Parks 2009).

These data demonstrating adaptations for reduced masking pertain mainly to the very high frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies or in other types of marine mammals. For example, Zaitseva et al. (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency is 18 kilohertz, in contrast to the pronounced effect at higher frequencies. Studies have noted directional hearing at frequencies as low as 0.5 to 2 kilohertz in several marine mammals, including killer whales (Richardson et al. 1995c). This ability may be useful in reducing masking at these frequencies.

In summary, high levels of sound generated by the proposed seismic survey activities may act to mask the detection of weaker biologically important sounds by some marine mammals considered in this opinion. This masking is expected to be more prominent for baleen whales given the lower frequencies at which they hear best and produce calls. For toothed whales (e.g., sperm whales), which hear best at frequencies above the predominant ones produced by airguns and may have adaptations to allow them to reduce the effects of masking on higher frequency sounds such as echolocation clicks like other toothed whales mentioned above (e.g., belugas, Au et al. 1985), masking is not expected to be significant for individual marine mammals.

Marine Mammals and Behavioral Responses

We expect the greatest response of marine mammals to airgun array sounds in terms of number of responses and overall impact to be in the form of changes in behavior. ESA-listed individuals may briefly respond to underwater sound by slightly changing their behavior or relocating a short distance. Displacement from important feeding or breeding areas over a prolonged period would likely be more significant for individuals and could affect the population depending on the extent of the feeding area and duration of displacement. This has been suggested for humpback whales along the Brazilian coast as a result of increased seismic survey activity (Parente et al. 2007). Marine mammal responses to anthropogenic sound vary by species, state of maturity, prior exposure, current activity, reproductive state, time of day, and other factors (Ellison et al. 2012; Harris et al. 2018) This is reflected in a variety of aquatic, aerial, and terrestrial animal responses to anthropogenic noise that may ultimately have fitness consequences (NRC 2005a; Francis and Barber 2013; New et al. 2014; Costa et al. 2016; Fleishman et al. 2016). Although some studies are available that address responses of ESA-listed marine mammals considered in this opinion directly, additional studies of other related whales (such as bowhead and gray whales) are relevant in determining the responses expected by species under consideration. Therefore, studies from non-ESA-listed or species outside the action area are also considered here. Animals generally respond to anthropogenic perturbations as they will predators, increasing vigilance, and altering habitat selection (Reep et al. 2011). There is increasing support that this prey-predator-like response is true for animals' response to anthropogenic sound (Harris et al. 2018). Habitat abandonment due to anthropogenic noise exposure has been found in terrestrial species (Francis and Barber 2013). Because of the similarities in hearing anatomy of terrestrial and marine mammals, we expect it possible for ESA-listed marine mammals to behave in a similar manner as terrestrial mammals when they detect a sound stimulus. For additional information on the behavioral responses marine mammals exhibit in response to anthropogenic noise, including non-ESA-listed marine mammal species, see the *Federal Register* notice of the proposed IHA (84 FR 26940), as well as one of several reviews (e.g., Southall et al. 2007c; Gomez et al. 2016).

Several studies have aided in assessing the various levels at which whales may modify or stop their calls in response to sounds for airguns. Whales continue calling while seismic surveys are operating locally (Richardson et al. 1986a; McDonald et al. 1993; McDonald et al. 1995; Greene Jr et al. 1999; Madsen et al. 2002b; Tyack et al. 2003; Nieukirk et al. 2004; Smultea et al. 2004; Jochens et al. 2006). However, humpback whale males increasingly stopped vocal displays on Angolan breeding grounds as received seismic airgun levels increased (Cerchio 2014). Some blue, fin, and sperm whales stopped calling for short and long periods apparently in response to airguns (Bowles et al. 1994; McDonald et al. 1995; Clark and Gagnon 2006). Fin whales (presumably adult males) engaged in singing in the Mediterranean Sea moved out of the area of a seismic survey while airguns were operational, as well as for at least a week thereafter (Castellote et al. 2012a). Dunn and Hernandez (2009) tracked blue whales during a seismic survey on the R/V *Maurice Ewing* in 2007 and did not observe changes in call rates or find evidence of anomalous behavior that they could directly ascribe to the use of airguns at sound levels of approximately less than 145 dB re: 1 μPa (rms) (Wilcock et al. 2014). Blue whales may attempt to compensate for elevated ambient sound by calling more frequently during seismic surveys (Iorio and Clark 2009). Bowhead whale calling rates were found to decrease during migration in the Beaufort Sea when seismic surveys were being conducted (Nations et al. 2009). Calling rates decreased when exposed to seismic airguns at estimated received levels of 116 to

129 dB re: 1 μPa (rms), but did not change at received levels of 99 to 108 dB re: 1 μPa (rms) (Blackwell et al. 2013). A more recent study examining cumulative sound exposure found that bowhead whales began to increase call rates as soon as airgun sounds were detectable, but this increase leveled off at approximate 94 dB re: 1 μPa^2-s over the course of ten minutes (Blackwell et al. 2015). Once sound levels exceeded approximately 127 dB re: 1 μPa^2-s over ten minutes, call rates began to decline and at approximately 160 dB re: 1 μPa^2-s over ten minutes, bowhead whales appeared to cease calling all together (Blackwell et al. 2015). While we are aware of no data documenting changes in North Atlantic right whale vocalization in association with seismic surveys, as mentioned previously, they do shift calling frequencies and increase call amplitude over both long- and short-term periods due to chronic exposure to vessel sound (Parks and Clark 2007; Parks et al. 2007; Parks et al. 2009; Parks et al. 2011; Parks et al. 2012; Tennessen and Parks 2016). Sperm whales, at least under some conditions, may be particularly sensitive to airgun sounds, as they have been documented to cease calling in association with airguns being fired hundreds of kilometers away (Bowles et al. 1994). Other studies have found no response by sperm whales to received airgun sound levels up to 146 dB re: 1 μPa (peak-to-peak) (McCall Howard 1999; Madsen et al. 2002a). For the species considered in this consultation, some exposed individual ESA-listed marine mammals may cease calling or otherwise alter their vocal behavior in response to the R/V *Marcus G. Langseth*'s airgun array during the seismic survey activities. The effect is expected to be temporary and of short duration because the research vessel is constantly moving when the airgun array is active. Animals may resume or modify calling at a later time or location away from the R/V *Marcus G. Langseth*'s airgun array during the course of the proposed seismic survey once the acoustic stressor has diminished.

There are numerous studies of the responses of some baleen whales to airgun arrays. Although responses to lower-amplitude sounds are known, most studies seem to support a threshold of approximately 160 dB re: 1 μPa (rms) (the level used in this opinion to determine the extent of acoustic effects for marine mammals) as the received sound level to cause behavioral responses other than vocalization changes (Richardson et al. 1995c). Activity of individuals seems to influence response (Robertson et al. 2013), as feeding individuals respond less than mother and calf pairs and migrating individuals (Malme et al. 1984b; Malme and Miles 1985; Richardson et al. 1995c; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007). Migrating bowhead whales show strong avoidance reactions to exposures to received sound levels of 120 to 130 dB re: 1 μPa (rms) at distances of 20 to 30 kilometers (10.8 to 16.2 nautical miles), but only changed dive and respiratory patterns while feeding and showed avoidance at higher received sound levels (152 to 178 dB re: 1 μPa [rms]) (Richardson et al. 1986b; Ljungblad et al. 1988; Richardson et al. 1995c; Miller et al. 1999; Richardson et al. 1999; Miller et al. 2005; Harris et al. 2007). Nations et al. (2009) also found that bowhead whales were displaced during migration in the Beaufort Sea during active seismic surveys. In fact, as mentioned previously, the available data indicate that most, if not all, baleen whale species exhibit avoidance of active seismic airguns (Gordon et al. 2003; Stone and Tasker 2006; Potter et al. 2007; Southall et al. 2007c; Barkaszi et al. 2012a; Castellote et al. 2012b; NAS 2017; Stone et al. 2017). Despite the above observations and exposure to repeated seismic surveys, bowhead whales continue to return to summer feeding areas and, when displaced, appear to re-occupy within a day (Richardson et al. 1986b). We do not know whether the individuals exposed in these ensonified areas are the same returning or whether though they tolerate repeat exposures, they may still experience a stress response. However, we expect the presence of the PSOs and the shut-down that will occur if a marine mammal were present in the exclusion zone that are part of the proposed action will lower the likelihood that marine mammals will be exposed to significant sound levels from the airgun array.

Gray whales respond similarly to seismic survey sounds as described for bowhead whales. Gray whales discontinued feeding and/or moved away at received sound levels of 163 dB re: 1 μPa (rms) (Malme et al. 1984b; Malme and Miles 1985; Malme et al. 1986; Malme et al. 1987; Würsig et al. 1999; Bain and Williams 2006; Gailey et al. 2007; Johnson et al. 2007a; Meier et al. 2007; Yazvenko et al. 2007). Migrating gray whales began to show changes in swimming patterns at approximately 160 dB re: 1 μPa (rms) and slight behavioral changes at 140 to 160 re: 1 μPa (rms) (Malme et al. 1984a; Malme and Miles 1985). As with bowhead whales, habitat continues to be used despite frequent seismic survey activity, but long-term effects have not been identified, if they are present at all (Malme et al. 1984a). Johnson et al. (2007b) reported that gray whales exposed to airgun sounds during seismic surveys off Sakhalin Island, Russia, did not experience any biologically significant or population level effects, based on subsequent research in the area from 2002 through 2005. Furthermore, when strict mitigation measures, such as those that will be required in the IHA by the NMFS Permits and Conservation Division, are taken to avoid conducting seismic surveys during certain times of the year when most gray whales are expected to be present, gray whales may not exhibit any noticeable behavioral responses to seismic survey activities (Gailey et al. 2016).

Humpback whales exhibit a pattern of lower threshold responses when not occupied with feeding. Migrating humpbacks altered their travel path (at least locally) along Western Australia at received levels as low as 140 dB re: 1 μPa (rms) when females with calves were present, or 7 to 12 kilometers (3.8 to 6.5 nautical miles) from the acoustic source (McCauley et al. 1998; McCauley et al. 2000b). A startle response occurred as low as 112 dB re: 1 μPa (rms). Closest approaches were generally limited to 3 to 4 kilometers (1.6 to 2.2 nautical miles), although some individuals (mainly males) approached to within 100 meters (328.1 feet) on occasion where sound levels were 179 dB re: 1 μPa (rms). Changes in course and speed generally occurred at estimated received levels of 157 to 164 dB re: 1 μPa (rms). Similarly, on the east coast of Australia, migrating humpback whales appear to avoid seismic airguns at distances of 3 kilometers (1.6 nautical miles) at levels of 140 dB re: 1 μPa^2-second. A recent study examining the response of migrating humpback whales to a full 51,291.5 cubic centimeters (3,130 cubic inch) airgun array found that humpback whales exhibited no abnormal behaviors in response to the active airgun array and, while there were detectible changes in respiration and diving, these were similar to those observed when baseline groups (i.e., not exposed to active sound sources) were joined by another humpback whale (Dunlop et al. 2017). While some humpback whales were also found to reduce their speed and change course along their migratory route, overall these results suggest that the behavioral responses exhibited by humpback whales are unlikely to have significant biological consequences for fitness (Dunlop et al. 2017). Feeding humpback whales appear to be somewhat more tolerant. Humpback whales off the coast of Alaska startled at 150 to 169 dB re: 1 μPa (rms) and no clear evidence of avoidance was apparent at received levels up to 172 dB re: 1 μPa (rms) (Malme et al. 1984b; Malme et al. 1985). Potter et al. (2007) found that humpback whales on feeding grounds in the Atlantic Ocean did exhibit localized avoidance to airgun arrays. Among humpback whales on Angolan breeding grounds, no clear difference was observed in encounter rate or point of closest approach during seismic versus non-seismic periods (Weir 2008).

Observational data are sparse for specific baleen whale life histories (breeding and feeding grounds) in response to airguns. Available data support a general avoidance response. Some fin and sei whale sighting data indicate similar sighting rates during seismic versus non-seismic periods, but sightings tended to be further away and individuals remained underwater longer (Stone 2003; Stone and Tasker 2006; Stone et al. 2017). Other studies have found at least small differences in sighting rates (lower during seismic survey activities), as well as whales being more distant during seismic survey activities (Moulton and Miller 2005b). When spotted at the average sighting distance, individuals will have likely been exposed to approximately 169 dB re: 1 μPa (rms) (Moulton and Miller 2005a).

Sperm whale response to airguns has thus far included mild behavioral disturbance (temporarily disrupted foraging, avoidance, cessation of vocal behavior) or no reaction. Several studies have found sperm whales in the Atlantic Ocean to show little or no response (Davis et al. 2000; Stone 2003; Moulton and Miller 2005b; Madsen et al. 2006; Stone and Tasker 2006; Weir 2008; Miller et al. 2009; Stone et al. 2017). Detailed study of sperm whales in the Gulf of Mexico suggests some alteration in foraging from less than 130 to 162 dB re: 1 μPa peak-to-peak, although other behavioral reactions were not noted by several authors (Gordon et al. 2004; Gordon et al. 2006; Jochens et al. 2006; Madsen et al. 2006; Winsor and Mate 2006). This has been contradicted by other studies, which found avoidance reactions by sperm whales in the Gulf of Mexico in response to seismic ensonification (Mate et al. 1994; Jochens 2003; Jochens and Biggs 2004). Johnson and Miller (2002) noted possible avoidance at received sound levels of 137 dB re: 1 μPa. Other anthropogenic sounds, such as pingers and sonars, disrupt behavior and vocal patterns (Watkins and Schevill 1975b; Watkins et al. 1985; Goold 1999). Miller et al. (2009) found sperm whales to be generally unresponsive to airgun exposure in the Gulf of Mexico, although foraging behavior may have been affected based on changes in echolocation rate and slight changes in dive behavior. Displacement from the area was not observed. Winsor and Mate (2013) did not find a non-random distribution of satellite-tagged sperm whales at and beyond 5 kilometers (2.7 nautical miles) from airgun arrays, suggesting individuals were not displaced or move away from the airgun array at and beyond these distances in the Gulf of Mexico (Winsor and Mate 2013). However, no tagged whales within 5 kilometers (2.7 nautical miles) were available to assess potential displacement within 5 kilometers (2.7 nautical miles) (Winsor and

Mate 2013). In a follow-up study using additional data, Winsor et al. (2017) found no evidence to suggest sperm whales avoid active airguns within distances of 50 kilometers (27 nautical miles). The lack of response by this species may in part be due to its higher range of hearing sensitivity and the low-frequency (generally less than 200 Hertz) pulses produced by seismic airguns (Richardson et al. 1995c). However, sperm whales are exposed to considerable energy above 500 Hertz during the course of seismic surveys (Goold and Fish 1998), so even though this species generally hears at higher frequencies, this does not mean that it cannot hear airgun sounds. Breitzke et al. (2008) found that source levels were approximately 30 dB re: 1 μPa lower at 1 kilohertz and 60 dB re: 1 μPa lower at 80 kilohertz compared to dominant frequencies during a seismic source calibration. Another odontocete, bottlenose dolphins, progressively reduced their vocalizations as an airgun array came closer and got louder (Woude 2013). Reactions of sperm whales to impulse noise likely vary depending on the activity at time of exposure. For example, in the presence of abundant food or during breeding encounters, toothed whales sometimes are extremely tolerant of noise pulses (NMFS 2010a).

Similar to other marine mammal species, behavioral responses of pinnipeds can range from a mild orienting response, or a shifting attention, to flight and panic. They may react in a number of ways depending on their experience with the sound source that what activity they are engaged in at the time of the exposure. For example, different responses displayed by captive and wild phocid seals to sound judged to be 'unpleasant' have been reported; where captive seals habituated (did not avoid the sound), and wild seals showed avoidance behavior (Götz and Janik 2011). Captive seals received reinforcement during sound playback, while wild seals were exposed opportunistically. These results indicate that motivational state (e.g., reinforcement via food acquisition) can be a factor in whether or not an animal habituates to novel or unpleasant sounds. Captive studies with other pinnipeds have shown a reduction in dive times when presented with qualitatively 'unpleasant' sounds. These studies indicated that the subjective interpretation of the pleasantness of a sound, minus the more commonly studied factors of received sound level and sounds associated with biological significance, can affect diving behavior (Götz and Janik 2011). More recently, a controlled-exposure study was conducted with U.S. Navy California sea lions at the Navy Marine Mammal Program facility specifically to study behavioral reactions (Houser et al. 2013). Animals were trained to swim across a pen, touch a panel, and return to the starting location. During transit, a simulated mid-frequency sonar signal was played. Behavioral reactions included increased respiration rates, prolonged submergence, and refusal to participate, among others. Younger animals were more likely to respond than older animals, while some sea lions did not respond consistently at any level.

Kvadsheim et al. (2010) found that captive hooded seal (*Cystophora cristata*) reacted to 1 to 7 kilohertz sonar signals by moving to the areas of last sound pressure level, at levels between 160 and 170 dB re: 1 μPa. Finneran et al. (2003b) found that trained captive sea lions showed avoidance behavior in response to impulsive sounds at levels above 165 to 170 dB re: 1 μPa (rms). These studies are in contrast to the results of Costa (1993) which found that free-ranging elephant seals showed no change in diving behavior when exposed to very low frequency sounds

(55 to 95 Hertz) at levels up to 137 dB re: 1 μPa (though the received level in this study were much lower (Costa et al. 2003). Similar to behavioral responses of mysticetes and odontocetes, potential behavioral responses of pinnipeds to the proposed seismic survey activities are not expected to impact the fitness of any individual animals as the responses are not likely to adversely affect the ability of the animals to forage, detect predators, select a mate, or reproduce successfully. As noted in (Southall et al. 2007b), substantive behavioral reactions to noise exposure (such as disruption of critical life functions, displacement, or avoidance of important habitat) are considered more likely to be significant if they last more than 24 hours, or recur on subsequent days. Behavioral reactions are not expected to last more than 24 hours or recur on subsequent days such that an animal's fitness could be impacted. That we do not expect fitness consequences is further supported by Navy monitoring of Navy-wide activities since 2006, which has documented hundreds of thousands of marine mammals on training and testing range complexes. Only two instances of overt behavioral change have been observed and there have been no demonstrable instances of injury to marine mammals because of non-impulsive acoustic sources such as low frequency active sonar. We do not expect significant fitness consequences to individual animals to result from instances of behavioral response.

Pinnipeds are not likely to show a strong avoidance reaction to the airgun array sources proposed for use. Visual monitoring from seismic survey vessels has shown only slight (if any) avoidance of airgun arrays by pinnipeds and only slight (if any) changes in behavior. Monitoring work in the Alaskan Beaufort Sea during 1996 through 2001 provided considerable information regarding the behavior of Arctic ice seals exposed to seismic pulses (Harris et al. 2001; Moulton and Lawson 2002). These seismic survey projects usually involved airgun arrays of six to 16 airguns with total volumes of 9,176.8 to 24,580.6 cubic centimeters (560 to 1,500 cubic inches). The combined results suggest that some seals avoid the immediate area around seismic survey vessels. In most survey years, ringed seal (*Phoca hispida*) sightings tended to be farther away from the seismic survey vessel when the airgun arrays were operating than when they were not (Moulton and Lawson 2002). However, these avoidance movements were relatively small, approximately 100 meters (328.1 feet) to a few hundreds of meters, and many seals remained within 100 to 200 meters (328.1 to 656.2 feet) of the trackline as the operating airgun array passed by the animals. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997. Similarly, seals are often very tolerant of pulsed sounds from seal-scaring devices (Mate and Harvey 1987; Jefferson and Curry 1994; Richardson et al. 1995a). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun array sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998).

Elephant seals are unlikely to be affected by short-term variations in prey availability (Costa 1993), as cited in New et al. (2014). We expect the Guadalupe fur seals considered in this opinion to be similarly unaffected. We have no information to suggest animals eliciting a behavioral response (e.g., temporary disruption of feeding) from exposure to the proposed seismic survey activities will be unable to compensate for this temporary disruption in feeding activity by either immediately feeding at another location, by feeding shortly after cessation of acoustic exposure, or by feeding later.

In summary, ESA-listed marine mammals are expected to exhibit a wide range of behavioral responses when exposed to sound fields from the airgun array. Baleen whales are expected to mostly exhibit avoidance behavior, and may also alter their vocalizations. Toothed whales (i.e., sperm whales) are expected to exhibit less overt behavioral changes, but may alter foraging behavior, including echolocation vocalizations. Pinnipeds (i.e., Guadalupe fur seals) are expected to exhibit avoidance and behavioral changes. These responses are expected to be temporary with behavior returning to a baseline state shortly after the sound source becomes inactive or leaves the area.

Marine Mammals and Physical or Physiological Effects

Individual whales exposed to airguns (as well as other sound sources) could experience effects not readily observable such as stress (Romano et al. 2002) that may have adverse effects. Other possible responses to impulsive sound sources like airgun arrays include neurological effects, bubble formation, resonance effects, and other types of organ or tissue damage (Cox et al. 2006; Southall et al. 2007c; Zimmer and Tyack 2007; Tal et al. 2015), but similar to stress, these effects are not readily observable. Importantly, these more severe physical and physiological responses have been associated with explosives and/or mid-frequency tactical sonar, but not seismic airguns. There have been no reported stranding events after NSF surveys. Thus, we do not expect ESA-listed marine mammals to experience any of these more severe physical and physiological responses because of the proposed seismic survey activities.

Stress is an adaptive response and does not normally place an animal at risk. Distress involves a stress response resulting in a biological consequence to the individual. The mammalian stress response involves the hypothalamic-pituitary-adrenal axis being stimulated by a stressor, causing a cascade of physiological responses, such as the release of the stress hormones cortisol, adrenaline (epinephrine), glucocorticosteroids, and others (Thomson and Geraci 1986; St. Aubin and Geraci 1988; St. Aubin et al. 1996; Gulland et al. 1999; Gregory and Schmid 2001; Busch and Hayward 2009). These hormones subsequently can cause short-term weight loss, the liberation of glucose into the blood stream, impairment of the immune and nervous systems, elevated heart rate, body temperature, blood pressure, and alertness, and other responses (Thomson and Geraci 1986; Kaufman and Kaufman 1994; Dierauf and Gulland 2001; Cattet et al. 2003; Elftman et al. 2007; Fonfara et al. 2007; Noda et al. 2007; Mancia et al. 2008; Busch and Hayward 2009; Dickens et al. 2010; Costantini et al. 2011). In some species, stress can also increase an individual's susceptibility to gastrointestinal parasitism (Greer et al. 2005). In highly stressful circumstances, or in species prone to strong "fight-or-flight" responses, more extreme consequences can result, including muscle damage and death (Cowan and Curry 1998; Cowan and Curry 2002; Herraez et al. 2007; Cowan 2008). The most widely-recognized indicator of vertebrate stress, cortisol, normally takes hours to days to return to baseline levels following a significantly stressful event, but other hormones of the hypothalamic-pituitary-adrenal axis may persist for weeks (Dierauf and Gulland 2001). Stress levels can vary by age, sex, season, and health status (St. Aubin et al. 1996; Gardiner and Hall 1997; Hunt et al. 2006; Keay et al. 2006; Romero et al. 2008). For example, stress is lower in immature North Atlantic right whales than adults and mammals with poor diets or undergoing dietary change tend to have higher fecal cortisol levels (Hunt et al. 2006; Keay et al. 2006).

Loud sounds generally increase stress indicators in mammals (Kight and Swaddle 2011). Romano et al. (2004) found beluga whales and bottlenose dolphins exposed to a seismic water gun (up to 228 dB re: 1 μPa m peak-to-peak and single pure tones (up to 201 dB re: 1 μPa) had increases in stress chemicals, including catecholamines, which could affect an individual's ability to fight off disease. During the time following September 11, 2001, shipping traffic and associated ocean noise decreased along the northeastern U.S. This decrease in ocean sound was associated with a significant decline in fecal stress hormones in North Atlantic right whales, providing evidence that chronic exposure to increased noise levels, although not acutely injurious, can produce stress (Rolland et al. 2012). These levels returned to baseline after 24 hours of traffic resuming.

As whales use hearing for communication as a primary way to gather information about their environment, we assume that limiting these abilities, as is the case when masking occurs, will be stressful. We also assume that any individuals exposed to sound levels sufficient to trigger onset of TTS will also experience physiological stress response (NRC 2003b; NMFS 2006b). Finally, we assume that some individuals exposed at sound levels below those required to induce a TTS, but above the 160 dB re: 1 μPa (rms) threshold, will experience a stress response, which may also be associated with an overt behavioral response. However, exposure to sounds from airgun arrays (or fisheries echosounder) are expected to be temporary so we expect any such stress responses to be short-term. Given the available data, animals will be expected to return to baseline state (e.g., baseline cortisol level) within hours to days, with the duration of the stress response depending on the severity of the exposure (i.e., we expect a TTS exposure will result in a longer duration response before returning to a baseline state as compared to exposure to levels below the TTS threshold).

Data specific to cetaceans are not readily available to assess other non-auditory physical and physiological responses to sound. However, based on studies of other vertebrates, exposure to loud sound may also adversely affect reproductive and metabolic physiology (reviewed in Kight and Swaddle 2011). Premature birth and indicators of developmental instability (possibly due to disruptions in calcium regulation) have been found in embryonic and neonatal rats exposed to loud sound. Fish eggs and embryos exposed to sound levels only 15 dB greater than background showed increased mortality and surviving fry and slower growth rates, although the opposite trends have also been found in sea bream. Studies of rats have shown that their small intestine leaks additional cellular fluid during loud sound exposure, potentially exposing individuals to a higher risk of infection (reflected by increases in regional immune response in experimental animals). In addition, exposure to 12 hours of loud sound may alter cardiac tissue in rats. In a variety of response categories, including behavioral and physiological responses, female animals appear to be more sensitive or respond more strongly than males. It is noteworthy that, although various exposures to loud sound appear to have adverse results, exposure to music largely appears to result in beneficial effects in diverse taxa. Clearly, the impacts of even loud sound are complex and not universally negative (Kight and Swaddle 2011). Given the available data, and the short duration of exposure to sounds generated by airgun arrays, we do not anticipate any effects to reproductive and metabolic physiology of ESA-listed marine mammals exposed to these sounds.

It is possible that an animal's prior exposure to sounds from seismic surveys influence its future response. We have little information available to us as to what response individuals will have to future exposures to sources from seismic surveys compared to prior experience. If prior exposure produces a learned response, then this subsequent learned response will likely be similar to or less than prior responses to other stressors where the individual experienced a stress response associated with the novel stimuli and responded behaviorally as a consequence (such as moving away and reduced time budget for other activities like feeding that would otherwise be undertaken) (Andre 1997; André 1997; Gordon et al. 2006). We do not believe sensitization will occur based upon the lack of severe responses previously observed in marine mammals and sea turtles exposed to sounds from seismic surveys, including those conducted by NSF in or near the action area. The proposed action will take place over approximately 37 days; minimizing the likelihood that sensitization will occur. As stated before, we believe that exposed individuals will move away from the sound source, especially in the open ocean of the action area, where we expect species to be transiting.

Marine Mammals and Strandings

There is some concern regarding the coincidence of marine mammal strandings and proximal seismic surveys. No conclusive evidence exists to causally link stranding events to seismic surveys. Suggestions that there was a link between seismic surveys and strandings of humpback whales in Brazil (Engel et al. 2004) were not well founded (Iagc 2004; IWC 2007a). In September 2002, two Cuvier's beaked whales (*Ziphius cavirostris*) stranded in the Gulf of California, Mexico. The R/V *Maurice Ewing* had been operating a 20-airgun array (139,126.2 cubic centimeters [8,490 cubic inch]) 22 kilometers (11.9 nautical miles) offshore at the time that stranding occurred. The link between the stranding and the seismic surveys was inconclusive and not based on any physical evidence, as the individuals who happened upon the stranding were ill-equipped to perform an adequate necropsy (Taylor et al. 2004). Furthermore, the small numbers of animals involved and the lack of knowledge regarding the spatial and temporal correlation between the beaked whales and the sound source underlies the uncertainty regarding the linkage between sound sources from seismic surveys and beaked whale strandings (Cox et al. 2006). Numerous studies suggest that the physiology, behavior, habitat relationships, age, or condition of cetaceans may cause them to strand or might pre-dispose them to strand when exposed to another phenomenon. These suggestions are consistent with the conclusions of numerous other studies that have demonstrated that combinations of dissimilar stressors commonly combine to kill an animal or dramatically reduce its fitness, even though one exposure without the other does not produce the same result (Fair and Becker 2000; Moberg 2000; Kerby et al. 2004; Romano et al. 2004; Creel 2005). At present, the factors of airgun arrays from seismic surveys that may contribute to marine mammal strandings are unknown and we have no evidence to lead us to believe that aspects of the airgun array proposed for use will cause marine mammal strandings. The seismic survey will take place in the Northeast Pacific Ocean, and the closest approach to the United States coastline will be approximately 370.1 kilometers (230 miles) from land off Washington and Oregon. If exposed to seismic survey activities, we expect ESA-listed marine mammals will have sufficient space in the open ocean to move away from the sound source and will not be likely to experience exposure to the sound source to the point that animals would strand.

Marine Mammal Response to Multi-Beam Echosounder, Sub-Bottom Profiler, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

We expect ESA-listed marine mammals to experience ensonification from not only the airgun array, but also from the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. The multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler used during the seismic survey operate at a frequency of 10.5 to 13 (usually 12) kilohertz, 3.5 kilohertz, and 75 kilohertz, respectively. These frequencies are within the functional hearing range of baleen whales (7 Hertz to 35 kilohertz), such as blue, fin, humpback, and sei whales, as well as sperm whales (150 Hertz to 160 kilohertz) (NOAA 2018). We expect that these mapping systems will produce harmonic components in a frequency range above and below the center frequency similar to other commercial sonars (Deng 2014). Although Todd et al. (1992) found that mysticetes reacted to sonar sounds at 3.5 kilohertz within the 80 to 90 dB re: 1 μPa range, it is difficult to determine the significance of this because the sound source was a signal designed to be alarming and the sound level was well below typical ambient noise. Goldbogen et al. (2013) found blue whales to respond to 3.5 to 4 kilohertz mid-frequency sonar at received levels below 90 dB re: 1 μPa. Responses included cessation of foraging, increased swimming speed, and directed travel away from the source (Goldbogen 2013). Hearing is poorly understood for ESA-listed baleen whales, but it is assumed that they are most sensitive to frequencies over which they vocalize, which are much lower than frequencies emitted by the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder (Richardson et al. 1995e; Ketten 1997).

Assumptions for humpback and sperm whale hearing are much different than for ESA-listed baleen whales. Humpback and sperm whales vocalize between 3.5 to 12.6 kilohertz and an audiogram of a juvenile sperm whale provides direct support for hearing over this entire range (Payne 1970; Winn et al. 1970a; Levenson 1974; Tyack 1983a; Tyack and Whitehead 1983; Payne and Payne 1985; Silber 1986a; Thompson et al. 1986a; Carder and Ridgway 1990;

Weilgart and Whitehead 1993; Goold and Jones 1995; Richardson et al. 1995e; Weilgart and Whitehead 1997b; Au 2000; Frazer and Mercado 2000; Erbe 2002a; Au et al. 2006a; Weir et al. 2007). The response of a blue whale to 3.5 kilohertz sonar supports this species' ability to hear this signal as well (Goldbogen 2013). Maybaum (1990a; 1993) observed that Hawaiian humpback whales moved away and/or increased swimming speed upon exposure to 3.1 to 3.6 kilohertz sonar. Kremser et al. (2005) concluded the probability of a cetacean swimming through the area of exposure when such sources emit a pulse is small. The animal would have to pass the transducer at close range and be swimming at speeds similar to the vessel in order to receive the multiple pulses that might result in sufficient exposure to cause TTS. Sperm whales have stopped vocalizing in response to six to 13 kilohertz pingers, but did not respond to 12-kilohertz echosounders (Backus and Schevill 1966; Watkins and Schevill 1975a; Watkins 1977). Sperm whales exhibited a startle response to 10-kilohertz pulses upon exposure while resting and feeding, but not while traveling (Andre 1997; André 1997).

Investigations stemming from a 2008 stranding event in Madagascar indicated a 12 kilohertz multi-beam echosounder, similar in operating characteristics as that proposed for use aboard the R/V *Marcus G. Langseth*, suggest that this sonar played a significant role in the mass stranding of a large group of melon-headed whales (*Peponocephala electra*) (Southall 2013). Although pathological data suggest a direct physical effect is lacking and the authors acknowledge that, while the use of this type of sonar is widespread and commonplace globally without noted incidents (like the Madagascar stranding), all other possibilities were either ruled out or believed to be of much lower likelihood as a cause or contributor to stranding compared to the use of the multi-beam echosounder (Southall 2013). This incident highlights the caution needed when interpreting effects that may or may not stem from anthropogenic sound sources, such as the R/V *Marcus G. Langseth*'s use of the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler. Although effects such as the stranding in Madagascar have not been documented for ESA-listed species, the combination of exposure to this stressor with other factors, such as behavioral and reproductive state, oceanographic and bathymetric conditions, movement of the source, previous experience of individuals with the stressor, and other factors may combine to produce a response that is greater than would otherwise be anticipated or has been documented to date (Ellison et al. 2012; Francis 2013).

Although navigational sonars are operated routinely by thousands of vessels around the world, strandings have not been correlated to use of these sonars. Stranding events associated with the operation of naval sonar suggest that mid-frequency sonar sounds may have the capacity to cause serious impacts to marine mammals. The sonars proposed for use by the R/V *Marcus G. Langseth* differ from sonars used during naval operations, which generally have a longer pulse duration and more horizontal orientation than the more downward-directed multi-beam echosounder. The sound energy received by any individuals exposed to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler sound sources during the proposed seismic survey activities is lower relative to naval sonars, as is the duration of exposure. The area of possible influence for the multi-beam echosounder, sub-bottom profiler, acoustic Doppler current profiler, and acoustic release transponder is also much smaller, consisting of a narrow zone close to and below the source vessel. Because of these differences, we do not expect these systems to contribute to a stranding event on the part of ESA-listed marine mammals exposed to sound from operation of these systems during the proposed action.

We do not expect appreciable masking of blue, fin, humpback, sei, or sperm whales communication to occur due to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler's signal directionality, low duty cycle, and brief period when an individual could be within their beam. These factors were considered when Burkhardt et al. (2013) estimated the risk of injury from multi-beam echosounder was less than three percent that of vessel strike. Behavioral responses to the multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler are likely to be similar to the pulsed sources associated with the rest of the equipment operating during the seismic surveys if received at the same levels. We do not expect hearing impairment such as TTS and other physical effects if the animal is in the area while these equipment are operating, as it would have to pass the transducers at close range in order to be subjected to sound levels that could cause injurious effects.

10.2.2.2 Potential Responses of Sea Turtles to Acoustic Sources

As with marine mammals, ESA-listed sea turtles may exhibit a variety of responses to sound fields associated with seismic survey activities. Below we review what is known about the following responses that sea turtles may exhibit (reviewed in Nelms et al. 2016):

- Hearing threshold shifts;
- Behavioral responses; and
- Non-auditory physical or physiological effects.

To our knowledge, strandings of sea turtles in association with anthropogenic sound has not been documented, and so no such stranding response is expected. In addition, masking is not expected to affect sea turtles because they are not known to rely heavily on acoustics for life functions (Popper et al. 2014b; Nelms et al. 2016).

Acoustic Thresholds

In order to estimate exposure of ESA-listed sea turtles to sound fields generated by the airgun arrays that will be expected to result in a response, we relied on the available scientific literature. Currently, the best available data come from studies by O'Hara and Wilcox (1990) and McCauley et al. (2000a), who experimentally examined behavioral responses of sea turtles in response to airgun arrays. O'Hara and Wilcox (1990) found that loggerhead turtles exhibited avoidance behavior at estimated sound levels of 175 to 176 dB re: 1 μPa (rms) (or slightly less) in a shallow canal. McCauley et al. (2000a) reported a noticeable increase in swimming behavior for both green and loggerhead turtles at received levels of 166 dB re: 1 μPa (rms). At 175 dB re: 1 μPa (rms), both green and loggerhead turtles displayed increased swimming speed and increasingly erratic behavior (McCauley et al. 2000a). Based on these data, we assume that sea turtles will exhibit a behavioral response when exposed to received levels of 175 dB re: 1 μPa (rms) and higher, and so use this threshold to estimate the number of instances of exposure that will result in harassment response. The predicted distances to which sound levels of 175 dB re: 1 μPa (rms) will be received from the single (40 cubic inch), 36 airgun arrays for sea turtles during the seismic activities were presented in Table 3. To summarize, the predicted distances to the 175 dB re: 1 μPa (rms) threshold in shallow, intermediate, and deep waters are 3,924 meters, 2,542 meters, and 1,864 meters, respectively.

We have determined that PTS for sea turtles is highly unlikely to occur. For sea turtles, the thresholds for PTS are 204 dB re 1 $\mu Pa^2 \cdot s$ SEL_{cum}; and 232 dB re: 1 μPa SPL (0-pk). With a source level at the frequency of greatest energy, which is within the sensitive hearing range of sea turtles, the animal will almost have to be directly under the sound source exactly when it fires. Further, PTS may not ever be realized at close distances due to near-field interactions. The airgun array will be shut down if a leatherback sea turtle is about to enter the 100 meter exclusion zone; the calculated isopleth distance to the PTS threshold for sea turtles is 20.5 meters. In addition, the overall density of sea turtles in the action area will be relatively low (0.000114 #/km^2), further decreasing the chances of PTS occurring. Thus, we believe the only responses of leatherback sea turtles will be behavioral and assess the consequences of these responses in our risk analysis.

Sea Turtles and Hearing Thresholds

Like marine mammals, if exposed to loud sounds sea turtles may experience TTS and/or PTS. Although all sea turtle species exhibit the ability to detect low frequency sound in studies, the potential effects of exposure to loud sounds on sea turtle biology remain largely unknown (Samuel et al. 2005; Nelms et al. 2016). Few data are available to assess sea turtle hearing, let alone the effects sound sources from seismic surveys may have on their hearing potential. The only study which addressed sea turtle TTS was conducted by Moein et al. (1994), in which a loggerhead turtle experienced TTS upon multiple exposures to an airgun in a shallow water enclosure, but recovered full hearing sensitivity within one day.

As with marine mammals, we assume that sea turtles will not move towards a sound source that causes them stress or discomfort. Some experimental data suggest sea turtles may avoid seismic sound sources (Moein et al. 1994; McCauley et al. 2000b; McCauley et al. 2000c), but monitoring reports from seismic surveys in other regions suggest that some sea turtles do not avoid airguns and were likely exposed to higher levels of pulses from seismic airgun arrays (Smultea and Holst 2003). For this reason, mitigation measures will be implemented to limit sea turtle exposure at 100 meters (328.1 feet) through the use of observers and shutdowns. In most cases, we expect sea turtles will move away from sounds produced by the airgun array. Although data on the precise sound levels that can result in TTS or PTS are lacking for sea turtles and the effectiveness of mitigation measures such as those that will be implemented as part of the proposed action is not fully understood, we do not expect the vast majority of sea turtles present in the action area to be exposed to sound levels that will result in TTS or PTS. For those individuals that experience TTS, the available data suggest hearing will return to normal within days of the exposure (Moein et al. 1994).

Sea Turtles and Behavioral Responses

As with ESA-listed marine mammals, it is likely that sea turtles will exhibit behavioral responses in the form of avoidance. We do not have much information on how sea turtles will respond, but we present the available information. Behavioral responses to human activity have been investigated for only a few species of sea turtles: green and loggerhead (O'Hara and Wilcox 1990; McCauley et al. 2000a); and leatherback, loggerhead, olive ridley, and 160 unidentified turtles (hardshell species) (Weir 2007). The work by O'Hara and Wilcox (1990) and McCauley et al. (2000a) reported behavioral changes of sea turtles in response to seismic airgun arrays. These studies formed the basis for our 175 dB re: 1 μPa (rms) threshold for determining when sea turtles could experience behavioral or injurious effects due to sound exposure because at and above this level loggerhead turtles were observed to exhibit avoidance behavior, increased swimming speed, and erratic behavior. Loggerhead turtles have also been observed to move towards the surface upon exposure to an airgun (Lenhardt et al. 1983; Lenhardt 1994). In contrast, loggerhead turtles resting at the ocean surface were observed to startle and dive as an active seismic source approached them, with the responses decreasing with increasing distance from the source (Deruiter and Larbi Doukara 2012). Some of these animals may have reacted to the vessel's presence rather than the sound source (Deruiter and Larbi Doukara 2012). Monitoring reports from seismic surveys show that some sea turtles move away from approaching airgun arrays, although other sea turtles approach active airgun arrays within 10 meters (32.8 feet) with minor behavioral responses (Holst et al. 2005c; Smultea et al. 2005; Holst et al. 2006; NMFS 2006c; NMFS 2006a; Holst and Smultea 2008a).

Observational evidence suggests that sea turtles are not as sensitive to sound as are marine mammals and behavioral changes are only expected when sound levels rise above received sound levels of 175 dB re: 1 μPa (rms). If exposed at such sound levels, based on the available data, we anticipate some change in swimming patterns. Some sea turtles may approach the active airgun array, but we expect them to eventually turn away in order to avoid the active airgun array. As such, we expect temporary displacement of exposed individuals from some portions of the action area while the R/V *Marcus G. Langseth* transits through because of behavioral responses to sound sources.

Sea Turtles and Physical or Physiological Effects

Direct evidence of seismic sound causing stress is lacking in sea turtles. However, animals often respond to anthropogenic stressors in a manner that resembles a predator-prey response (Harrington and Veitch 1992; Lima 1998; Gill et al. 2001; Frid and Dill 2002; Frid 2003; Beale and Monaghan 2004; Romero 2004; Harris et al. 2018). As predators generally induce a stress response in their prey (Lopez 2001; Dwyer 2004; Mateo 2007), we assume that sea turtles experience a stress response if exposed to loud sounds from airgun arrays. Individuals may experience a stress response at levels lower than approximately 175 dB re: 1 μPa (rms), but data are lacking to evaluate this possibility. Therefore, we follow the best available evidence identifying a behavioral response as the point at which we also expect a significant stress response.

Sea Turtles Response to Multi-Beam Echosounder, Sub-Bottom Profiler, Acoustic Doppler Current Profiler, and Acoustic Release Transponder

Sea turtles do not possess a hearing range that includes frequencies emitted by the multi-beam echosounder (10.5 to 13 [usually 12] kilohertz), sub-bottom profiler (3.5 kilohertz), acoustic Doppler current profiler (75 kilohertz), and acoustic release transponder (8 to 13 kilohertz). Therefore, ESA-listed sea turtles are not expected to detect these sounds even if they are exposed and are not expected to respond to them.

10.2.2.3 Potential Response of Fishes to Acoustic Sources

Airguns are characterized as impulsive sounds. Possible effects for fish from impulsive sounds can be auditory (hearing impairments) or non-auditory (e.g., tissue effects, injury, barotrauma). There have been several documented effects to fish from seismic airguns, including:

- Hearing impairment or physical damage to fish ears;
- Barotrauma;
- Physiological stress responses;
- Masking; and
- Behavioral responses (displacement.

We do not expect mortality to occur for fishes exposed to the seismic airguns. A study examining the effects of a single airgun pulse on pallid sturgeon (*Scaphirhynchus albus*) found no mortality or lethal injury, but the authors pointed out that the effects of multiple exposures were still unknown (Popper et al. 2016).

Ensonified areas that are large and are subject to repeated blasts by the airgun array may impact ESA-listed fishes to a different degree than would other smaller or temporary impulsive sound sources (e.g., pile driving). For injury, the distance to the threshold for fish is 616 meters. Fish may not be able to leave the area at all or quickly enough to get to a quieter place and avoid the effects of the airguns (Popper and Casper 2011). The shot interval is 37.5 meters, and the R/V *Marcus G. Langseth* will conduct the survey while traveling at 4.2 knots per hour (about 7.8 kilometers per hour). The airgun blasts would occur 208 times in an hour.

Displacement of ESA-listed fishes, particularly Chinook, could be problematic for Southern Resident killer whales. If the proposed action causes Chinook to disperse and they become more difficult for the Southern Resident killer whales to find while foraging, causing Southern Resident killer whales to expend more energy, and perhaps a caloric deficit, leading to fitness consequences for individual animals. If displacement of ESA-listed fishes (or non-listed fish prey species) occurs in coastal Oregon, we are not concerned about indirect effects to Southern Resident killer whales through reduced foraging opportunities because we do not expect the

Southern Resident killer whales to be in those locations. Furthermore, while there is evidence to show that fish can be displaced from an area after seismic airgun operations (Skalski et al. 1992; Slotte et al. 2004), we do not expect fish to be displaced for more than a few days. That the survey will shoot the tracklines and then move on from that area (as opposed to shooting the same area in a lawnmower pattern) lends support to our belief that fish will return to the area within a few days after the survey concludes in an area. As a result, we consider the overall risk to Southern Resident killer whales from indirect effects to ESA-listed Chinook and other salmonids to be reduced.

The revised tracklines off the coast of Washington and Vancouver Island extend to the 100-meter isobaths, and thus do not cover the entirety of the continental shelf. For our analysis, we assumed that the habitat areas for Pacific salmonids was waters out to 200 meters deep. We would expect displacement of fish in those areas, and that fish would return to normal behavior and pre-survey distribution after a few days.

Because sound generated from the survey is brief (i.e., the survey would occur in continental shelf waters over the course of about three days), long-term effects on fish behavior are unlikely. The location of the tracklines in continental shelf waters is also spread out over the action area such that rather short portions of the continental shelf tracklines would be surveyed at one time. The survey would take place over a large action area, with the R/V *Marcus G. Langseth* conducting seismic activities over a trackline then proceeding to others. Thus we expect a single area to be ensonified only once during the entire action. Similarly, long periods of masking are unlikely from airgun activity for fishes, although some brief masking periods could occur and fishes may avoid the area of disturbance. Thus, most physiological stress and behavioral effects are expected to be temporary and of a short duration, and stress levels and behavior would return to normal after cessation of the airgun operation.

Acoustic Thresholds

Impulsive sound sources such as airguns are known to injure or kill fishes or elicit behavioral responses. For airguns, NMFS analyzed impacts from sound produced by airguns using the recommendations consistent with *ANSI Guidelines* (Popper et al. 2014b). These dual metric criteria—peak pressure and cumulative sound exposure level (SEL_{cum})—are used to estimate zones of effects related to mortality and injury from airgun exposure. NMFS assumes that a specified effect will occur when either metric is met or exceeded.

In the 2014 *ANSI Guidelines*, airgun thresholds are derived from the thresholds developed for impact pile-driving exposures (Halvorsen et al. 2011; Halvorsen et al. 2012b; Halvorsen et al. 2012c). This use of a dual metric criteria is consistent with the current impact hammer criteria NMFS applies for fishes with swim bladders (FHWG 2008; Stadler and Woodbury 2009). The interim criteria developed by the Fisheries Hydroacoustic Working Group include dual metric criteria wherein the onset of physical injury will be expected if either the peak SPL exceeds 206 dB re: 1 µPa, or the SEL_{cum}, exceeds 187 dB re: 1 μPa^2-s for fish two grams or larger, or 183 dB 1 μPa^2-s for fish smaller than two grams. However, at the same time the interim criteria were developed, very little information was available from airgun exposures. As such, it is also often applied to other impulsive sound sources. The 2008 interim criteria did not specifically separate thresholds according to severity of hearing impairment such as TTS to recoverable injury to mortality, which was done in the 2014 *ANSI Guidelines*. The 2008 interim criteria also do not differentiate between fish with swim bladders and those without, despite the presence of a swim bladder affecting hearing capabilities and fish sensitivity to sound. The 2008 interim criteria based the lower $\mathrm{SEL_{cum}}$ thresholds (187 dB re: 1 $\mu\mathrm{Pa}^2$-s and 183 dB re: 1 $\mu\mathrm{Pa}^2$-s) upon when TTS or minor injuries will be expected to occur. Therefore, these criteria establish the starting point when the whole spectrum of potential physical effects may occur for fishes, from TTS to minor, recoverable injury, up to lethal injury (i.e., either resulting in either instantaneous or delayed mortality). Because some generalized groupings of fish species can be made regarding what is currently known about fish hearing sensitivities (Popper and Hastings 2009; Casper et al. 2012b; Popper et al. 2014b) and influence of a swim bladder, and the fact that none of the ESA-listed Pacific salmonids or green sturgeon in the action area have a swim bladder associated with hearing (and eulachon do not have swim bladders), our analysis of ESA-listed fishes considered in this consultation is focused upon fishes with swim bladders not used in hearing. Southern DPS eulachon is the only ESA-listed fish species considered in this opinion that does not have a swim bladder. Therefore, for eulachon we used the criteria (187/206 dB peak SPL criteria for injury and TTS) for fish with swim bladders as it is likely conservative for this species.

Categories and descriptions of hearing sensitivities are further defined in this document (Popper and N. 2014) as the following[22]:

- Fishes with a swim bladder that is not involved in hearing, lack hearing specializations and primarily detect particle motion at frequencies below 1 kilohertz include all Pacific salmonid species and green sturgeon.

Criteria and thresholds to estimate TTS in fishes exposed to sound produced by airguns are greater than 186 $\mathrm{SEL_{cum}}$[23]. Exposure to sound produced from airguns at a cumulative sound exposure level of 186 dB (re: 1 $\mu\mathrm{Pa}^2$-s) has resulted in TTS in fishes (Popper et al. 2005a).[24]

For the National Science Foundation and L-DEO's seismic survey activities, airgun thresholds for fishes with swim bladders not involved in hearing are 210 $\mathrm{SEL_{cum}}$ and greater than 207

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[22] The 2014 ANSI Guidelines provide distinctions between fish with and without swim bladders and fish with swim bladders involved in hearing. None of the ESA-listed fish species considered in this consultation have swim bladders involved with their hearing abilities (e.g., Pacific salmonids and green sturgeon), but eulachon do not have swim bladders. Thus, we simplified the distinction to fishes with swim bladders.

[23] Notes: TTS = Temporary Threshold Shift, $\mathrm{SEL_{cum}}$ = Cumulative sound exposure level (decibel referenced to 1 micro Pascal squared seconds [dB re 1 µPa2-s]), NC = effects from exposure to sound produced by airguns is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

[24] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 $\mathrm{SEL_{cum}}$.

SPL_{peak} for onset of mortality and 203 SEL_{cum} and greater than 207 SPL_{peak} for onset of injury.[25] Criteria and thresholds to estimate TTS in fishes exposed to sound produced by airguns are greater than 186 $SEL_{cum.}$[26] Exposure to sound produced from airguns at a cumulative sound exposure level of 186 dB (re: 1 μPa^2-s) has resulted in TTS in fishes (Popper et al. 2005a).[27] As noted above, in fish that are two grams or larger, the onset of physical injury is expected when the SEL_{cum}, exceeds 187 dB re: 1 μPa^2-s. For this consultation, we expect that all fish exposed to the proposed action will be greater than two grams, and thus use 187 dB as the threshold for the onset of injury. Fish smaller than two grams would be in their natal rivers, not in the marine environment.

For potential behavioral responses of fishes (i.e., sub-injury) from exposure to anthropogenic sounds, there are no formal criteria yet established. This is largely due to the sheer diversity of fishes, their life histories and behaviors, as well as the inherent difficulties conducting studies related to fish behavior in the wild. The NMFS applies a conservative threshold of 150 dB re: 1 μPa (rms) to assess potential behavioral responses of fishes from acoustic stimuli, described below.

In a study conducted by McCauley et al. (2003b), fish were exposed to airgun arrays and observed to exhibit alarm responses from sound levels of 158 to 163 dB re: 1 μPa. In addition, when the 2008 criteria were being developed, one of the technical panel experts, Dr. Mardi Hastings, recommended a "safe limit" of fish exposure, meaning where no injury will be expected to occur to fishes from sound exposure, set at 150 dB re: 1 μPa (rms) based upon her research (Hastings 1990). This "safe limit" was also referenced in a document investigating fish effects from underwater sound generated from construction (Sonalysts 1997) where the authors mention two studies conducted by Dr. Hastings that noted no physical damage to fishes occurred when exposed to sound levels of 150 dB re: 1 μPa (rms) at frequencies between 100 to 2,000 Hertz. In that same report, the authors noted they also observed fish behavioral responses during sound exposure of 160 dB re: 1 μPa (rms), albeit at very high frequencies. More recently, Fewtrell and McCauley (2012) exposed fishes to airgun sound between 147 to 151 dB SEL, and observed alarm responses in fishes, as well as tightly grouped swimming or fast swimming speeds.

None of the current research available on fish behavioral response to sound make recommendations for a non-injury threshold. The studies mentioned here, as with most data available on behavioral responses to anthropogenic sound for fishes, have been obtained through

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[25] Notes: SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micro Pascal squared seconds [dB re 1 μPa2-s]), SPL_{peak} = Peak sound pressure level (decibel referenced to 1 micro Pascal [dB re: 1 μPa]), > indicates that the given effect would occur above the reported threshold.

[26] Notes: TTS = Temporary Threshold Shift, SEL_{cum} = Cumulative sound exposure level (decibel referenced to 1 micro Pascal squared seconds [dB re 1 μPa2-s]), NC = effects from exposure to sound produced by airguns is considered to be unlikely, therefore no criteria are reported, > indicates that the given effect would occur above the reported threshold.

[27] This is also slightly more conservative than the 2008 interim pile driving criteria of 187 SEL_{cum}.

controlled laboratory studies. In other cases, behavioral studies have been conducted in the field with caged fish. Research on fish behaviors has demonstrated that caged fish do not show normal behavioral responses, which makes it difficult to extrapolate caged fish behavior to wild, unconfined fishes (Hawkins et al. 2014; Popper and Hawkins 2014). It is also important to mention that some of the information regarding fish behavior while exposed to anthropogenic sounds has been obtained from unpublished documents such as monitoring reports, grey literature, or other non-peer reviewed documents with varying degrees of quality. Therefore, behavioral effects from anthropogenic sound exposure remains poorly understood for fishes, especially in the wild. Nonetheless, potential behavioral responses must be considered as an effect of acoustic stressors on ESA-listed fishes. For the reasons discussed, and until new data indicate otherwise, NMFS believes a 150 dB re: 1 μPa (rms) threshold for behavioral responses of fishes is appropriate. This criterion is used as a guideline to establish a sound level where responses of fishes may occur and could be a concern. For ESA-listed fishes, NMFS applies this criterion when considering the life stage affected, and any adverse effects that could occur from behavioral responses such as attentional disruption, which could lead to reduced foraging success, impaired predatory avoidance, leaving protected cover, release of stress hormones affecting growth rates, poor reproductive success rates, and disrupted migration. The thresholds for fishes with swim bladders (injury, TTS, behavioral responses) are summarized in Table 50. Eulachon do not have swim bladders; however, NMFS has not come to a consensus on thresholds for fishes without swim bladders. As a result, in the absence of that information, we use the thresholds shown in Table 58 and Table 59 for eulachon as well.

Table 57. Thresholds for fishes with swim bladders not associated with hearing exposed to sound produced by airguns.

Onset of Injury	TTS	Behavioral Responses
203 SEL_{cum} and greater than 206 SPL_{peak}	Greater than 187 SEL_{cum}	150 dB re: 1 μPa (rms)

We calculated the distances (isopleths) at which we expect the onset of injury to occur for fish during the proposed action (Table 59). Currently, NMFS does not have agreed-upon thresholds for the onset of mortality in fish due to sound from airguns.

Table 58. Distances (meters) for onset of injury and TTS for fishes with swim bladders not associated with hearing.

TTS Onset of Isopleth (meters)	Injury Onset Isopleth (meters)
187 SEL_{cum}	206 SPL_{peak}
3,211	230.1

In addition to sound pressure levels, we also considered effects from particle motion of fish. Fishes within the action area such as salmonids have a swim bladder that is distant from the ear and does not contribute to sound pressure reception. These fishes are primarily particle motion detectors. Particle motion is the back-and-forth motion of the component particles of the medium, measured as the particle displacement, velocity, or acceleration. While it is clear that the use of particle motion for establishing criteria is something that should be done in the future, the lack of data on how particle motion impacts fishes, as well as the lack of easily used methods to measure particle motion, currently precludes the evaluation of particle motion in our acoustic effects analysis (Hawkins et al. 2020).

Hearing Impairment (TTS) or Physical Damage to Ears

ESA-listed fishes may experience TTS or permanent injury as a result of seismic activities in the action area. There have been numerous studies conducted on the effects of seismic airguns on fish hearing. One study focusing on pink snapper (*Pristipomoides filamentosus*) kept in cages while a seismic airgun fired as close as 5 to 15 meters away showed physical damage to fish ears, with no evidence of recovery after 58 days (McCauley et al. 2003a). Lake chub (*Couesius plumbeus*) and northern pike (*Esox lucius*) exposed to five airgun blasts experienced hearing loss immediately after the exposure, with a return to normal hearing thresholds 18 to 24 hours afterwards (Popper et al. 2005b). A later follow-up study conducted under similar circumstances found no damage to the sensory epithelia in any of the otoloithic end organs in fish subjected to seismic airguns; northern pike and lake chub did exhibit TTS (Song et al. 2008). This is in contrast to other earlier sound exposure studies which did show physical damage to fish ears (Hastings et al. 1996; McCauley et al. 2003a). However, as Song et al. (2008) point out, factors like water depth and the airgun specifications likely make a difference in the degree of effects to fish.

We are unaware of any research demonstrating TTS in the species considered in this opinion (or other fish species with a swim bladder not involved in hearing) from seismic airguns. Coho, Chinook, chum, sockeye salmon, and steelhead all have a swim bladder, but it is not involved in hearing. Green sturgeon have a swim bladder but no known structures in the auditory system that would enhance hearing, and sensitivity (lowest sound detectable at any frequency) is not very great. Although TTS has not been demonstrated in the species groups considered in this opinion, this does not mean it does not occur. Because we know it can occur from other acoustic stressors, we assume it is possible from exposure to a sound stressor caused by seismic airguns. The criteria used for TTS was based upon a conservative value for more sensitive fish species and life stages with swim bladders. If TTS does occur, it would likely co-occur with barotraumas (i.e., non-auditory injury), and therefore would be within the range of other injuries these fishes are likely to experience from airgun blast exposures. None of the ESA-listed fish considered in this opinion (i.e., salmonids, eulachon, or sturgeon) have a hearing specialization or a swim bladder involved in hearing, thus, minimizing the likelihood of each instance of TTS affecting an individual's fitness. Most fish species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in salmonid migration (e.g., Putnam et al. 2013). TTS is also short-term in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Depending on the severity of the TTS and underlying degree of hair cell damage, a fish would be expected to recover from the impairment over a period of weeks (for the worst degree of TTS).

In summary, because the ESA-listed fish species considered in this opinion are not known to rely on hearing for essential life functions, and any effects from TTS would be short-term and temporary, individuals would be expected to recover with no long-term consequences.

Barotrauma

The term "barotrauma" refers to physical damage to tissues or organs, and occurs when there is a rapid change in pressure that directly affects the body gases in the fish (Board et al. 2011). When the seismic airgun discharges, it causes such a change in pressure. These types of sound pressures cause the swim bladder in a fish to rapidly and repeatedly expand and contract, and pound against the internal organs. This pneumatic pounding may result in hemorrhage and rupture of blood vessels and internal organs, including the swim bladder, spleen, liver and kidneys. External damage has also been documented, evident with loss of scales, hematomas in the eyes, at the base of fins, etc. (e.g., Yelverton et al. 1975; Wiley et al. 1981; Gisiner 1998; Casper et al. 2012b; Halvorsen et al. 2012a). Fishes can survive and recover from some injuries, but in other cases death can be instantaneous, occur within minutes after exposure, or occur several days later.

One study demonstrated barotrauma to juvenile Chinook from pile driving (an impulsive sound like airguns, but one that is stationary rather than mobile) (Halvorsen et al. 2012c). Another study evaluated the ability of juvenile Chinook to recover from barotrauma after exposure to pile driving, which provided evidence that the fish could recover from mild injuries and that exposure would not affect their survival (Casper et al. 2012a).

Physiological Stress

Physiological effects to fishes from exposure to anthropogenic sound are increases in stress hormones or changes to other biochemical stress indicators (e.g., Sverdrup et al. 1994; D'amelio et al. 1999; Wysocki et al. 2006). Physiological responses of fishes to acoustic stressors have been described in greater detail for other acoustics stressors on fishes. Exposure to seismic airguns could cause spikes in stress hormone levels, or alter a fish's natural behavioral patterns. Physiological effects to fishes from exposure to anthropogenic sound are increases in stress hormones or changes to other biochemical stress indicators (e.g., Sverdrup et al. 1994; D'amelio et al. 1999; Wysocki et al. 2006). Fishes may have physiological stress reactions to sounds that they can detect. For example, a sudden increase in sound pressure level or an increase in overall background noise levels can increase hormone levels and alter other metabolic rates indicative of a stress response. Studies have demonstrated elevated hormones such as cortisol, or increased ventilation and oxygen consumption (Pickering 1981; Smith et al. 2004b; Smith et al. 2004a; Hastings and C. 2009; Simpson et al. 2015; Simpson et al. 2016). Although results from these studies have varied, it has been shown that chronic or long-term (days or weeks) exposures to continuous anthropogenic sounds can lead to a reduction in embryo viability (Sierra-Flores et al. 2015b) and decreased growth rates (Nedelec et al. 2015).

Generally, stress responses are more likely to occur in the presence of potentially threatening sound sources such as predator vocalizations or the sudden onset of loud and impulsive sound signals. Stress responses are typically considered to be brief (a few seconds to minutes) if the exposure is short or if fishes habituate or have previous experience with the sound**.** However, exposure to chronic noise sources may lead to more severe effects leading to fitness consequences such as reduced growth rates, decreased survival rates, reduced foraging success, etc. Although physiological stress responses may not be detectable on fishes during sound exposures, NMFS assumes a stress response occurs when other physiological impacts such as injury or hearing loss occur.

Some studies have been conducted that measure changes in cortisol levels in response to sound sources. Cortisol levels have been measured in fishes exposed to vessel noises, predator vocalizations, or other tones during playback experiments**.** Nichols et al. (2015) exposed giant kelpfish (*Heterostichus rostratus*) to vessel playback sounds, and fish increased levels of cortisol were found with increased sound levels and intermittency of the playbacks. Gulf toadfish (*Opsanus beta*) were found to have elevated cortisol levels when exposed to low-frequency dolphin vocalization playbacks (Remage-Healey et al. 2006). Interestingly, the researchers observed none of these effects in toadfish exposed to low frequency snapping shrimp "pops.", indicating what sound the fish may detect and perceive as threats. Daily exposure of a short duration upsweep (a tone that sweeps upward across multiple frequencies) across 100 to 1,000 hertz of Atlantic cod (*Gadus morhua*) to artificial sound elicited a minor cortisol response, and when the broodstock was exposed during the spawning period, egg production and fertilization rates were reduced, leading to a more than 50 percent reduction in viable embryos (Sierra-Flores et al. 2015a). The levels returned to normal within one hour post-exposure, which supports the general assumption that spikes in stress hormones generally return to normal once the sound of concern ceases**.** The proposed action will not take place in the streams where salmonids spawn, so we do not expect to see similar effects in exposed fishes.

Not all research has indicated stress responses resulting in increased hormone levels. Goldfish exposed to continuous (0.1 to 10 kilohertz) sound at a pressure level of 170 dB re 1 μPa for one month showed no increase in stress hormones (Smith et al. 2004b). Similarly, Wysocki et al. (2007) exposed rainbow trout to continuous band-limited noise with a sound pressure level of about 150 dB re 1 μPa for nine months with no observed stress effects. Additionally, the researchers found no significant changes to growth rates or immune systems compared to control animals held at a sound pressure level of 110 dB re 1 μPa.

Other parameters can be an indicator of stress. A study examining the effects of seismic airguns on Atlantic cod and saithe (also known as pollock, *Pollachius virens*) found that cod exhibited a reduced heart rate in response to the particle motion component when the airgun were fired. Saithe did not exhibit alterations in heart rate (Davidsen et al. 2019). Heart rate can be a sensitive indicator of stress, although other components of cardiac output such as stroke volume play a role and would be necessary to fully consider the effects to fish. Based on the variety of responses shown in the studies presented here, it is difficult to definitively say how precisely ESA-listed fish will experience physiological stress upon exposure to airgun noise. However, we cannot rule it out. Individuals exposed may experience responses like increased cortisol levels, but these are expected to be brief, lasing for the duration of exposure while the airguns are operating near exposed fish, and not pose long-term consequences.

Masking

Masking generally results from a sound impeding an animal's ability to hear other sounds of interest. The frequency of the received level and duration of the sound exposure determine the potential degree of auditory masking. Similar to hearing loss, the greater the degree of masking, the smaller the area becomes within which an animal can detect biologically relevant sounds such as those required to attract mates, avoid predators or find prey (Slabbekoorn et al. 2010). Because the ability to detect and process sound may be important for fish survival, anything that may significantly prevent or affect the ability of fish to detect, process or otherwise recognize a biologically or ecologically relevant sound could decrease chances of survival. For example, some studies on anthropogenic sound effects on fishes have shown that the temporal pattern of fish vocalizations (e.g., sciaenids and gobies) may be altered when fish are exposed to sound-masking (Parsons et al. 2009b). This may indicate fish are able to react to noisy environments by exploiting "quiet windows" (e.g., Lugli and Fine 2003) or moving from affected areas and congregating in areas less disturbed by nuisance sound sources. In some cases, vocal compensations occur, such as increases in the number of individuals vocalizing in the area, or increases in the pulse/sound rates produced (Picciulin et al. 2012). Fish vocal compensations could have an energetic cost to the individual, which may lead to a fitness consequence such as affecting their reproductive success or increase detection by predators (Bonacito et al. 2001; Amorin et al. 2002).

Behavioral Responses (*Displacement*)

Behavioral responses could be expected to occur within the ensonified area for other injurious or physiological responses, and perhaps be extended beyond these ranges if a fish could detect the sound at those greater distances. Given that none of the species considered here have any specialized hearing adaptations, and the threshold for TTS is considered conservative for these hearing groups, most behavioral responses would be expected to occur within the ensonified area for injury and TTS.

In general, NMFS assumes that most fish species would respond in a similar manner to air guns as they do to other impulsive sounds like pile driving. These reactions could include startle or alarm responses; quick bursts in swimming speeds, diving, or changes in swimming orientation. In other responses, fish may move from the area or stay and try to hide if they perceive the sound as a potential threat. Other potential changes include reduced predator awareness and reduced feeding effort. The potential for adverse behavioral effects will depend on a number of factors, including the sensitivity to sound, the type and duration of the sound, as well as life stages of fish that are present in the areas affected.

Fish that detect an impulsive sound may respond in "alarm" detected by Fewtrell (2003), or another startle responses may be exhibited. The startle response in fishes is a quick burst of swimming that may be involved in avoidance of predators. A fish that exhibits a startle response may not necessarily be injured, but it is exhibiting behavior that suggests it perceives a stimulus indicating potential danger in its immediate environment. However, fish do not exhibit a startle response every time they experience a strong hydroacoustic stimulus. A study in Puget Sound, Washington suggests that pile driving operations disrupt juvenile salmon behavior (Feist et al. 1992). Though no underwater sound measurements are available from that study, comparisons between juvenile salmon schooling behavior in areas subjected to pile driving/construction and other areas where there was no pile driving/construction indicate that there were fewer schools of fish in the pile-driving areas than in the non-pile driving areas. The results are not conclusive but there is a suggestion that pile-driving operations may result in a disruption in the normal migratory behavior of the salmon in that study, though the mechanisms salmon may use for avoiding the area are not understood at this time.

Because of the inherent difficulties with conducting fish behavioral studies in the wild, data on behavioral responses for fishes is largely limited to caged or confined fish studies, mostly limited to studies using caged fishes and the use of seismic air guns (Lokkeborg et al. 2012). One way that researchers have been evaluating the effects of seismic airguns on fish is through examining fisheries catch rates before and after seismic surveys. There is evidence of fish displacement due to seismic surveys causing decreased catch rates of cod (Løkkeborg and Soldal 1993a). Another study showed that fishing catch rates decreased for haddock (68 percent) and cod (69 percent) within the seismic activity area, with effects observed up to 18 nautical miles from the seismic sound source and greater reductions closer to the sound source (Engås et al. 1996a). Catch rates did not return to normal in the five days after seismic activity ended. The authors also found that the effects of seismic activity were more pronounced on large cod (>60 centimeters) than smaller cod, with smaller cod still caught in the trawls and longlines. The authors hypothesized that this may be due to a size-dependent swimming capability of the larger fish to get away from the seismic sound source, or that the smaller fish are more able to take the bait on the longlines when the larger fish are not present (Engås et al. 1996a). A single airgun that created peak pressures above 186 dB caused a decline of 52.4 percent in rockfish (Sebastes spp.) catch per unit effort compared to control conditions (Skalski et al. 1992). It is important to point out that there has been a wide range of responses of fish catch rates to seismic surveys. In another study in Prudhoe Bay, Alaska, seismic activity changed fish catch rates, increasing catches of some species, and decreasing catches of others (Streever et al. 2016). A study examining reef fish behavior with video cameras during a seismic survey that approached within 0.7 and 6.5 kilometers found that reef fish abundance declined by 78 percent in the evening hours, when fish abundance had been highest. One fish was observed to exhibit a behavioral response by swimming away from a ledge (Paxton et al. 2017). However, another study looking at the response of reef fish to a three-dimensional seismic study found no measurable effect on species richness or abundance (Miller and Cripps 2013). In light of other studies described here, it still remains possible that ESA-listed fishes in the action area could experience displacement or other behavioral responses.

Responses of Marine Mammal, Sea Turtle, and Fish Prey

Seismic surveys may also have indirect, adverse effects on ESA-listed marine mammals, sea turtles, and fishes by affecting their prey (including larval stages) through lethal or sub-lethal damage, stress responses, or alterations in their behavior or distribution. Such prey include fishes (blue, fin, humpback, sei, sperm, Southern Resident killer whales, adult salmon, and Guadalupe fur seals), zooplankton (blue, fin, humpback, and sei whales), cephalopods (sperm whales and Guadalupe fur seals), and other invertebrates such as crustaceans, mollusks, amphipods, isopods, aquatic insects, insect larvae, and jellyfish (blue whales, juvenile salmon, green sturgeon, eulachon, and leatherback sea turtles). In a recent, fairly exhaustive review, Carroll et al. (2017) summarized the available information on the impact seismic surveys have on fishes and invertebrates. In many cases, species-specific information on the prey of ESA-listed marine mammals, sea turtles, and fishes is not available. Until more specific information becomes available, we expect that the prey of ESA-listed marine mammals, leatherback sea turtles, and fishes will respond to sound associated with the proposed action in a similar manner to those fishes and invertebrates described below (information derived from Carroll et al. (2017) unless otherwise noted).

Like with marine mammals and sea turtles, it is possible that seismic surveys can cause physical and physiological responses, including direct mortality, in fishes and invertebrates. In fishes, such responses appear to be highly variable, and depend on the nature of the exposure to seismic survey activities, as well as the species in question. Current data indicate that possible physical and physiological responses include hearing threshold shifts, barotraumatic ruptures, stress responses, organ damage, and/or mortality. For invertebrates, research is more limited, but the available data suggest that exposure to seismic survey activities can result in anatomical damage and mortality in some cases. In crustaceans and bivalves, there are mixed results with some studies suggesting that seismic surveys do not result in meaningful physiological and/or physical effects, while others indicate such effects may be possible under certain circumstances.

Furthermore, even within studies there are sometimes differing results depending on what aspect of physiology one examines (e.g., Fitzgibbon et al. 2017). In some cases, the discrepancies likely relate to differences in the contexts of the studies. For example, in a relatively uncontrolled field study, Parry et al. (2002) did not find significant differences in mortality between oysters that were exposed to a full seismic airgun array and those that were not, but a recent study by Day et al. (2017) in a more controlled setting did find significant differences in mortality between scallops exposed to a single airgun and a control group that received no exposure. However, the increased mortality documented by Day et al. (2017) was not significantly different from the expected natural mortality. All available data on echinoderms suggests they exhibit no physical or physiological response to exposure to seismic survey activities. Based on the available data, we assume that some fishes and invertebrates that serve as prey for ESA-listed marine mammals, sea turtles, and fish may experience physical and physiological effects, including mortality.

There has been research suggesting that that seismic airgun arrays may lead to a significant reduction in zooplankton, including copepods. McCauley et al. (2017) found that the use of a single airgun (approximately 150 cubic inches) led to a decrease in zooplankton abundance by over 50 percent and a two- to three-fold increase in dead adult and larval zooplankton when compared to control scenarios. In addition, effects were found out to 1.2 kilometers (0.6 nautical miles); the maximum distance to which sonar equipment used in the study was able to detect changes in abundance. McCauley et al. (2017) noted that for seismic activities to have a significant impact on zooplankton at an ecological scale, the spatial or temporal scale of the seismic activity must be large in comparison to the ecosystem in question. In particular, three-dimensional seismic surveys, which involve the use of multiple overlapping tracklines to extensively and intensively survey a particular area, are of concern (McCauley et al. 2017). This is in part because, in order for such activities to have a measurable effect, they need to outweigh the naturally fast turnover rate of zooplankton (McCauley et al. 2017). The proposed action takes place over a broad spatial area, with the tracklines spaced far apart and will last for 37 days, meaning that we do not believe that the spatial or temporal scale of the seismic survey is large in relation to the marine environment off the U.S. West Coast.

However, Fields et al. (2019a) has demonstrated different results through a series of control experiments using seismic blasts from two airguns (260 cubic inches) during 2009 and 2010 on the zooplankton *Calanus finmarchicus*. Their data show that seismic blasts have limited effects on the mortality of *C. finmarchicus* within 10 meters (32.8 feet) of the seismic airguns, but there was no measurable impact at greater distances. The study also found significantly higher immediate mortality at distances of <5 meters from the airgun and a higher cumulative mortality (7 days after exposure) at a distance somewhere between 10 and 20 meters from the airgun, and observed no sublethal effects but did see changes in gene expression (Fields et al. 2019b). Furthermore, Fields et al. (2019a) demonstrated that seismic airgun blasts had no effect on the escape response of *C. finmarchicus*. They conclude that the effects of seismic airgun blasts are much less than reported by McCauley et al. (2017).

Given the results from each of these studies, it is difficult to fully assess the exact impact seismic airgun arrays may have on the instantaneous or long-term survivability of zooplankton/krill that are exposed. Furthermore, the energy of the proposed seismic arrays (6,630 cubic inches versus 150 or 260 cubic inches) proposed in this consultation suggests that any copepod or crustacean directly exposed to the seismic airguns (underneath or within five meters [16.4 feet]) would likely suffer mortality to an extent greater than described by McCauley et al. (2017).

Results of McCauley et al. (2017) provide little information on the effects to copepods at the surface because their analyses excluded zooplankton at the surface bubble layer. Given that airguns primarily transmit sound downward, and that those associated with the proposed action will be towed at depths of 12 meters (39 feet), we expect that sounds from airgun array will be relatively low at the surface (i.e., above the airgun array), and greater below the airguns. Krill and copepod prey can be found throughout the water column. Baleen whales will dive to different depths to feed, depending on the locations of dense prey aggregations. The foraging depth dives vary by location, whale species, and, in some cases, by time of day, as whales will follow zooplankton prey vertical diel movements.

Seismic surveys are less likely to have significant effects over a broad area on zooplankton because of their fast growth rate and because of the high turnover rate of zooplankton. We expect ocean currents will circulate zooplankton within the action area within a matter of days to weeks (3 to 39 days; (see Richardson et al. 2017 for simulations based on the results of McCauley et al. 2017 that suggest ocean circulation greatly reduce the impact of seismic surveys on zooplankton at the population level). Richardson et al. (2017) simulated a "typical" seismic survey (60 survey lines in a lawnmower pattern, acquired over 35 days). The seismic activities in the proposed action will last for 37 days, and involve the vessel surveying a given area briefly over several hours then transiting to another area (i.e., survey lines will not be repeatedly shot in a given area as in the lawnmower pattern described in Richardson et al. 2017). While the proposed seismic survey may temporarily alter copepod or krill abundance in the action area, we expect such effects to be temporary because of the design of the survey, the high turnover rate of zooplankton, and ocean circulation that will minimize any effects.

Some evidence has been found for fish mortality resulting from exposure to airguns, and this is limited to close-range exposure to high amplitudes (Falk and Lawrence 1973; Kostyuchenko 1973; Holliday et al. 1987; La Bella et al. 1996; D'Amelio 1999; McCauley et al. 2000b; McCauley et al. 2000c; Bjarti 2002; Hassel et al. 2003; McCauley et al. 2003b; Popper et al. 2005a). Lethal effects, if any, are expected within a few meters of the airgun array (Dalen and Knutsen 1986; Buchanan et al. 2004). We expect that, if fish detect the sound and perceive it as a threat or some other signal that induces them to leave the area, they are capable of moving away from the sound source (e.g., airgun array) if it causes them discomfort. We also expect they will return to the area and be available as prey for marine mammals, leatherback sea turtles, and other fishes.

There are reports showing sub-lethal effects to some fish species from airgun arrays. Several species at various life stages have been exposed to high-intensity sound sources (220 to 242 dB re: 1 μPa) at close distances, with some cases of injury (Booman et al. 1996; McCauley et al. 2003b). Effects from TTS were not found in whitefish at received levels of approximately 175 dB re: 1 $\mu Pa^2 s$, but pike did show 10 to 15 dB of hearing loss with recovery within one day (Popper et al. 2005a). Caged pink snapper (*Pelates spp.*) have experienced PTS when exposed over 600 times to received sound levels of 165 to 209 dB re: 1 μPa peak-to-peak. Exposure to airguns at close range were found to produce balance issues in exposed fry (Dalen and Knutsen 1986). Exposure of monkfish (*Lophius* spp.) and capelin (*Mallotus villosus*) eggs at close range to airguns did not produce differences in mortality compared to control groups (Payne 2009). Salmonid swim bladders were reportedly damaged by received sound levels of approximately 230 dB re: 1 μPa (Falk and Lawrence 1973).

The prey of ESA-listed marine mammals, sea turtles, and fishes may also exhibit behavioral responses if exposed to active seismic airgun arrays. Based on the available data, as reviewed by Carroll et al. (2017), considerable variation exists in how fishes behaviorally respond to seismic survey activities, with some studies indicating no response and other noting startle or alarm responses and/or avoidance behavior. However, no effects to foraging or reproduction have been documented. Similarly, data on the behavioral response of invertebrates suggests that some species may exhibit a startle response, but most studies do not suggest strong behavioral responses. For example, a recent study by Charifi et al. (2017) found that oysters appear to close their valves in response to low frequency sinusoidal sounds. In addition, Day et al. (2017) recently found that when exposed to seismic airgun array sounds, scallops exhibit behavioral responses such as flinching, but none of the observed behavioral responses were considered to be energetically costly. As with marine mammals and sea turtles, behavioral responses by fishes and invertebrates may also be associated with a stress response.

Although received sound levels were not reported, caged *Pelates* spp., pink snapper, and trevally (*Caranx ignobilis*) generally exhibited startle, displacement, and/or grouping responses upon exposure to airguns (Fewtrell 2013a). These responses generally persisted for several minutes, although subsequent exposures of the same individuals did not necessarily elicit a response (Fewtrell 2013a).

Startle responses were observed in rockfish at received airgun levels of 200 dB re: 1 μPa 0-to-peak and alarm responses at greater than 177 dB re: 1 μPa 0-to-peak (Pearson et al. 1992). Fish also tightened schools and shifted their distribution downward. Normal position and behavior resumed 20 to 60 minutes after firing of the airgun ceased. A downward shift was also noted by Skalski et al. (1992) at received seismic sounds of 186 to 191 re: 1 μPa 0-to-peak. Caged European sea bass (*Dichentrarchus labrax*) showed elevated stress levels when exposed to airguns, but levels returned to normal after three days (Skalski 1992). These fish also showed a startle response when the seismic survey vessel was as much as 2.5 kilometer (1.3 nautical miles) away; this response increased in severity as the vessel approached and sound levels increased, but returned to normal after about two hours following cessation of airgun activity.

Whiting (*Merlangius merlangus*) exhibited a downward distributional shift upon exposure to 178 dB re: 1 μPa 0-to-peak sound from airguns, but habituated to the sound after one hour and returned to normal depth (sound environments of 185 to 192 dB re: 1 μPa) despite airgun activity (Chapman and Hawkins 1969). Whiting may also flee from sounds from airguns (Dalen and Knutsen 1986). Hake (*Merluccius* spp.) may re-distribute downward (La Bella et al. 1996). Lesser sand eels (*Ammodytes tobianus*) exhibited initial startle responses and upward vertical movements before fleeing from the seismic survey area upon approach of a vessel with an active source (Hassel et al. 2003; Hassel et al. 2004).

McCauley et al. (2000; 2000b) found small fish show startle responses at lower levels than larger fish in a variety of fish species and generally observed responses at received sound levels of 156 to 161 dB re: 1 μPa (rms), but responses tended to decrease over time suggesting habituation. As with previous studies, caged fish showed increases in swimming speeds and downward vertical shifts. Pollock (*Pollachius* spp.) did not respond to sounds from airguns received at 195 to 218 dB re: 1 μPa 0-to-peak, but did exhibit continual startle responses and fled from the acoustic source when visible (Wardle et al. 2001). Blue whiting (*Micromesistius poutassou*) and mesopelagic fishes were found to re-distribute 20 to 50 meters (65.6 to 164 feet) deeper in response to airgun ensonification and a shift away from the seismic survey area was also found (Slotte et al. 2004). Startle responses were infrequently observed from salmonids receiving 142 to 186 dB re: 1 μPa peak-to-peak sound levels from an airgun (Thomsen 2002). Cod (*Gadus* spp.) and haddock (*Melanogrammus aeglefinus*) likely vacate seismic survey areas in response to airgun activity and estimated catchability decreased starting at received sound levels of 160 to 180 dB re: 1 μPa 0-to-peak (Dalen and Knutsen 1986; Løkkeborg 1991; Engås et al. 1993; Løkkeborg and Soldal 1993b; Turnpenny et al. 1994; Engås et al. 1996b).

Increased swimming activity in response to airgun exposure on fish, as well as reduced foraging activity, is supported by data collected by Lokkeborg et al. (2012). Bass did not appear to vacate during a shallow-water seismic survey with received sound levels of 163 to 191 dB re: 1 μPa 0-to-peak (Turnpenny and Nedwell 1994). Similarly, European sea bass apparently did not leave their inshore habitat during a four- to five-month seismic survey (Pickett et al. 1994). La Bella et al. (1996) found no differences in trawl catch data before and after seismic survey activities and echosurveys of fish occurrence did not reveal differences in pelagic biomass. However, fish kept in cages did show behavioral responses to approaching operating airguns.

Squid are known to be important prey for sperm whales. Squid responses to operating airguns have also been studied, although to a lesser extent than fishes. In response to airgun exposure, squid exhibited both startle and avoidance responses at received sound levels of 174 dB re: 1 μPa (rms) by first ejecting ink and then moving rapidly away from the area (McCauley et al. 2000b; McCauley et al. 2000c; Fewtrell 2013b). The authors also noted some movement upward. During ramp-up, squid did not discharge ink but alarm responses occurred when received sound levels reached 156 to 161 dB re: 1 μPa (rms). Tenera Environmental (2011) reported that Norris and Mohl (1983, summarized in Mariyasu et al. 2004) observed lethal effects in squid (*Loligo vulgaris*) at levels of 246 to 252 dB after three to 11 minutes. Andre et al. (2011) exposed four cephalopod species (*Loligo vulgaris*, *Sepia officinalis*, *Octopus vulgaris*, and *Ilex coindetii*) to two hours of continuous sound from 50 to 400 Hertz at 157 ±5 dB re: 1 μPa. They reported lesions to the sensory hair cells of the statocysts of the exposed animals that increased in severity with time, suggesting that cephalopods are particularly sensitive to low-frequency sound. The received sound pressure level was 157 ±5 dB re: 1 μPa, with peak levels at 175 dB re: 1 μPa. Guerra et al. (2004) suggested that giant squid mortalities were associated with seismic surveys based upon coincidence of carcasses with the seismic surveys in time and space, as well as pathological information from the carcasses. Another laboratory story observed abnormalities in larval scallops after exposure to low frequency noise in tanks (de Soto et al. 2013).

Lobsters did not exhibit delayed mortality, or apparent damage to mechanobalancing systems after up to eight months post-exposure to airguns fired at 202 or 227 dB peak-to-peak pressure (Christian 2013). However, feeding did increase in exposed individuals (Christian 2013). Sperm whales regularly feed on squid and some fishes, and we expect individuals to feed while in the action area during the proposed seismic survey activities. Based upon the best available information, fishes and squids located within the sound fields corresponding to the approximate 160 dB re: 1 μPa (rms) isopleths could vacate the area and/or dive to greater depths.

The overall response of fishes and squids is to exhibit startle responses and undergo vertical and horizontal movements away from the sound field. We are not aware of any specific studies regarding sound effects on and the detection ability of other invertebrates such as krill (*Euphausiacea* spp.), the primary prey of most ESA-listed baleen whales. However, we do not expect krill to experience effects from sounds of airguns. Although humpback whales consume fish regularly, we expect that any disruption to their prey will be temporary, if at all. Therefore, we do not expect any adverse effects from a potential temporary lack of prey availability in localized areas to baleen whales. We expect indirect effects from airgun array operations through reduced feeding opportunities for ESA-listed marine mammals to be temporary and, if displaced, both marine mammals, sea turtles, and listed fish and their prey will re-distribute back into the action area once seismic survey activities have passed or concluded.

Based on the available data, we anticipate seismic survey activities will result in temporary and minor reduction in availability of prey for ESA-listed species near the airgun array immediately following the use of active seismic sound sources. This may be due to changes in prey distributions (i.e., due to avoidance) or abundance (i.e., due to mortality) or both. However, we do not expect this to have a meaningful impact on ESA-listed marine mammals, sea turtles, or fishes. As described above, we believe that, in most cases, ESA-listed marine mammals, sea turtles, and fishes will avoid closely approaching the airgun array when active, and as such will not be in areas from which prey have been temporarily displaced or otherwise affected.

10.3 Risk Analysis

In this section, we assess the consequences of the responses of the individuals that have been exposed, the populations those individuals represent, and the species those populations comprise.

We measure risks to individuals of threatened or endangered species based upon effects on the individual's fitness, which may be indicated by changes to the individual's growth, survival, annual reproductive fitness, and lifetime reproductive success. We expect the numbers of the following species to be exposed to the airgun array within 160 dB re: 1 µPa (rms) ensonified areas during the seismic survey activities:

- 40 blue,
- 94 fin,
- 42 Central DPS of humpback,
- 34 Mexico DPS of humpback,
- 30 sei,
- 72 sperm, and
- Southern Resident killer whales, and
- 2,048 Guadalupe fur seals

We expect up to three leatherback turtles to be exposed the airgun array within 175 dB re: 1 µPa (rms) ensonified areas during the seismic survey activities.

Expected exposures for ESA-listed Pacific salmon that would experience sound levels for TTS (187 dB) and injury (206 dB) are in Table 60, Table 61, and Table 62. We expect that 708,515 Southern DPS eulachon could be exposed at sound levels that could result in TTS, and of those, 39,179 could be exposed at sound levels that could result in injury. We were not able to calculate the number of individual Southern DPS green sturgeon.

Table 59. Estimated number of ESA-listed salmonids (hatchery fish w/adipose fin intact) that would experience TTS (187 dB) or be injured (206 dB) by seismic activities in the action area. Unless noted otherwise, - indicates there are no fish at this lifestage and ESU/DPS that would be affected by TTS or injury.

Species	Life stage	ESU/DPS	TTS	TTS Percentage	Injury	Injury Percentage
Chinook salmon	Adult	Sac River winter run - E	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Central valley spring run - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	California coastal - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult		879	2	56	0

Species	Life stage	ESU/DPS	TTS	TTS Percentage	Injury	Injury Percentage
	Juvenile	Snake River fall - T	61,886	2	3,965	0
	Adult	Snake River spring/summer - T	27	2	2	0
	Juvenile		16,762	2	1,074	0
	Adult[1]	Lower Columbia River - T	2,928	3	188	0
	Juvenile		19,090	3	1,560	0
	Adult[1]	Upper Willamette River - T	2,116	2	136	0
	Juvenile		4	2	-	-
	Adult	Upper Columbia River spring - E	218	2	14	0
	Juvenile		7,970	2	511	0
	Adult[1]	Puget Sound - T	2,744	6	176	0
	Juvenile		427,855	6	27,414	0
Coho salmon	Adult	Central California coast - E	186	28	12	2
	Juvenile		47,257	28	3,028	2
	Adult[1]	S. Oregon/N. California coast - T	1,712	8	110	1
	Juvenile		45,017	8	2,884	1
	Adult	Oregon coast - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Lower Columbia River - T	2,351	13	151	1
	Juvenile		33,397	13	2,140	1
Chum salmon	Adult	Hood Canal summer run	14	0	1	0
	Juvenile		480	0	31	0
	Adult	Columbia River - T	4	0	-	-
	Juvenile		1,925	0	123	
Sockeye salmon	Adult	Ozette Lake - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Snake River - E	-	-	-	-
	Juvenile		-	-	-	-
Steelhead	Adult	South-Central California - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult		-	-	-	-

Species	Life stage	ESU/DPS	TTS	TTS Percentage	Injury	Injury Percentage
	Juvenile	Central California - T	-	-	-	-
	Adult	California Central Valley - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Northern California - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Upper Columbia River - E	4	0	-	-
	Juvenile		148	0	9	0
	Adult	Snake River basin - T	52	0	3	0
	Juvenile		752	0	48	0
	Adult[1]	Lower Columbia River - T	71	0	5	0
	Juvenile		10	0	1	0
	Adult	Upper Willamette River - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Middle Columbia River - T	-	-	-	-
	Juvenile		118	0	8	0
	Adult	Puget Sound - T	-	-	-	-
	Juvenile		120	0	8	0

Table 60. Estimated number of ESA-listed salmonids (hatchery fish w/adipose fin clipped) that would experience TTS (187 dB) or be injured (206 dB) by seismic activities in the action area. Unless noted otherwise, - indicates there are no fish at this lifestage and ESU/DPS that would be affected by TTS or injury.

Species	Life stage	ESU/DPS	TTS	TTS Percentage	Injury	Injury Percentage
Chinook salmon	Adult	Sac River winter run - E	770	11	49	1
	Juvenile		22,985	11	1,473	1
	Adult	Central valley spring run - T	784	11	50	1
	Juvenile		249,307	11	15,974	1
	Adult	California coastal - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Snake River fall - T	1,006	2	64	0
	Juvenile		53,698	2	3,441	0

Species	Life stage	ESU/DPS	TTS	TTS Percentage	Injury	Injury Percentage
	Adult	Snake River spring/summer - T	155	2	10	0
	Juvenile		96,289	2	6,170	0
	Adult[1]	Lower Columbia River - T	-	-	-	-
	Juvenile		792,955	3	50,808	0
	Adult[1]	Upper Willamette River - T	-	-	-	-
	Juvenile		105,547	2	6,763	0
	Adult	Upper Columbia River spring - E	404	2	26	0
	Juvenile		13,443	2	861	0
	Adult[1]	Puget Sound - T	-	-	-	-
	Juvenile		2,135,854	6	136,852	0
Coho salmon	Adult	Central California coast - E	-	-	-	-
	Juvenile		-	-	-	-
	Adult[1]	S. Oregon/N. California coast - T	-	-	-	-
	Juvenile		15,658	8	1,003	1
	Adult	Oregon coast - T	121	11	8	1
	Juvenile		6,477	11	415	1
	Adult	Lower Columbia River - T	-	-	-	-
	Juvenile		974,391	13	62,433	1
Chum salmon	Adult	Hood Canal summer run - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Columbia River - T	-	-	-	-
	Juvenile		-	-	-	-
Sockeye salmon	Adult	Ozette Lake - T	38	0	2	0
	Juvenile		776	0	50	0
	Adult	Snake River - E	-	-	-	-
	Juvenile		-	-	-	-
Steelhead	Adult	South-Central California - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Central California - T	12	0	1	0
	Juvenile		692	0	44	0

Species	Life stage	ESU/DPS	TTS	TTS Percentage	Injury	Injury Percentage
	Adult	California Central Valley - T	12	0	1	0
	Juvenile		1,706	0	109	0
	Adult	Northern California - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Upper Columbia River - E	17	0	1	0
	Juvenile		733	0	47	0
	Adult	Snake River basin - T	254	0	16	0
	Juvenile		3,518	0	225	0
	Adult[1]	Lower Columbia River - T	-	-	-	-
	Juvenile		1,276	0	82	0
	Adult	Upper Willamette River - T	-	-	-	-
	Juvenile		-	-	-	-
	Adult	Middle Columbia River - T	1	0	-	-
	Juvenile		474	0	30	0
	Adult	Puget Sound - T	-	-	-	-
	Juvenile		117	0	8	0

Table 61. Estimated number of ESA-listed salmonids (natural fish) that would experience TTS (187 dB) or be injured (206 dB) by seismic activities in the action area. Unless noted otherwise, - indicates there are no fish at this lifestage and ESU/DPS that would be affected by mortality or injury.

Species	Life stage	ESU/DPS	TTS	TTS Percetage	Injury	Injury Percentage
Chinook salmon	Adult	Sac River winter run - E	72	11	5	1
	Juvenile		22,451	11	1,439	1
	Adult	Central valley spring run - T	1,285	11	82	1
	Juvenile		89,120	11	5,710	1
	Adult	California coastal - T	4,665	22	299	1
	Juvenile		282,538	22	18,103	1
	Adult	Snake River fall - T	670	2	43	0
	Juvenile		14,979	2	960	0
	Adult		830	2	53	0

Species	Life stage	ESU/DPS	TTS	TTS Percetage	Injury	Injury Percentage
	Juvenile	Snake River spring/summer - T	21,783	2	1,396	0
	Adult[1]	Lower Columbia River - T	2,236	3	143	0
	Juvenile		297,042	3	19,033	0
	Adult[1]	Upper Willamette River - T	686	2	44	0
	Juvenile		27,162	2	1,740	0
	Adult	Upper Columbia River spring - E	186	2	12	0
	Juvenile		10,136	2	649	0
	Adult[1]	Puget Sound - T	3,954	6	253	0
	Juvenile		178,605	6	11,444	0
Coho salmon	Adult	Central California coast - E	1,101	28	71	2
	Juvenile		45,049	28	2,886	2
	Adult[1]	S. Oregon/N. California coast - T	1,419	8	91	1
	Juvenile		157,644	8	10,101	1
	Adult	Oregon coast - T	20,365	11	1,305	1
	Juvenile		717,012	11	45,942	1
	Adult	Lower Columbia River - T	7,986	13	512	1
	Juvenile		88,441	13	5,667	1
Chum salmon	Adult	Hood Canal summer run - T	241	0	15	0
	Juvenile		12,449	0	798	0
	Adult	Columbia River - T	102	0	7	0
	Juvenile		21,206	0	1,359	0
Sockeye salmon	Adult	Ozette Lake - T	5	0	-	-
	Juvenile		61	0	4	0
	Adult	Snake River - E	2	0	-	-
	Juvenile		84	0	5	0
Steelhead	Adult	South-Central California - T	7	0	-	-
	Juvenile		265	0	5	0
	Adult	Central California - T	5	0	-	-
	Juvenile		672	0	17	0

Species	Life stage	ESU/DPS	TTS	TTS Percetage	Injury	Injury Percentage
	Adult	California Central Valley - T	23	0	1	0
	Juvenile		876	0	56	0
	Adult	Northern California - T	5	0	1	0
	Juvenile		672	0	43	0
	Adult	Upper Columbia River - E	23	0	1	0
	Juvenile		876	0	56	0
	Adult	Snake River basin - T	6	0	-	-
	Juvenile		213	0	14	0
	Adult[1]	Lower Columbia River - T	34	0	2	0
	Juvenile		851	0	55	0
	Adult	Upper Willamette River - T	41	0	3	-
	Juvenile		375	0	24	0
	Adult	Middle Columbia River - T	9	0	3	0
	Juvenile		150	0	24	0
	Adult	Puget Sound - T	16	0	1	0
	Juvenile		435	0	28	0

As described above, the proposed action will result in temporary effects, largely behavioral but with some potential for TTS to the exposed marine mammals and sea turtles (blue, fin, Central America DPS and Mexico DPS of humpback, sei, sperm, Southern Resident killer whales, Guadalupe fur seals, and leatherback turtles). Similarly, we expect that the proposed action will result in temporary behavioral effects with limited potential for TTS or injurious effects to exposed ESA-listed Chinook, Coho, chum, sockeye, steelhead, Southern DPS green sturgeon, or Southern DPS eulachon. The potential for adverse effects to result in injury or mortality is low in part due to the required mitigation measures (e.g., shutdown procedures) in the proposed IHA for the proposed seismic survey activities to protect ESA-listed species. As such, we believe the fitness consequences to ESA-listed marine mammals, sea turtles, or fishes exposed to the sound sources from the seismic survey will have a minimal effect on the populations of these species.

11 CUMULATIVE EFFECTS

"Cumulative effects" are those effects of future state or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation (50 C.F.R. §402.02). Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

We expect that those aspects described in the *Environmental Baseline* (Section 9) will continue to impact ESA-listed resources into the foreseeable future. We expect climate change, oceanic temperature regimes, vessel strikes, whale watching, fisheries (fisheries interactions and aquaculture), pollution (marine debris, pesticides and contaminants, and hydrocarbons), aquatic nuisance species, anthropogenic sound (vessel sound and commercial shipping, aircraft, seismic surveys, and marine construction), military activities, and scientific research activities to continue into the future with continuing impacts to marine mammals, sea turtles, and fishes. Because of recent trends and based on available information, we expect the amount and frequency of vessel activity to persist in the action area, and that ESA-listed species will continue to be impacted. Different aspects of vessel activity can impact ESA-listed species, such as vessel noise, disturbance, and the risk of vessel strike causing injury or mortality to marine mammals, especially large whales, and to a lesser extent, sea turtles and fishes. However, movement towards bycatch reduction and greater foreign protections of sea turtles are generally occurring throughout the Northeast Pacific Ocean, which may aid in abating the downward trajectory of sea turtle populations due to activities such as fishing in the action area. Similar legislative efforts for the conservation of Pacific salmon may also aid in improving the status of those populations in the action area; see discussion below.

During this consultation, we searched for information on future state, tribal, local, or private (non-Federal) actions that were reasonably certain to occur in the action area. We conducted electronic searches of *Google* and other electronic search engines for other potential future state or private activities that are likely to occur in the action area.

Future tribal, state, and local government actions will likely be in the form of legislation, administrative rules, or policy initiatives and fishing permits. Activities occurring in the action area are primarily those conducted under state and tribal management. These actions may include changes in ocean policy and increases and decreases in the types of activities currently seen in the action area, including changes in the types of fishing activities, resource extraction, and designation of marine protected areas, any of which could influence the status of listed species in the action area in the future. Government actions are subject to political, legislative and fiscal uncertainties. As a result, any analysis of cumulative effects is difficult, particularly when taking into account the geographic scope of the action area, the various authorities involved in the action, and the changing economies of the region.

An example of one such initiative is the Southern Resident Killer Whale Task Force, established through an executive order by the governor of Washington State to identify, prioritize, and support the implementation of a longer-term action plan for Southern Resident killer whale recovery. The Task Force provided recommendations in a final report in November 2018. Although it is likely that several of the recommended actions will occur, it is currently uncertain which ones will be implemented. In response to recommendations of the Task Force, the

Washington State Legislature provided approximately $13 million in funding "prioritized to increase prey abundance for southern resident orcas" (Engrossed Substitute House Bill 1109) for the 2019-2021 biennium (July 2019 through June 2021). The planned 2020 production associated with this legislative action is a release of an additional 13.5 million Chinook salmon (approximately 6.4 million from Puget Sound facilities, approximately 5.6 million from Washington coastal facilities, and approximately 1.5 million from Columbia River facilities). A similar level of Chinook salmon production funded by this legislative action is anticipated in the spring of 2021, meaning that the effects of hatchery releases on ESA-listed salmonids will continue and may increase in the future.

Washington State passed House Bill 1579 that addresses habitat protection of shorelines and waterways (Chapter 290, Laws of 2019 [2SHB 1579]), and funding was included for salmon habitat restoration programs and to increase technical assistance and enforcement of state water quality, water quantity, and habitat protection laws. Other state actions included measures to increase survival through the hydropower system on the Lower Snake and Lower Columbia Rivers, passed legislation to decrease impacts of predatory fish on salmon (Chapter 290, Laws of 2019 [2SHB 1579]), passed the federal Endangered Salmon Predation Prevention Act (PL 115-329) to provide state and tribal managers more flexibility to manage sea lion predation on the Columbia River, and provided funding to the Washington State Department of Transportation to complete fish barrier corrections and to implement a Lower Snake River dams stakeholder engagement process.

12 INTEGRATION AND SYNTHESIS

The *Integration and Synthesis* section is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the proposed action. In this section, we add the *Effects of the Action* (Section 10) to the *Environmental Baseline* (Section 9) and the *Cumulative Effects* (Section 11) to formulate the agency's biological opinion as to whether the proposed action is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a ESA-listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) reduce the value of designated or proposed critical habitat for the conservation of the species. These assessments are made in full consideration of the *Status of the Species and Critical Habitat* (Section 8).

Some ESA-listed species and designated critical habitat are located within the action area but are not expected to be affected by the action, or the effects of the action on these ESA resources were determined to be insignificant or discountable. Some activities evaluated individually were determined to have insignificant or discountable effects and thus to be not likely to adversely affect some ESA-listed species and designated critical habitats (Section 7).

The following discussions separately summarize the probable risks the proposed action poses to threatened and endangered marine mammals, leatherback sea turtles, and ESA-listed fish. These summaries integrate the exposure profiles presented previously with the results of our response analyses for each of the activities considered further in this opinion; specifically seismic survey activities and associated equipment sound levels.

12.1 Jeopardy Analysis

The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of a listed species," which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species (50 C.F.R. §402.02). Therefore, the jeopardy analysis considers both the survival and recovery of the species.

Based on our effects analysis, adverse effects to ESA-listed species are likely to result from the action. The following discussions summarize the probable risks that seismic survey activities pose to ESA-listed species that are likely to be exposed over the approximately 37 days of the seismic survey activities. These summaries integrate our exposure, response, and risk analyses from Section 10.

12.1.1 Blue Whale

Adult and juvenile blue whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an animal's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

The minimum population size for Eastern North Pacific Ocean blue whales is 1,050; the more recent abundance estimate is 1,496 whales (Carretta et al. 2020). Current estimates indicate a growth rate of just under three percent per year (Calambokidis et al. 2009). We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. Take may have short- or long-term consequences, depending on the level of noise from detonations to which animals are exposed. The anticipated take of animals is not expected to result in the loss of reproduction at an individual level or to have a measurable effect on reproduction at the population level.

No reduction in the distribution of blue whales from the Pacific Ocean or changes to the geographic range of the species are expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. Therefore, no reduction in reproduction is expected as a result of the proposed actions. Non-lethal take of 59 individuals, adults and juveniles, is expected as a result of the proposed seismic survey activities. We anticipate temporary behavioral responses, with individuals returning to normal shortly after the exposure has ended, and thus do not anticipate any delay in reproduction as a result. Because we do not anticipate a reduction in numbers or reproduction of blue whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Final Recovery Plan for the blue whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Reduce or eliminate human-caused injury and mortality of blue whales.
- Minimize detrimental effects of directed vessel interactions with blue whales.
- Coordinate state, federal, and international efforts to implement recovery actions for blue whales.

Because no mortalities or effects on the abundance, distribution, and reproduction of blue whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for blue whales. In conclusion, we believe the non-lethal effects of take associated with the proposed actions will not jeopardize the continued existence of blue whales.

12.1.2 Fin Whale

Adult and juvenile fin whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of the individual's response to noise associated with the seismic survey will depend on the duration and severity of the exposure.

Current estimates indicate approximately 10,000 fin whales in U.S. Pacific Ocean waters, with an annual growth rate of 4.8 percent in the Northeast Pacific and a stable population abundance in the California/Oregon/Washington stock (Nadeem et al. 2016).

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. We anticipate temporary behavioral responses, with individuals returning to normal shortly after the exposure has ended. No reduction in the distribution of fin whales from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. No reduction in numbers is anticipated due to the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. There are expected to be one individual harmed and 96 individuals, adults and juveniles, harassed because of the proposed seismic survey activities. Because we do not anticipate a reduction in numbers, distribution, or reproduction of fin whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the fin whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable population in all ocean basins.

- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of fin whale populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for fin whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of fin whales in the wild.

12.1.3 Sei Whale

Adult and juvenile sei whales are present in the action area and are expected to be exposed to noise from the seismic survey activities. The severity of an individual's response to noise associated with the seismic survey will depend on the duration and severity of exposure.

Models indicate that total abundance declined from 42,000 to 8,600 individuals between 1963 and 1974 in the North Pacific Ocean. More recently, the North Pacific Ocean population was estimated to be 29,632 (95 percent confidence intervals 18,576 to 47,267) between 2010 and 2012 (IWC 2016; Thomas et al. 2016). Population growth rates for sei whales are not available at this time as there are little to no systematic survey efforts to study sei whales.

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. There are expected to be two individuals harmed and 31 individuals, adults and juveniles, harassed because of the proposed seismic survey activities. No reduction in the distribution of sei whales from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. No reduction in numbers is anticipated due to the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sei whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2001 Final Recovery Plan for the sei whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of sei whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for sei whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sei whales in the wild.

12.1.4 Humpback Whale—Central America DPS

Adult and juvenile Central America DPS humpback whales are present in the action area and are expected to be exposed to noise from the seismic survey activities.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Central America DPS is 411. A population growth rate is currently unavailable for the Central America DPS of humpback whales.

We expect that adults and juveniles may be affected by take in the form of PTS, TTS, or behavioral changes from sound sources associated with the seismic survey. The severity of an animal's response to noise associated with the seismic survey will depend on the duration and severity of exposure. No reduction in the distribution of Central America DPS of humpback whales from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. There are expected to be 11 individuals harmed and 42 individuals harassed, adults and juveniles, because of the proposed seismic surveys. Because we do not anticipate a reduction in numbers or reproduction of Central DPS of humpback whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 1991 Final Recovery Plan for the humpback whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and morality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

Because no mortalities or effects on the distribution of Central America DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Central America DPS of humpback whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Central America of DPS of humpback whales in the wild.

12.1.5 Humpback Whale—Mexico DPS

Adult and juvenile Mexico DPS humpback whales are present in the action area and are expected to be exposed to noise from the seismic survey activities.

The global, pre-exploitation estimate for humpback whales is 1,000,000 (Roman and Palumbi 2003). The current abundance of the Mexico DPS is unavailable. A population growth rate is currently unavailable for the Mexico DPS of humpback whales.

There are expected to be nine individuals harmed and 34 individuals, juveniles and adults, harassed because of the proposed seismic survey activities. No reduction in the distribution of Mexico DPS of humpback whales from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's research activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Mexico DPS of humpback whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 1991 Final Recovery Plan for the humpback whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Maintain and enhance habitats used by humpback whales currently or historically.
- Identify and reduce direct human-related injury and morality.
- Measure and monitor key population parameters.
- Improve administration and coordination of recovery program for humpback whales.

Because no mortalities or effects on the distribution of Mexico DPS of humpback whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Mexico DPS of humpback whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Mexico DPS of humpback whales in the wild.

12.1.6 Sperm Whale

Adult and juvenile sperm whales are present in the action area and are expected to be exposed to noise from the seismic survey activities.

The sperm whale is the most abundant of the large whale species, with total abundance estimates between 200,000 and 1,500,000. The most recent estimate indicated a global population of between 300,000 and 450,000 individuals (Whitehead 2009). The higher estimates may be approaching population sizes prior to commercial whaling. In the Northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. In the northeast Pacific Ocean, the abundance of sperm whales was estimated to be between 26,300 and 32,100 in 1997. There is insufficient data to evaluate trends in abundance and growth rates of sperm whales at this time.

There are expected to be zero individuals harmed and 73 individuals, adults and juveniles, harassed because of the proposed seismic survey activities. No reduction in the distribution of sperm whales from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization. No reduction in numbers is anticipated as part of the proposed actions. Therefore, no reduction in reproduction is expected due to the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of sperm whales as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The 2010 Final Recovery Plan for the sperm whale lists recovery objectives for the species. The following recovery objectives are relevant to the impacts of the proposed actions:

- Achieve sufficient and viable populations in all ocean basins.
- Ensure significant threats are addressed.

Because no mortalities or effects on the distribution of sperm whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for sperm whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of sperm whales in the wild.

12.1.7 Southern Resident Killer Whale

The Southern Resident killer whale DPS was listed as endangered under the ESA on November 18, 2005. The cumulative and synergistic effects of multiple threats have resulted in the continued decline of the Southern Resident killer whale population. Between 1967 and 1973, about 30 percent of the population was captured live for displays in oceanaria. The primary ongoing threats to the recovery of this population include quantity and quality of prey, toxic chemicals that accumulate in top predators, and disturbance from sound and vessels. Based on their population size and life history traits (i.e., slow-growing mammals that give birth to single calves with several years between births), we assume that Southern Resident killer whales would have elevated extinction probabilities due to a combination of exogenous anthropogenic threats (as discussed above in the Section 8.4.4 *Status of the Species* and Section 9 *Environmental Baseline*), natural phenomena (including vulnerability to disease), and endogenous threats resulting from their small population size.

A growing body of evidence documents how Southern Resident killer whales are affected by prey limitations, particularly Chinook salmon. Salmon populations in the Pacific Northwest have declined due to a combination of factors including land alteration associated with agriculture and timber harvest practices, the construction of dams, urbanization, fishery harvest practices, hatchery operations, and increased predation from a growing population of pinnipeds. When prey is scarce, whales likely spend more time foraging than when it is plentiful. Increased energy expenditure and prey limitation can cause nutritional stress. Nutritional stress is the condition of being unable to acquire adequate energy and nutrients from prey resources and as a chronic condition can lead to reduced body size and condition of individuals and lower birth and survival rates in a population. Indicators of nutritional stress include the poor condition individual Southern Resident killer whales are occasionally found in, and variable levels of the thyroid hormone triiodothyronine (Wasser et al. 2017). In addition, Southern Resident killer whale fecundity, death rates and rates of population increase have shown statistical correlations with some indices of Chinook salmon abundance (Hilborn et al. 2012).

Vessel traffic exposes Southern Resident killer whales to several threats that have consequences for the species' likelihood of survival and recovery. Three vessels strikes, two lethal and one sublethal, of Southern Resident killer whales have been documented in the past 15 years. In addition to strikes, the number and proximity of vessels, particularly whale-watch vessels in the inland areas occupied by Southern Resident killer whales, represents a source of chronic disturbance and stress for this population. With the disruption of feeding behavior that has been observed, it is estimated that the presence of vessels could result in an 18 percent decrease in energy intake, a consequence that could have a significant negative effect on an already prey-limited species (Williams et al. 2006a; Lusseau et al. 2009b). Foraging behavior may also be impacted by sound that interferes with the whales' echolocation from vessels or other sounds sources. In addition to the disturbance associated with the presence of vessels, vessel traffic affects the acoustic landscape that may affect Southern Resident killer whale communication and social ecology. Vessels in the path of the whales can interfere with important social behaviors such as prey sharing (Ford and Ellis 2006) or nursing (Kriete 2007).

Exposure to contaminants may also harm Southern Resident killer whales. Because of their long life span, position at the top of the food chain, and their blubber stores, killer whales are capable of accumulating high concentrations of contaminants. The presence of high levels of persistent organic pollutants, such as PCB, DDT, and flame-retardants has been documented in Southern Resident killer whales (Ross et al. 2000; Krahn et al. 2007b). Although the consequences of these pollutants on the fitness of individual killer whales and the population as a whole remain unknown, in other species these pollutants have been reported to suppress immune responses (Wright et al. 2007), impair reproduction, and exacerbate the energetic consequences of physiological stress responses when they interact with other compounds in an animal's tissues (Martineau 2007).

In the mid- to late-1800s, the Southern Resident killer whale DPS was estimated to have numbered around 200 individuals. For the period between 1974 and the mid-1990s, when the population increased from 76 to 93 animals, the population growth rate was 1.8 percent. A delisting criterion for the Southern Resident killer whale DPS is an average growth rate of 2.3 percent for 28 years (NMFS 2008d). More recent data indicate the population is now in decline (Carretta 2019b). The current population estimate of 74 represents a decline from the recent past, when in 2012 there were 85 whales. As compared to stable or growing populations, the DPS reflects lower fecundity and has demonstrated little to no growth in recent decades (NMFS 2016h).

Given the low current population size, Southern Resident killer whales likely have a higher probability of becoming extinct because of demographic stochasticity, demographic heterogeneity (Coulson et al. 2006; Fox 2007), including stochastic sex determination (Lande et al. 2003), and the effects of phenomena interacting with environmental variability. The very small estimated effective population size (about 26 individuals), the absence of gene flow from other populations, and documented breeding within pods may elevate the risk from inbreeding and other issues associated with genetic deterioration (Ford et al. 2018b). These phenomena would likely amplify the potential consequences of anthropogenic stressors on this species.

The proposed action is expected to expose 11 Southern Resident killer whales, adults and juveniles, to behavioral harassment over the 37 days of seismic activities. No exposures resulting in PTS of Southern Resident killer whales were predicted (see 10.2.1.2 for details).

Southall et al. (2016) suggested that even minor, sub-lethal behavioral changes may still have significant energetic and physiological consequences given sustained or repeated exposure. The consequences of exposure to the anticipated acoustics effects would be more significant for whales that are already in poor condition; as such, animals would be less likely to compensate for additional energy expenditures or lost foraging or reproductive opportunities. Southern Resident killer whale individuals are occasionally found in poor condition, which may indicate nutritional stress. However, sustained or repeated disturbance is unlikely for any individual Southern Resident killer whale given the relatively low estimated number of exposures predicted. The proposed action would not take place in the areas of the Washington and Vancouver Island coasts where we expect the highest density of Southern Resident killer whales (see Figure 44; (Navy 2019)). Seismic activities would occur further off the coast than where we expect Southern Resident killer whales to spend the majority of their time in waters less than 100 meters deep, and within 34 kilometers of shore (NMFS 2019c).

Exposures would likely be short-term. The seismic activities in the proposed action will last 37 days, with seismic activities nearest the Washington and Vancouver Island coasts lasting a few days at most. Based on the available literature that indicates such infrequent exposures are unlikely to impact an individual's overall energy budget (Southall et al. 2007a; New et al. 2014; King et al. 2015; Villegas-Amtmann et al. 2015; Harris et al. 2017; NAS 2017; Farmer et al.

2018). We do not expect this level of exposure to impact the fitness of exposed Southern Resident killer whales, even individuals that are already in poor condition.

The injury, TTS, and behavioral effects for salmonids that would result from the stressors associated with the airgun array could have indirect effects on Southern Resident killer whales by reducing prey availability. We do not expect any mortality of fish because of the proposed action. A reduction in the availability of their prey may cause killer whales to forage for longer periods, travel to alternate locations, or abandon foraging efforts. Limitations in their prey availability is considered one of the primary threats affecting the survival and recovery of Southern Resident killer whales. Our analysis of the effects of the proposed action on Southern Resident killer whales via impacts to their prey focused on Chinook salmon, their primary prey throughout their range (Ford et al. 2010; Hanson et al. 2010a; Hilborn et al. 2012; Ford et al. 2016; NMFS 2019a; Hanson In prep), as well as Coho and chum salmon, which may be important as substitute species when the availability of Chinook salmon is reduced (Ford et al. 2016).

Based on our quantitative analysis, the estimated annual number of Chinook, Coho, and chum exposed to injury and TTS during the proposed seismic activities represents an extremely small fraction of the total number of salmon in those populations. As discussed previously, our fish effects analysis is based on a number of conservative assumptions that likely result in conservatively high estimates of salmonid fish injury and TTS from seismic activities. Behavioral effects that may cause displacement of ESA-listed Pacific salmonids are expected to last for a few days (Skalski et al. 1992; Slotte et al. 2004). While a displacement of prey may cause Southern Resident killer whales to expend more time and energy to search for prey, we do not consider these effects to last for such a duration that would result in fitness consequences for the Southern Resident killer whales. As described earlier, the proposed action would take place away from the areas with the highest expected Southern Resident killer whales densities. Southern Resident killer whales are presumably in those areas for foraging, and excluding those areas from the proposed seismic activities would reduce the effects to prey species there as well. Based on our effects analysis and considering the proposed mitigation measures, we do not expect these changes in prey distribution to persist or be so large that they result in more than a minor change to the overall health of any individual whale, or that they change the status of the population. Thus, even assuming a measurable effect, this would not rise to the level of an appreciable reduction in the likelihood of survival of any individual whale or the population as a whole.

The Recovery Plan for Southern Resident killer whales includes recovery goals concerning ensuring prey availability, reducing pollution and contamination, reducing the effects of vessels, preventing oil spills, minimizing the effects of anthropogenic sound, promoting education and outreach, improving response for sick, stranded, or injured killer whales, improving transboundary and interagency coordination for conservation efforts, and conducting research and monitoring to enhance conservation.

Because no mortalities or effects on the distribution of Southern Resident killer whales are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Southern Resident killer whales. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Southern Resident killer whales in the wild.

12.1.8 Guadalupe Fur Seal

Adult Guadalupe fur seals are present in the action area and are expected to be exposed to noise from the seismic survey activities.

All Guadalupe fur seals represent a single population, with two known breeding colonies in Mexico, and a purported breeding colony in the United States. When the more recent NMFS stock assessment report for Guadalupe fur seals was published in 2000, the breeding colonies in Mexico were increasing; evidence that is more recent indicates that this trend is continuing (Aurioles-Gamboa et al. 2010; Esperon-Rodriguez and Gallo-Reynoso 2012). After compiling data from counts over 30 years, Gallo calculated that the population of Guadalupe fur seals in Mexico was increasing, with an average annual growth rate of 13.3 percent on Guadalupe Island (Gallo-Reynoso 1994). More recent estimates of the Guadalupe fur seal population of the San Benito Archipelago (from 1997 through 2007) indicates that it is increasing as well at an annual rate of 21.6 percent (Esperon-Rodriguez and Gallo-Reynoso 2012), and that this population is at a phase of exponential increase (Aurioles-Gamboa et al. 2010). The most recent NMFS stock assessment report states that Guadalupe fur seals are increasing at an average rate of 10.3 percent. Direct counts of animals at Isla Guadalupe and Isla San Benito during 2010 resulted in a minimum of 13,327 animals and 2,503 animals respectively, for a minimum population size of 15,380 animals (Carretta et al. 2017).

No reduction in the distribution of Guadalupe fur seals from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. There are expected to be zero individuals harmed and 2,161 adults harassed because of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in numbers or reproduction of Guadalupe fur seals as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

There has been no Recovery Plan prepared for Guadalupe fur seals.

Because no mortalities or effects on the distribution of Guadalupe fur seals are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the

NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for Guadalupe fur seals. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of Guadalupe fur seals in the wild.

12.1.9 Leatherback Sea Turtle

Adult leatherback sea turtles are present in the action area and are expected to be exposed to noise from the seismic survey activities.

Leatherback turtle populations in the Pacific Ocean are low. Overall populations in the Pacific Ocean have declined from an estimated 81,000 individuals to less than 3,000 total adults and subadults (Spotila et al. 2000). Counts of leatherback turtles at nesting beaches in the western Pacific Ocean indicate that the subpopulation has been declining at a rate of almost six percent per year since 1984 (Tapilatu et al. 2013).

No reduction in the distribution of leatherback turtles from the Pacific Ocean is expected because of the National Science Foundation and L-DEO's seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization.

No reduction in numbers is anticipated due to the proposed actions. There are expected to be zero individuals harmed and three adults harassed because of the proposed seismic survey activities. Therefore, no reduction in reproduction is expected because of the proposed actions. Because we do not anticipate a reduction in the numbers or reproduction of leatherback turtles as a result of the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization, a reduction in the species' likelihood of survival is not expected.

The Pacific Recovery Plan for the population of leatherback turtles lists recovery objectives for the species. The following recovery objective is relevant to the impacts of the proposed action:

- Monitoring and research.

Because no mortalities or effects on the distribution of leatherback turtle populations are expected as a result of the proposed actions, we do not anticipate the proposed seismic survey activities and the NMFS Permits and Conservation Division's issuance of an incidental harassment authorization will impede the recovery objectives for leatherback turtles. In conclusion, we believe the effects associated with the proposed actions are not expected to cause a reduction in the likelihood of survival and recovery of leatherback turtles in the wild.

12.1.10 Chinook Salmon

Within the action area, nine ESUs of Chinook salmon may be exposed to sounds associated with the National Science Foundation's proposed seismic activities. These include the endangered Sacramento River winter-run and Upper Columbia River spring-run ESUs, and threatened California coastal, Central Valley spring-run, Lower Columbia River, Puget Sound, Snake River fall-run, Snake River spring/summer-run, and Upper Willamette River ESUs. Individuals exposed will be in the marine environment, and will be subadults or adults.

Listing dates for each of these Chinook salmon ESUs are provided in Table 5. Primary threats to Chinook salmon include blocked access to spawning grounds, habitat degradation caused by dams and culverts, and commercial fishing. Further, impacts from recent draughts have also caused the species population numbers to decrease.

Any Chinook salmon located within the ensonified area of the airgun array could be injured, sustain some degree of TTS or exhibit behavioral disruptions. Severity of injury would likely increase closer to the array, where impacts are more probable within a close distance.

The maximum annual total number of estimated injuries and TTS along with the proportion of Chinook salmon experiencing those effects from all nine ESUs likely to be adversely affected by seismic activities are presented in Table 60, Table 61, and Table 62.

Further, the ranges to effects used in our effects analysis are based on a zone of impact that would encompass the distance it would take for the sound wave to reach the criteria for the most sensitive fish species and life stages. This is likely a conservative approach for adult and subadult Chinook salmon which, given their large size, would likely be less sensitive to the effects of explosives than the smaller species and life stages these criteria were based on. If injured, large adult and subadult Chinook would also likely recover faster from sublethal injuries, as compared to juveniles, with a lower likelihood of fitness consequences or long-term effects on their survival or future reproductive potential.

Overall, the level of injury represents a reduction in abundance that may impact the future reproductive potential of Chinook populations but is not likely to appreciably reduce the likelihood of survival and recovery of any ESA-listed Chinook salmon ESU.

Some individual Chinook salmon may experience TTS because of the action's impulsive acoustic stressors. However, Chinook salmon lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in Chinook salmon migration (e.g., Putnam et al. 2013). TTS is also short in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because Chinook salmon are able to rely on alternative mechanisms for essential life functions, instances of TTS would not increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Additionally, behavioral effects resulting from reactions to sound created by the airguns will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-exposure behavior soon after the airgun array leaves the area. Similar to instances of TTS, we do not expect these short-term behavioral reactions to increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by seismic activities, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of ESA-listed Chinook salmon ESUs in the wild by reducing the reproduction, numbers, or distribution of the species or ESUs. We also conclude that effects from seismic activities continuing into the reasonably foreseeable future would not be expected, directly or indirectly, to appreciably reduce the likelihood of recovery of ESA-listed Chinook salmon ESUs in the wild by reducing the reproduction, numbers, or distribution of that species. Therefore, we do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the California coastal, Central Valley spring-run, Lower Columbia River, Puget Sound, Sacramento River winter-run, Snake River fall-run, Snake River spring/summer-run, Upper Columbia River spring-run, and Upper Willamette River ESUs of Chinook salmon.

12.1.11 Chum Salmon

Within the action area, two ESUs of ESA-listed chum salmon may be exposed to sound sources associated with the National Science Foundation's seismic activities. These include the threatened Columbia River ESU and Hood Canal summer-run ESU. Individuals exposed will be in the marine environment, and will be subadults or adults. Listing dates for each of these chum salmon ESUs are provided in Table 5. Major threats to chum salmon include blocked access to spawning grounds and habitat degradation caused by dams and culverts.

Any chum salmon located within the ensonified area of the airgun array could be injured, sustain some degree of TTS or exhibit behavioral disruptions. Severity of injury would likely increase closer to the array, where impacts are more probable within a close distance. As shown in Tables 60, 61, and 62, an extremely small percentage of each chum salmon ESU would be injured from the seismic activities. Due to their size, injured adult and subadult chum would also likely recover faster from sublethal injuries, as compared to juveniles, with a lower likelihood of fitness consequences or long-term effects on their survival or future reproductive potential.

Some individual chum salmon may experience TTS because of the seismic impulsive acoustic stressors. However, chum salmon lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in chum salmon migration (e.g., Putnam et al. 2013). TTS is also short in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because chum salmon are able to rely on alternative mechanisms for essential life functions, instances of TTS would not increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Additionally, behavioral effects on chum salmon resulting from reactions to sound created by the airguns will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-exposure behavior soon after the airgun array leaves the area. Similar to instances of TTS, we do not expect these short-term behavioral reactions to increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

A proportion of chum salmon from the Hood Canal summer-run ESU would likely be injured because of the seismic survey. Although we cannot quantify based on the available information, we expect that some proportion of chum salmon injuries from exposure to the seismic survey would likely result in fitness consequences, thus affecting the future survival and reproductive potential of the individual fish affected. As described in Section 9.3.1.5, the methodology used to quantify injury and mortality was based on several conservative assumptions which likely resulted in conservatively high estimates.

The two most recent status reviews (2011 and 2015) indicate some positive signs for the Hood Canal summer-run chum salmon ESU. Diversity has increased from the low levels seen in the 1990s due to both the reintroduction of spawning aggregates and the more uniform relative abundance between populations; considered a good sign for viability in terms of spatial structure and diversity (Ford 2011b). Spawning distribution within most streams was also extended further upstream with increased abundance. At present, spatial structure and diversity viability parameters for each population nearly meet the viability criteria (NWFSC 2015b). Spawning abundance has remained relatively high compared to the low levels observed in the early 1990's (Ford 2011b). Natural-origin spawner abundance has shown an increasing trend since 1999, and spawning abundance targets in both populations were met in some years (NWFSC 2015b). Thus, while some proportion of chum salmon injuries from seismic activity would likely result in fitness consequences, the level of impacts anticipated would not appreciably affect the population abundance or trend of the Hood Canal summer-run chum salmon ESU at the population level.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by the National Science Foundation's seismic survey, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of either the Hood Canal summer-run ESU or Columbia River ESU of chum salmon in the wild by reducing the reproduction, numbers, or distribution of the species or ESUs. Therefore, we do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Hood Canal summer-run ESU or Columbia River ESU of chum salmon.

12.1.12 Coho

Within the action area, four ESUs of Coho salmon may be exposed to sound associated with the National Science Foundation's seismic survey. These include the endangered Central California coast ESU and the threatened Lower Columbia River ESU, Oregon coast ESU, and Southern Oregon and Northern California coast ESU. Individuals exposed will be in the marine environment, and will be subadults or adults.

Listing dates for each of the Coho salmon ESUs are listed in Table 5. The main threats to Coho salmon include blocked access to spawning grounds and habitat degradation caused by dams and culverts.

Any Coho salmon located within the ensonified area of the airgun array could be injured, sustain some degree of TTS or exhibit behavioral disruptions. Severity of injury would likely increase closer to the array, where impacts are more probable within a close distance.

As shown in Tables 60, 61, and 62, only a small annual percentage of each Coho salmon ESU may be injured or experience TTS by the National Science Foundation's seismic activities. If injured, large adult and subadult Coho would also likely recover faster from sublethal injuries, as compared to juveniles, with a lower likelihood of fitness consequences or long-term effects on their survival or future reproductive potential.

This level of TTS and injury anticipated represents a very small reduction in abundance that is not likely to appreciably reduce the likelihood of survival and recovery of any ESA-listed Coho salmon ESU. Additionally, we conclude that the diversity of ESA-listed Coho salmon ESUs will not be affected by this limited amount of mortality or injury because it is expected to be distributed across populations through the species' ranges in the ocean. As a result, the seismic activities proposed by the National Science Foundation would not appreciably reduce the likelihood of ESA-listed Coho salmon surviving and recovering in the wild.

Some individual Coho salmon may experience TTS because of the seismic airgun impulsive acoustic stressors. However, Coho salmon lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in Coho salmon migration (e.g., Putnam et al. 2013). TTS is also short in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because Coho salmon are able to rely on alternative mechanisms for essential life functions, instances of TTS would not increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Additionally, behavioral effects resulting from reactions to sound created by the airguns will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-exposure behavior soon after the airgun array leaves the area. Similar to instances of TTS, we do not expect these short-term behavioral reactions to increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by the National Science Foundation's seismic activities, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of ESA-listed Coho salmon ESUs in the wild by reducing the reproduction, numbers, or distribution of the species or ESUs. Therefore, we do not anticipate any measurable or detectable reductions in the survival rate or trajectory of recovery of the Central California coast, Lower Columbia River, Oregon coast, and Southern Oregon & Northern California coast ESUs of Coho salmon.

12.1.13 Steelhead

Within the action area, ten DPSs of steelhead may be exposed to sound from the airgun array associated with the National Science Foundation's proposed seismic survey. These include the threatened California Central Valley DPS, Central California coast DPS, Lower Columbia River DPS, Middle Columbia River, Northern California DPS, Puget Sound DPS, Snake River Basin DPS, South-Central California Coast DPS, Upper Columbia River DPS, and Upper Willamette River DPS. Individuals exposed will be in the marine environment, and will be subadults or adults.

Listing dates for each of these steelhead DPSs are provided in Section 5. Primary threats to steelhead salmon include blocked access to spawning grounds, habitat degradation caused by dams and culverts, commercial fishing, and issues stemming from climate change (i.e., drought).

Any steelhead located within the ensonified area of the airgun array could be injured, sustain some degree of TTS or exhibit behavioral disruptions. Severity of injury would likely increase closer to the array, where impacts are more probable within a close distance.

As shown in Tables 60, 61, and 62, only a small annual percentage of each steelhead DPS would be injured or experience TTS due to the seismic activities.

The anticipated level of TTS and injury represents a very small reduction in abundance that is not likely to appreciably reduce the likelihood of survival and recovery of any ESA-listed steelhead. Additionally, we conclude that the diversity of ESA-listed steelhead populations will not be affected by this limited amount of take because it is expected to be distributed across populations through species' ranges in the ocean. As a result, the seismic activities the National

Science Foundation plans to conduct action area would not appreciably reduce the likelihood of ESA-listed Pacific steelhead surviving and recovering in the wild.

Some individual steelhead may experience TTS because of the seismic activities (i.e., impulsive acoustic stressors). However, the steelhead lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in steelhead migration (e.g., Putnam et al. 2013). TTS is also short in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because these species are able to rely on alternative mechanisms for essential life functions, instances of TTS would not increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Additionally, behavioral effects on steelhead resulting from reactions to sound created by the seismic activities will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-exposure behavior soon after the seismic activities conclude in an area. Similar to instances of TTS, we do not expect these short-term behavioral reactions to increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by seismic activities the National Science Foundation will fund in the action area, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of ESA-listed Pacific steelhead DPSs in the wild by reducing the reproduction, numbers, or distribution of the species or DPSs.

12.1.14 Sockeye

Within the action area, the endangered Snake River ESU and Ozette Lake ESU of sockeye salmon may be exposed to seismic activities. The listing date for these sockeye salmon ESUs are provided in Section 5. Individuals exposed will be in the marine environment, and will be subadults or adults. Threats to sockeye salmon include habitat impediments (dams), habitat degradation, habitat loss, commercial and recreational fishing, and impacts from climate change including drought.

As with other ESA-listed fishes in the action area, any sockeye salmon located within the ensonified area of the airgun array could be injured, sustain some degree of TTS, or exhibit behavioral disruptions. Severity of injury would likely increase closer to the array, where injury is more probable within a close distance of the airgun array. The maximum annual number of estimated injuries and TTS along with the proportion of sockeye salmon injured or experiencing TTS using abundances from NMFS (2020) from the Ozette Land and Snake River ESUs are presented in Tables 60, 61, and 62. As shown in Tables 60, 61, and 62, only a small annual percentage of Snake River and Ozette Lake sockeye salmon may be injured or experience TTS as a result of the seismic activities.

The anticipated level of TTS and injury represents a very small reduction in abundance that is not likely to appreciably reduce the likelihood of survival and recovery of any ESA-listed sockeye salmon. Additionally, we conclude that the diversity of ESA-listed sockeye salmon populations will not be affected by this limited amount of take because it is expected to be distributed across populations throughout species' ranges in the ocean. As a result, the seismic activities in the action area would not appreciably reduce the likelihood of ESA-listed sockeye salmon surviving and recovering in the wild.

Some individual sockeye salmon may experience TTS as a result of the seismic activities (i.e., impulsive acoustic stressors). However, sockeye salmon lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in sockeye salmon migration (e.g., Putnam et al. 2013). TTS is also short in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because these species are able to rely on alternative mechanisms for essential life functions, instances of TTS would not increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Additionally, behavioral effects on sockeye salmon resulting from reactions to sound created by the airgun array will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-exposure behavior soon after the seismic survey concludes in an area. Similar to instances of TTS, we do not expect these short-term behavioral reactions to increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by the seismic activities, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of the Ozette Lake or Snake River ESU of sockeye salmon in the wild by reducing the reproduction, numbers, or distribution of the species or ESUs.

Therefore, we do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Ozette Lake or Snake River ESU of sockeye salmon.

12.1.15 Green Sturgeon—Southern Distinct Population Segment

Within the action area, the Southern DPS of green sturgeon may be exposed to sound from the airgun array associated with the National Science Foundation's proposed seismic survey. Individuals exposed will be in the marine environment, and will be subadults or adults.

The Southern DPS of green sturgeon was listed as a threatened species under the ESA in 2006 (71 FR 17757). The final rule listing Southern DPS green sturgeon indicates that the principle factor for the decline in the DPS is the reduction of spawning to a limited area in the Sacramento River caused primarily by impoundments. Green sturgeon also face threats related to water temperature, water flow, and from commercial and recreational fishing bycatch. Climate change has the potential to impact Southern DPS green sturgeon in the future, but it is unclear how changing oceanic, nearshore and river conditions will affect the Southern DPS overall (NMFS 2015f).

Based on the best available information, the current population abundance estimate for the Southern DPS green sturgeon is 4,387 juveniles, 11,055 subadults, and 2,106 adults (Mora et al. 2018). No estimate of intrinsic growth rates are available for Southern DPS green sturgeon. Attempts to evaluate the status of Southern DPS green sturgeon have been met with limited success due to the lack of reliable long-term data.

With the exception of acoustic stressors, we found that the effects all other potential stressors (i.e., vessel strike, pollution, operational noise and visual disturbance, and gear interaction) analyzed in this opinion on Southern DPS green sturgeon were either discountable or insignificant (see Section 7). From our fish exposure analysis (Section 10.2.1.4), we were not able to quantify the amount of expected take for Southern DPS green sturgeon, and rely on the extent of take based the 187 dB ensonified area.

As described in 10.2.1.4, green sturgeon tend to occupy shallow water (less than 70 meters deep). Based on the location of the tracklines and the resulting ensonified areas, we expect that if Southern DPS green surgeon are in the areas of the survey off Oregon, they are most likely to experience the stressors associated with the seismic survey. The survey will not take place in waters less than 100 meters deep off the coast of Washington and Vancouver Island, so we expect it to be less likely that exposure of Southern DPS green sturgeon would occur in those areas.

We do not expect the proposed action to result in mortality of Southern DPS green sturgeon. The proposed action is likely to result in sublethal effects on Southern DPS green sturgeon including behavioral responses, TTS, and sublethal injuries. As noted above (Section 9.3.1.5), because green sturgeon are not known to rely on hearing for essential life functions, and any effects from TTS would likely be short-term and temporary, and instances of TTS would not likely result in measurable effects on any individual's fitness. Similarly, behavioral effects on green sturgeon resulting from reactions to sound created by the seismic activities will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. Some proportion of sub-lethal injuries from the seismic activities would likely result in fitness consequences for individual green sturgeon exposed. With an estimated subadult/adult population size of 13,161 (Mora et al. 2018), and an overall low expected amount of exposure, and the short duration of the survey in shallow areas (less than 100 meters), we do not believe the Southern DPS green sturgeon population would experience fitness consequences as a result of the proposed action. In addition, considering their size, longevity and low rate of natural mortality, we would expect most subadult and adult green sturgeon to recover from sublethal injuries with little or no long-term effect on their survival or future reproductive potential.

In summary, we anticipate Southern DPS green sturgeon subadults and adults would be adversely affected because of the proposed action, with the likely effects including sub-lethal injury, temporary hearing loss, and behavioral harassment. While the serious injury of individuals would likely have adverse effects on this threatened population, the population level impacts are not anticipated to result in appreciable reductions in overall reproduction, numbers, or distribution of this species. Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by the proposed seismic survey, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival of the Southern DPS green sturgeon in the wild by reducing the reproduction, numbers, or distribution of the DPS. Therefore, we do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Southern DPS green sturgeon.

12.1.16 Eulachon—Southern Distinct Population Segment

Within the action area, Southern DPS eulachon may be exposed to sound associated with seismic activities. Individuals exposed will be in the marine environment, and will be subadults or adults. Southern DPS eulachon was listed as threatened in October 20, 2011. The primary threats facing Southern DPS eulachon include habitat degradation, habitat impediments, water pollution, and fisheries interaction.

As with other ESA-listed fishes in the action area, any Southern DPS eulachon located within the ensonified area of the airgun array could be injured, sustain some degree of TTS, or exhibit behavioral disruptions. Severity of injury would likely increase closer to the airgun array, where injury is more probable within a closer distance of the airgun array. The number of estimated injuries and TTS, along with the proportion of Southern DPS eulachon injured or experiencing TTS using abundances from NMFS (2020), are presented in 10.2.1.4.

Only an extremely small annual percentage (less than 0.004 percent) of the Southern DPS eulachon may be injured or experience TTS by the seismic activities. This level of TTS and injury represents an extremely small amount of the overall population that is not likely to appreciably reduce the likelihood of survival and recovery Southern DPS eulachon. Additionally, we conclude that the diversity of ESA-listed eulachon populations will not be affected by this limited amount of take because it is expected to be distributed across populations through species' ranges in the ocean. As a result, the seismic activities in the action area would not appreciably reduce the likelihood of ESA-listed eulachon surviving and recovering in the wild.

Some individual eulachon may experience TTS because of the seismic activities (i.e., impulsive acoustic stressors). However, eulachon lack notable hearing specialization, minimizing the likelihood of each instance of TTS affecting an individual's fitness. These species are able to rely on alternative mechanisms (e.g., sight, lateral line system) to detect prey, avoid predators, spawn, and to orient in the water column (Popper et al. 2014a). Additionally, hearing is not thought to play a role in eulachon migration (e.g., Putnam et al. 2013). TTS is also short in duration with fish being able to replace hair cells when they are damaged (Lombarte et al. 1993; Smith et al. 2006). Because these species are able to rely on alternative mechanisms for essential life functions, instances of TTS would not increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Additionally, behavioral effects on eulachon resulting from reactions to sound created by the airguns will be temporary (e.g., a startle response), and we do not expect these reactions to have any measurable effects on any individual's fitness. We expect individuals that exhibit a temporary behavioral response will return to pre-exposure behavior soon after the airgun array leaves the area. Similar to instances of TTS, we do not expect these short-term behavioral reactions to increase the likelihood of injury by annoying a fish to such an extent as to significantly disrupt normal behavioral patterns, including breeding, feeding, or sheltering and would not rise to the level of take.

Based on the evidence available, including the *Environmental Baseline, Effects of the Action* and *Cumulative Effects*, effects resulting from stressors caused by the National Science Foundation's seismic survey, or cumulatively for the reasonably foreseeable future (assuming there are no significant changes to the *Status of Listed Resources* or *Environmental Baseline*), would not be expected to appreciably reduce the likelihood of the survival and recovery of Southern DPS eulachon in the wild by reducing the reproduction, numbers, or distribution of the species or DPSs. Therefore, we do not anticipate any measurable or detectable reductions in survival rate or trajectory of recovery of the Southern DPS eulachon.

13 CONCLUSION

After reviewing the current status of the ESA-listed species, the environmental baseline within the action area, the effects of the proposed action, and cumulative effects, it is NMFS' biological opinion that the proposed action is not likely to jeopardize the continued existence of: blue whale, fin whale, humpback whale (Central America DPS and Mexico DPSs), sei whale, killer whale (Southern Resident DPS), sperm whales, Guadalupe fur seal, leatherback sea turtle, Pacific eulachon (Southern DPS), green sturgeon (Southern DPS), Chinook salmon (Sacramento River winter-run, Central valley spring-run, California coastal, Snake River fall-run, Snake River spring/summer-run, Lower Columbia River, Upper Willamette River, Upper Columbia River spring-run, and Puget Sound ESUs), chum salmon (Hood Canal summer-run and Columbia River ESUs), Coho salmon (Central California coast, Southern Oregon and Northern California coast, Lower Columbia River, and Oregon Coast ESUs), sockeye salmon (Snake River ESU), and steelhead (South-Central California Coast, Central California Coast, California Central Valley, Northern California, Upper Columbia River, Snake River Basin, Lower Columbia River, Upper Willamette River, Middle Columbia River, and Puget Sound DPSs).

It is also NMFS' biological opinion that the action is not likely to adversely affect the following ESA-listed species and designated and proposed critical habitat: blue whales; fin whales; the Mexico DPS or Central America DPS of humpback whales; sei whales; sperm whales; Southern Resident distinct population segment (DPS) killer whales; Guadalupe fur seals; leatherback sea turtles; Southern DPS of green sturgeon; southern DPS of eulachon; and ESA-listed evolutionary significant units (ESUs) of California Coastal ESU, Central Valley Spring-Run ESU, Lower Columbia River ESU, Puget Sound ESU, Sacramento River Winter-Run ESU, Snake River Fall-Run, Snake River Spring/Summer-Run ESU, Upper Columbia River Spring-Run ESU, and Upper Willamette River ESU Chinook, Columbia River ESU and Hood Canal Summer-Run ESU chum, Central California Coast ESU, Lower Columbia River ESU, Oregon Coast ESU, and Southern Oregon and Northern California Coasts ESU Coho, Ozette Lake ESU and Snake River ESU sockeye salmon, and Central Valley ESU, Central California Coast ESU, Lower Columbia River ESU, Middle Columbia River ESU Northern California DPS, Puget Sound DPS, Snake River Basin DPS, South-Central California Coast DPS, Upper Columbia River DPS, Upper Willamette River DPS steelhead trout.

14 INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without a special exemption. "Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by regulation to include significant habitat modification or degradation that results in death or injury to ESA-listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering.

Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Section 7(o)(2) provide that taking that is incidental to an otherwise lawful agency action is not considered to be prohibited taking under the ESA if that action is performed in compliance with the terms and conditions of this incidental take statement.

14.1 Amount or Extent of Take

Section 7 regulations require NMFS to specify the impact of any incidental take of endangered or threatened species; that is, the amount or extent, of such incidental taking on the species (50 C.F.R. §402.14(i)(1)(i)). The amount of take represents the number of individuals that are expected to be taken by actions while the extent of take specifies the impact, i.e., the amount or extent of such incidental taking on the species, which may be used if we cannot assign numerical limits for animals that could be incidentally taken during the course of an action (see 80 FR 26832).

If the amount or location of tracklines during the seismic survey changes, or the number of seismic survey days is increased, then incidental take for marine mammals and sea turtles may be exceeded. As such, if more tracklines are conducted during the seismic survey, an increase in the number of days beyond the 25 percent contingency, greater estimates of sound propagation, and/or increases in airgun array source levels occur, reinitiation of consultation will be necessary.

14.1.1 Marine Mammals

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed marine mammals by injury or harassment. Specifically, we anticipate the take of marine mammals in the action area as detailed in Table 63 below.

Table 62. Estimated amount of incidental take of Endangered Species Act-listed marine mammals authorized in the Northeast Pacific Ocean by the incidental take statement.

Species	Authorized Incidental Take by Harassment (Potential Temporary Threshold Shift and Behavioral)	Authorized Incidental Take by Harm (Permanent Threshold Shift)
Blue Whale	40	11
Fin Whale	94	1
Humpback Whale – Central America DPS	42	11
Humpback Whale – Mexico DPS	34	9
Sei Whale	30	2
Sperm Whale	72	0
Southern Resident Killer Whale	10	0
Guadalupe Fur Seal	2048	0

DPS=Distinct Population Segment

14.1.2 Sea Turtles

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed leatherback sea turtles by harassment. Specifically, we anticipate the take of three leatherback sea turtles in the action area.

14.1.3 Fishes

We anticipate noise from seismic survey activities is reasonably likely to result in the incidental take of ESA-listed fish by injury or harassment. Specifically, we anticipate the take of fish in the action area as detailed in Table 64 below.

Table 63. Expected amount of incidental take of Endangered Species Act-listed fishes authorized in the Northeast Pacific Ocean by the incidental take statement.

Species	Life stage	ESU/DPS	Natural		Hatchery: adipose clip[3]		Hatchery: adipose intact	
			TTS	Injury	TTS	Injury	TTS	Injury
Chinook salmon	Adult	Sac River winter run - E	72	5	770	49	-	-
	Juvenile		22,451	1,439	22,985	1,473	-	-
	Adult	Central valley spring run - T	1,285	82	784	50	-	-
	Juvenile		89,120	5,710	249,307	15,974	-	-
	Adult	California coastal - T	4,665	299	-	-	-	-
	Juvenile		282,538	18,103	-	-	-	-
	Adult	Snake River fall - T	670	43	1,006	64	879	56
	Juvenile		14,979	960	53,698	3,441	61,886	3,965
	Adult	Snake River spring/summer - T	830	53	155	10	27	2
	Juvenile		21,783	1,396	96,289	6,170	16,762	1,074
	Adult[4]	Lower Columbia River - T	2,236	143	-	-	2,928	188
	Juvenile		297,042	19,033	792,955	50,808	19,090	1,560
	Adult[4]	Upper Willamette River - T	686	44	-	-	2,116	136
	Juvenile		27,162	1,740	105,547	6,763	4	-

	Adult	Upper Columbia River spring - E	186	12	404	26	218	14
	Juvenile		10,136	649	13,443	861	7,970	511
	Adult[4]	Puget Sound - T	3,954	253	-	-	2,744	176
	Juvenile		178,605	11,444	2,135,854	136,852	427,855	27,414
Coho salmon	Adult	Central California coast - E	1,101	71	-	-	186	12
	Juvenile		45,049	2,886	-	-	47,257	3,028
	Adult[4]	S. Oregon/N. California coast - T	1,419	91	-	-	1,712	110
	Juvenile		157,644	10,101	15,658	1,003	45,017	2,884
	Adult	Oregon coast - T	20,365	1,305	121	8	-	-
	Juvenile		717,012	45,942	6,477	415	-	-
	Adult	Lower Columbia River - T	7,986	512	-	-	2,351	151
	Juvenile		88,441	5,667	974,391	62,433	33,397	2,140
Chum salmon	Adult	Hood Canal summer run	241	15	-	-	14	1
	Juvenile		12,449	798	-	-	480	31
	Adult	Columbia River - T	102	7	-	-	4	-
	Juvenile		21,206	1,359	-	-	1,925	123
Sockeye salmon	Adult	Ozette Lake - T	5	-	38	2	-	-
	Juvenile		61	4	776	50	-	-
	Adult	Snake River - E	2	-	-	-	-	-
	Juvenile		84	5	-	-	-	-
Steelhead	Adult	South-Central California - T	7	-	-	-	-	-
	Juvenile		265	5	-	-	-	-
	Adult	Central California - T	5	-	12	1	-	-
	Juvenile		672	17	692	44	-	-
	Adult	California Central Valley - T	23	1	12	1	-	-
	Juvenile		876	56	1,706	109	-	-
	Adult		5	1	-	-	-	-

	Juvenile	Northern California - T	672	43	-	-	9	0
	Adult	Upper Columbia River - E	23	1	17	1	3	0
	Juvenile		876	56	733	47	48	0
	Adult	Snake River basin - T	6	-	254	16	5	0
	Juvenile		213	14	3,518	225	1	0
	Adult[4]	Lower Columbia River - T	34	2	-	-	-	-
	Juvenile		851	55	1,276	82	-	-
	Adult	Upper Willamette River - T	41	3	-	-	-	-
	Juvenile		375	24	-	-	8	0
	Adult	Middle Columbia River - T	9	3	1	-	-	-
	Juvenile		150	24	474	30	8	0
	Adult[5]	Puget Sound - T	16	1	-	-	-	-
	Juvenile		435	28	117	8	-	-
Eulachon	Adult	Southern – T	708,515	39,179	-	-	-	-

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[3] It should be noted that ESA take prohibitions do not apply to hatchery fish with clipped adipose fins from threatened ESUs or DPSs

[4] Hatchery intact adipose mortality and injury estimates comprise of hatchery fish with intact and clipped adipose fins.

[5] Includes natural and hatchery (clipped and intact adipose fish) estimates.

We also expect Southern DPS green sturgeon could be exposed to sounds from the airgun arrays during the course of the proposed seismic surveys that could result in TTS or injury. No death is expected for any individual green sturgeon exposed to seismic survey activities. NMFS anticipates the proposed seismic survey is likely to result in the incidental take of Southern DPS green sturgeon by TTS or injury.

Where it is not practical to quantify the number of individuals that are expected to be taken by the action, a surrogate (e.g., similarly affected species, habitat, ecological conditions, and sound pressure thresholds) may be used to express the amount or extent of anticipated take (50 CFR 402. §14(i)(1)(i)). Because there are no reliable estimates of Southern DPS green sturgeon population densities in the action area, , it is not practical to develop numerical estimates of green sturgeon exposure. We are relying on the extent of the 187 dB re: 1 µPa (rms) ensonified areas. A green sturgeon within the 187 dB re: 1 µPa (rms) during airgun array operations will be affected by the stressor, and is expected to respond in a manner that constitutes take.

If the amount or location of trackline surveyed changes, or the number of seismic survey days is increased, then incidental take for green sturgeon may be exceeded. As such, if more tracklines are surveyed, there is an increase in the number of survey days beyond the 25 percent contingency, there are greater estimates of sound propagation, and/or increases in source levels from the airgun array occur, re-initiation of consultation will be necessary.

14.2 Reasonable and Prudent Measures

The measures described below are nondiscretionary, and must be undertaken by the National Science Foundation and the NMFS Permits and Conservation Division so that they become binding conditions for the exemption in section 7(o)(2) to apply. Section 7(b)(4) of the ESA requires that when a proposed agency action is found to be consistent with section 7(a)(2) of the ESA and the proposed action may incidentally take individuals of ESA-listed species, NMFS will issue a statement that specifies the impact of any incidental taking of endangered or threatened species. To minimize such impacts, reasonable and prudent measures, and term and conditions to implement the measures, must be provided. Only incidental take resulting from the agency actions and any specified reasonable and prudent measures, and terms and conditions identified in the incidental take statement are exempt from the taking prohibition of section 9(a), pursuant to section 7(o) of the ESA.

Reasonable and prudent measures are nondiscretionary measures to minimize the amount or extent of incidental take (50 C.F.R. §402.02). NMFS believes the reasonable and prudent measures described below are necessary and appropriate to minimize the impacts of incidental take on the ESA-listed marine mammals, fish, and leatherback sea turtles discussed in detail in this opinion:

- The NMFS Permits and Conservation Division must ensure that the National Science Foundation and L-DEO implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures incorporated as part of the proposed incidental harassment authorization for the incidental taking of blue, fin, Central America DPS of humpback, Mexico DPS of humpback, sei, and sperm whales and Guadalupe fur seals pursuant to section 101(a)(5)(D) of the MMPA and as specified below for leatherback turtles and fishes (i.e., the monitoring requirements). In addition, the NMFS Permits and Conservation Division must ensure that the provisions of the incidental harassment authorization are carried out, and to inform the NMFS ESA Interagency Cooperation Division if take is exceeded.
- The NMFS Permits and Conservation Division must ensure that the National Science Foundation and L-DEO implement a program to monitor and report any potential interactions between seismic survey activities and threatened and endangered species of marine mammals.
- The National Science Foundation and the L-DEO must implement a program to mitigate and report the potential effects of seismic survey activities as well as the effectiveness of mitigation measures for endangered and threatened leatherback sea turtles and fishes.

14.3 Terms and Conditions

To be exempt from the prohibitions of section 9 of the ESA and regulations issued pursuant to section 4(d), the National Science Foundation, L-DEO and NMFS Permits and Conservation Division must comply with the following terms and conditions, which implement the RPMs described above. These include the take minimization, monitoring and reporting measures required by the section 7 regulations (50 C.F.R. §402.14(i)). If the National Science Foundation, L-DEO and NMFS Permits and Conservation Division fail to ensure compliance with these terms and conditions to implement the RPMs applicable to the authorities of the agencies, the protective coverage of section 7(o)(2) may lapse.

The terms and conditions detailed below for each of the RPMs include monitoring and minimization measures where needed:

1. A copy of the draft comprehensive report on all seismic survey activities and monitoring results must be provided to the ESA Interagency Cooperation Division within 90 days of the completion of the seismic survey, or expiration of the incidental harassment authorization, whichever comes sooner.
2. Any reports of injured or dead ESA-listed species must be provided by the L-DEO and NSF to the ESA Interagency Cooperation Division within 24 hours to Cathy Tortorici, Chief, ESA Interagency Cooperation Division by e-mail at cathy.tortorici@noaa.gov.

15 CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of the threatened and endangered species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on ESA-listed species or critical habitat, to help implement recovery plans or develop information (50 C.F.R. §402.02).

We recommend the following discretionary conservation recommendations that we believe are consistent with this obligation and therefore may be considered by NSF and the NMFS Permits and Conservation Division in relation to their 7(a)(1) responsibilities. These recommendations will provide information for future consultations involving seismic surveys and the issuance of IHAs that may affect ESA-listed species:

1. We recommend that the National Science Foundation promote and fund research examining the potential effects of seismic surveys on ESA-listed sea turtle and fish species.
2. We recommend that the National Science Foundation develop a more robust propagation model that incorporates environmental variables into estimates of how far sound levels reach from airgun arrays.
3. We recommend that the National Science Foundation conduct a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth

distances to ESA harm and harassment thresholds and incorporate the results of that study into buffer and exclusion zones prior to starting seismic survey activities.

4. We recommend that the NMFS Permits and Conservation Division develop a flow chart with decision points for mitigation and monitoring measures to be included in future MMPA incidental take authorizations for seismic surveys.
5. We recommend the National Science Foundation use (and NMFS Permits and Conservation Division require in MMPA incidental take authorizations) thermal imaging cameras, in addition to binoculars (Big-Eye and handheld) and the naked eye, for use during daytime and nighttime visual observations and test their effectiveness at detecting ESA-listed species.
6. We recommend the National Science Foundation use the Marine Mammal Commission's recommended method for estimating the number of cetaceans in the vicinity of seismic surveys based on the number of groups detected for post-seismic survey activities take analysis and use in monitoring reports.
7. We recommend the National Science Foundation and NMFS Permits and Conservation Division work to make the data collected as part of the required monitoring and reporting available to the public and scientific community in an easily accessible online database that can be queried to aggregate data across protected species observer reports. Access to such data, which may include sightings as well as responses to seismic survey activities, will not only help us understand the biology of ESA-listed species (e.g., their range), it will inform future consultations and incidental take authorizations/permits by providing information on the effectiveness of the conservation measures and the impact of seismic survey activities on ESA-listed species.
8. We recommend the National Science Foundation and NMFS Permits and Conservation Division consider using the potential standards for towed array passive acoustic monitoring in the *Towed Array Passive Acoustic Operations for Bioacoustic Applications: ASA/JNCC Workshop summary March 14-18, 2016 Scripps Institution of Oceanography, La Jolla, California, USA* (Thode 2017).
9. We recommend the National Science Foundation use real-time cetacean sighting services such as the WhaleAlert application (http://www.whalealert.org/). We recognize that the research vessel may not have reliable internet access during operations far offshore, but nearshore, where many of the cetaceans considered in this opinion are likely found in greater numbers, we anticipate internet access may be better. Monitoring such systems will help plan seismic survey activities and transits to avoid locations with recent ESA-listed cetacean sightings, and may also be valuable during other activities to alert others of ESA-listed cetaceans within the area, which they can then avoid.
10. We recommend the National Science Foundation submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be

added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.

11. We recommend the vessel operator and other relevant vessel personnel (e.g., crewmembers) on the R/V *Marcus G. Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species and relay information to PSOs.

In order for NMFS' Office of Protected Resources ESA Interagency Cooperation Division to be kept informed of actions minimizing or avoiding adverse effects on, or benefiting, ESA-listed species or their critical habitat, the NMFS Permits and Conservation Division should notify the ESA Interagency Cooperation Division of any conservation recommendations they implement in their final action.

16 REINITIATION NOTICE

This concludes formal consultation for the National Science Foundation and L-DEO's proposed high-energy marine seismic survey by the R/V *Marcus G. Langseth* in the Northeast Pacific Ocean and NMFS Permits and Conservation Division's issuance of an incidental harassment authorization for the proposed high-energy marine seismic survey pursuant to section 101(a)(5)(D) of the MMPA. Consistent with 50 C.F.R. §402.16, reinitiation of formal consultation is required and shall be requested by the Federal agency or by the Service, where discretionary Federal agency involvement or control over the action has been retained or is authorized by law and:

1. The amount or extent of taking specified in the incidental take statement is exceeded.
2. New information reveals effects of the agency action that may affect ESA-listed species or critical habitat in a manner or to an extent not previously considered.
3. The identified action is subsequently modified in a manner that causes an effect to ESA-listed species or designated critical habitat that was not considered in this opinion.
4. A new species is listed or critical habitat designated under the ESA that may be affected by the action.

If the amount of tracklines, location of tracklines, acoustic characteristics of the airgun arrays, timing of the survey, or any other aspect of the proposed action changes in such a way that the incidental take of ESA-listed species can be greater than estimated in the incidental take statement of this opinion, then one or more of the reinitiation triggers above may be met and reinitiation of consultation may be necessary.

17 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT ESSENTIAL FISH HABITAT RESPONSE

Section 305(b) of the MSA directs Federal agencies to consult with NMFS on all actions or proposed actions that may adversely affect EFH. Under the MSA, this consultation is intended to promote the conservation of EFH as necessary to support sustainable fisheries and the managed species' contribution to a healthy ecosystem. For the purposes of the MSA, EFH means "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity", and includes the physical, biological, and chemical properties that are used by fish (50 C.F.R. §600.10). Adverse effect means any impact that reduces quality or quantity of EFH, and may include direct or indirect physical, chemical, or biological alteration of the waters or substrate and loss of (or injury to) benthic organisms, prey species and their habitat, and other ecosystem components, if such modifications reduce the quality or quantity of EFH. Adverse effects on EFH may result from actions occurring within EFH or outside of it and may include site-specific or EFH-wide impacts, including individual, cumulative, or synergistic consequences of actions (50 C.F.R. §600.810). Section 305(b) of the MSA also requires NMFS to recommend measures that can be taken by the action agency to conserve EFH. Such recommendations may include measures to avoid, minimize, mitigate, or otherwise offset the adverse effects of the action on EFH [50 C.F.R. §600.905(b)]

This analysis is based, in part, on the descriptions of EFH for Pacific Coast groundfish (PFMC 2005), coastal pelagic species (PFMC 1998), Pacific Coast salmon (PFMC 2014), and highly migratory species (PFMC (2007) contained in the fishery management plans developed by the Pacific Fishery Management Council (PFMC) and approved by the Secretary of Commerce.

17.1 Essential Fish Habitat Affected by the Project

The proposed action and action area for this consultation are described in the ESA sections of this document (Sections 3 and 4). The action area includes areas designated as EFH for various life-history stages of Pacific Coast groundfish, coastal pelagic species, Pacific Coast salmon, and highly migratory species (PFMC 2005, PFMC 1998, PFMC 2014, PFMC 2008). In addition, the action area includes many Habitat Areas of Particular Concern (HAPC) for Pacific Coast groundfish EFH.[28] Rocky reefs (those waters, substrates and other biogenic features associated with hard substrate) and canopy kelp (those waters, substrate, and other biogenic habitat associated with canopy-forming kelp species) are HAPCs because of their importance to many species managed by the PFMC. Areas of interest are discrete areas that are of special interest due to their unique geological and ecological characteristics.

17.2 Adverse Effects on Essential Fish Habitat

The ESA effects analysis (sections 5 and 9) describes the adverse effects of this proposed action on several ESUs and DPSs. Some of the species covered in the ESA effects analysis are also

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[28] See: https://archive.fisheries.noaa.gov/wcr/publications/gis_maps/maps/groundfish/map-gfish-hapc.pdf

species covered under the MSA and that have designated EFH. Notably, the Chinook salmon and Coho salmon ESA analyses are relevant to Pacific Coast salmon EFH. Because of the breadth of species covered in this opinion, we are also reasonably certain the ESA effects analysis is relevant to the effects on EFH.

The ESA Biological and Conference Opinion, Section 6, analyzed several potential stressors, including:

1. Pollution;
2. Vessel strike;
3. Operational noise and visual disturbance of vessels and equipment;
4. Gear interaction; and
5. Sound fields produced by airgun array, multi-beam echosounder, sub-bottom profiler, and acoustic Doppler current profiler.

The ESA analysis found only one stressor was likely to adversely affect ESA-listed species, sound fields produced by the airgun array, multi-beam echosounder, and sub-bottom profiler, and acoustic Doppler current profiler. Based on information developed in the ESA effects analysis, we conclude the effects from these sound fields constitute an adverse effect to Pacific Coast salmon, Pacific Coast groundfish, coastal pelagic species, and highly migratory species' EFH, and HAPCs for Pacific Coast groundfish.

While the ESA analysis of effects is relevant to EFH, the effects to some of the species protected under the MSA will be more severe. In particular, northern anchovy and Pacific sardine (included in the coastal pelagic species fishery management plan) have swim bladders connected to the inner ear for enhanced hearing (Ladich and Schulz-Mirbach 2016). This puts them in a category more sensitive to sound effects (Popper et al. 2014a).

In addition, as noted previously, rocky reefs are a designated HAPC and are preferred habitat for a number of Federally-managed species. Rockfish (*Sebastes* spp.) in particular exhibit strong affinities for hard substrate and even specific locations (Love et al. 2002; PFMC 2005). Moreover, hard bottom habitat provides an attachment surface, which is important for canopy kelp (also a HAPC) and most deep-sea corals, and has also been strongly associated with many sponge taxa (Huff et al. 2013). Deep-sea corals and sponges contribute significantly to biodiversity, serve an important ecological function for benthic communities, and enhance the diversity and structural component of fish habitat (Tissot et al. 2006, Henry et al. 2013). Direct impacts to these sensitive habitats could result from the deployment of anchoring systems.

17.3 Essential Fish Habitat Conservation Recommendations

Some impacts to EFH have already been minimized as part of the proposed action, or cannot be minimized. We determined that the following eight EFH conservation recommendations are necessary to avoid, minimize, mitigate, or otherwise offset the impact of the proposed action on EFH.

The action agencies should minimize adverse effects from sound fields produced by the proposed action by implementing the following recommendations:

1. NSF should ensure that all benthic habitat types throughout the project area are accurately delineated and mapped. It is particularly important to identify and delineate sensitive habitats, such as HAPCs and deep-sea corals.
2. NSF should avoid sensitive habitats (e.g., HAPCs, deep-sea corals) to the greatest extent practicable when deploying anchoring systems. The following NOAA Deep-Sea Coral and Sponge Map Portal contains information regarding observed coral and sponge locations within the Action Area: https://www.ncei.noaa.gov/maps/deep-sea-corals/mapSites.htm.
3. Much of the research available to date on the effects of seismic survey methods and how to minimize and mitigate those effects have been focused on marine mammals, not fish, and benthic invertebrates. Therefore, NSF should promote and fund research examining the potential effects of seismic surveys on EFH. Additional research and monitoring should be undertaken to gain a better understanding of the potential effects these seismic surveys may have on EFH, federally managed species, their prey and other NMFS trust resources. This research should be a component of future NSF funded seismic survey activities. This will aid in the development of site and project specific EFH conservation recommendations for future projects, as appropriate.
4. NSF should develop a more robust propagation model that incorporates environmental variables into estimates of how far elevated sound levels extend from airgun arrays.
5. NSF should conduct a sound source verification in the study area (and future locations) to validate predicted and modeled isopleth distances to effect thresholds and incorporate the results of that study into buffer and exclusion zones prior to starting seismic survey activities.
6. NSF should submit their monitoring data (i.e., visual sightings) by PSOs to the Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations online database so that it can be added to the aggregate marine mammal, seabird, sea turtle, and fish observation data from around the world.
7. The vessel operator and other relevant vessel personnel (e.g., crewmembers) on the R/V *Marcus G. Langseth* take the U.S. Navy's marine species awareness training available online at: https://www.youtube.com/watch?v=KKo3r1yVBBA in order to detect ESA-listed species that are also included in fishery management plans and have EFH in the action area and relay information to PSOs.

The action agencies should ensure completion of a monitoring and reporting program to confirm the program is meeting the objective of limiting adverse effects to EFH by implementing the following:

8. NSF and NMFS Permits and Conservation Division should provide a copy of the draft comprehensive report on all seismic survey activities and monitoring results to the ESA

Interagency Cooperation Division and the West Coast Region EFH Office within 90 days of the completion of the seismic survey.

17.4 Statutory Response Requirement

As required by section 305(b)(4)(B) of the MSA, the NSF and NMFS Permits and Conservation Division must provide a detailed response in writing to us within 30 days after receiving EFH Conservation Recommendations. Such a response must be provided at least 10 days prior to final approval of the action if the response is inconsistent with any of our EFH Conservation Recommendations unless the Federal agencies and we have agreed to use alternative time frames for the Federal agency response. The response must include a description of the measures proposed by the agency for avoiding, minimizing, mitigating, or otherwise offsetting the impact of the activity on EFH. In the case of a response that is inconsistent with the Conservation Recommendations, the Federal agencies must explain their reasons for not following the recommendations, including the scientific justification for any disagreements with us over the anticipated effects of the action and the measures needed to avoid, minimize, mitigate, or offset such effects (50 CFR 600.920(k)(1)).

In response to increased oversight of overall EFH program effectiveness by the Office of Management and Budget, we established a quarterly reporting requirement to determine how many conservation recommendations are provided as part of each EFH consultation and how many are adopted by the action agency. Therefore, we ask that in your statutory reply to the EFH portion of this consultation, you clearly identify the number of conservation recommendations accepted.

17.5 Supplemental Consultation

The NSF and NMFS Permits and Conservation Division must reinitiate EFH consultation with us if the proposed action is substantially revised in a way that may adversely affect EFH, or if new information becomes available that affects the basis for our EFH Conservation Recommendations (50 CFR 600.920(l)).

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70 FR 37160. Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

70 FR 52488. Endangered and Threatened Species; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California.

71 FR 17757. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon.

79 FR 20802. Endangered and Threatened Wildlife; Final Rule To Revise the Code of Federal Regulations for Species Under the Jurisdiction of the National Marine Fisheries Service.

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19 APPENDICES

Appendix A

INCIDENTAL HARASSMENT AUTHORIZATION

The Lamont-Doherty Earth Observatory of Columbia University (L-DEO) is hereby authorized under section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA; 16 U.S.C. 1371(a)(5)(D)) to harass marine mammals incidental to a geophysical survey in the Northeast Pacific Ocean, when adhering to the following terms and conditions.

1. This Incidental Harassment Authorization (IHA) is valid for a period of one year from the date of issuance.

2. This IHA is valid only for geophysical survey activity as specified in L-DEO's IHA application and using an array aboard the R/V *Langseth* with characteristics specified in the IHA application, in the Northeast Pacific Ocean along the Cascadia Subduction Zone.

3. General Conditions

(a) A copy of this IHA must be in the possession of L-DEO, the vessel operator, the lead protected species observer (PSO) and any other relevant designees of L-DEO operating under the authority of this IHA.

(b) The species authorized for taking are listed in Table 1. The taking, by Level A and Level B harassment only, is limited to the species and numbers listed in Table 1.

(c) The taking by serious injury or death of any of the species listed in Table 1 or any taking of any other species of marine mammal is prohibited and may result in the modification, suspension, or revocation of this IHA. Any taking exceeding the authorized amounts listed in Table 1 is prohibited and may result in the modification, suspension, or revocation of this IHA.

(d) During use of the acoustic source, if any marine mammal species that are not listed in Table 1 appear within or enter the Level B harassment zone (Table 2) or a species for which authorization has been granted but the takes have been met, is observed within or approaching the Level A or Level B harassment zones (Tables 2-3), the acoustic source must be shut down.

(e) L-DEO must ensure that relevant vessel personnel and PSO team participate in a joint onboard briefing led by the vessel operator and lead PSO to ensure that responsibilities, communication procedures, protected species monitoring protocols, operational procedures, and IHA requirements are clearly understood.

4. Mitigation Measures

The holder of this Authorization is required to implement the following mitigation measures:

(a) L-DEO must use independent, dedicated, trained visual and acoustic PSOs, meaning that the PSOs must be employed by a third-party observer provider, must not have tasks other than to conduct observational effort, collect data, and communicate with and instruct relevant vessel crew with regard to the presence of protected species and mitigation requirements (including brief alerts regarding maritime hazards), and must have successfully completed an approved PSO training course appropriate for their designated task (visual or acoustic). Individual PSOs may perform acoustic and visual PSO duties (though not at the same time).

(b) At least one visual and two acoustic PSOs aboard the R/V *Langseth* and at least one visual PSO aboard the second vessel (see condition 4(c)(iii)) must have a minimum of 90 days at-sea experience working in those roles, respectively, during a deep penetration seismic survey, with no more than 18 months elapsed since the conclusion of the at-sea experience.

(c) Visual Observation

(i) During survey operations *(e.g.*, any day on which use of the acoustic source is planned to occur, and whenever the acoustic source is in the water, whether activated or not), a minimum of two PSOs must be on duty and conducting visual observations at all times during daylight hours (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset) and 30 minutes prior to and during ramp-up of the airgun array. Visual monitoring of the exclusion and buffer zones must begin no less than 30 minutes prior to ramp-up and must continue until one hour after use of the acoustic source ceases or until 30 minutes past sunset.

(ii) Visual PSOs must coordinate to ensure 360° visual coverage around the vessel from the most appropriate observation posts, and must conduct visual observations using binoculars and the naked eye while free from distractions and in a consistent, systematic, and diligent manner. Estimated harassment zones are provided in Tables 2-3 for reference.

(iii) During survey operations in water depths shallower than 200 m between Tillamook Head, Oregon (45.9460903° N) and Barkley Sound, British Columbia (48.780291° N), and while surveying within Olympic Coast National Marine Sanctuary, a second vessel with additional visual PSOs must accompany the R/V *Langseth* and survey approximately 5 km ahead of the R/V *Langseth*. Two visual PSOs must be on watch on the second vessel during all such survey operations (according to the requirements provided in 4(c)(i) of this IHA) and communicate all observations of marine mammals to PSOs on the R/V *Langseth*.

(iv) Visual PSOs must immediately communicate all observations to the acoustic PSO(s) on duty, including any determination by the PSO regarding species identification, distance, and bearing and the degree of confidence in the determination.

(v) During good conditions (*e.g.*, daylight hours; Beaufort sea state (BSS) 3 or less), visual PSOs must conduct observations when the acoustic source is not operating for comparison of sighting rates and behavior with and without use of the acoustic source and between acquisition periods, to the maximum extent practicable.

(vi) Visual PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period.

Combined observational duties (visual and acoustic but not at same time) may not exceed 12 hours per 24-hour period for any individual PSO.

(d) Acoustic Monitoring

(i) The source vessel must use a towed passive acoustic monitoring system (PAM) which must be monitored by, at a minimum, one on duty acoustic PSO beginning at least 30 minutes prior to ramp-up and at all times during use of the acoustic source.

(ii) When both visual and acoustic PSOs are on duty, all detections must be immediately communicated to the remainder of the on-duty PSO team for potential verification of visual observations by the acoustic PSO or of acoustic detections by visual PSOs.

(iii) Acoustic PSOs may be on watch for a maximum of four consecutive hours followed by a break of at least one hour between watches and may conduct a maximum of 12 hours of observation per 24-hour period. Combined observational duties may not exceed 12 hours per 24-hour period for any individual PSO.

(iv) Survey activity may continue for 30 minutes when the PAM system malfunctions or is damaged, while the PAM operator diagnoses the issue. If the diagnosis indicates that the PAM system must be repaired to solve the problem, operations may continue for an additional five hours without acoustic monitoring during daylight hours only under the following conditions:

a. Sea state is less than or equal to BSS 4;

b. With the exception of delphinids (other than killer whales), no marine mammals detected solely by PAM in the applicable exclusion zone in the previous two hours;

c. NMFS is notified via email as soon as practicable with the time and location in which operations began occurring without an active PAM system; and

d. Operations with an active acoustic source, but without an operating PAM system, do not exceed a cumulative total of five hours in any 24-hour period.

(e) Exclusion zone and buffer zone

(i) Except as provided below in 4(e)(ii), the PSOs must establish and monitor a 500-m exclusion zone and additional 500-m buffer zone (total 1,000 m).

The 1,000-m zone shall serve to focus observational effort but not limit such effort; observations of marine mammals beyond this distance shall also be recorded as described in 5(d) below and/or trigger shutdown as described in 4(g)(iv) below, as appropriate. The exclusion zone encompasses the area at and below the sea surface out to a radius of 500 m from the edges of the airgun array (rather than being based on the center of the array or around the vessel itself) (0–500 m). The buffer zone encompasses the area at and below the sea surface from the edge of the exclusion zone, out to a radius of 1,000 meters from the edges of the airgun array (500–1,000 m). During use of the acoustic source, occurrence of marine mammals within the buffer zone (but outside the exclusion zone) must be communicated to the operator to prepare for the potential shutdown of the acoustic source. PSOs must monitor the exclusion zone and buffer zone for a minimum of 30 minutes prior to ramp-up (*i.e.*, pre-start clearance).

(ii) An extended 1,500-m exclusion zone must be established for all beaked whales, and dwarf and pygmy sperm whales. No buffer zone is required.

(f) Pre-start clearance and Ramp-up

(i) A ramp-up procedure must be followed at all times as part of the activation of the acoustic source, except as described under 4(f)(vi).

(ii) Ramp-up must not be initiated if any marine mammal is within the exclusion or buffer zone. If a marine mammal is observed within the exclusion zone or the buffer zone during the 30 minute pre-start clearance period, ramp-up may not begin until the animal(s) has been observed exiting the zone or until an additional time period has elapsed with no further sightings (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, false killer whales, and Risso's dolphins).

(iii) Ramp-up must begin by activating a single airgun of the smallest volume in the array and must continue in stages by doubling the number of active elements at the commencement of each stage, with each stage of approximately the same duration. Duration must not be less than 20 minutes.

(iv) PSOs must monitor the exclusion and buffer zones during ramp-up, and ramp-up must cease and the source must be shut down upon visual observation or acoustic detection of a marine mammal within the exclusion zone. Once ramp-up has begun, observations of marine mammals within the buffer zone do not require shutdown, but such observation must be communicated to the operator to prepare for the potential shutdown.

(v) Ramp-up may occur at times of poor visibility, including nighttime, if appropriate acoustic monitoring has occurred with no detections in the 30 minutes prior to beginning ramp-up.

(vi) If the acoustic source is shut down for brief periods (*i.e.*, less than 30 minutes) for reasons other than that described for shutdown (*e.g.*, mechanical difficulty), it may be activated again without ramp-up if PSOs have maintained constant visual and/or acoustic observation and no visual or acoustic detections of marine mammals have occurred within the applicable exclusion zone. For any longer shutdown, pre-start clearance observation and ramp-up are required. For any shutdown at night or in periods of poor visibility (*e.g.*, BSS 4 or greater), ramp-up is required, but if the shutdown period was brief and constant observation was maintained, pre-start clearance watch is not required.

(vii) Testing of the acoustic source involving all elements requires ramp-up. Testing limited to individual source elements or strings does not require ramp-up but does require pre-start clearance watch.

(g) Shutdown

(i) Any PSO on duty has the authority to delay the start of survey operations or to call for shutdown of the acoustic source.

(ii) The operator must establish and maintain clear lines of communication directly between PSOs on duty and crew controlling the acoustic source to ensure that shutdown commands are conveyed swiftly while allowing PSOs to maintain watch.

(iii) When the airgun array is active (*i.e.*, anytime one or more airguns is active, including during ramp-up) and (1) a marine mammal (excluding delphinids of the genera described in 4(g)(v)) appears within or enters the exclusion zone and/or (2) a marine mammal is detected acoustically and localized within the exclusion zone, the acoustic source must be shut down. When shutdown is called for by a PSO, the airgun array must be immediately deactivated. Any dispute regarding a PSO shutdown must be resolved after deactivation.

(iv) The airgun array must be shut down if any of the following are detected at any distance:

1. North Pacific right whale.

2. Killer whale (of any ecotype).

3. Large whale (defined as a sperm whale or any mysticete species) with a calf (defined as an animal less than two-thirds the body size of an adult observed to be in close association with an adult).

4. Aggregation of six or more large whales.

(v) The shutdown requirements described in 4(g)(iii) shall be waived for small dolphins of the following genera: *Tursiops, Delphinus, Stenella, Lagenorhynchus,* and *Lissodelphis*.

a. If a small delphinid (individual of the Family Delphinidae, which includes the aforementioned dolphin genera), is visually and/or acoustically detected and localized within the exclusion zone, no shutdown is required unless the acoustic PSO or a visual PSO confirms the individual to be of a genera other than those listed above, in which case a shutdown is required.

b. If there is uncertainty regarding identification, visual PSOs may use best professional judgment in making the decision to call for a shutdown.

(vi) Upon implementation of shutdown, the source may be reactivated after the marine mammal(s) has been observed exiting the applicable exclusion zone (*i.e.*, animal is not required to fully exit the buffer zone where applicable) or following a clearance period (15 minutes for small odontocetes and pinnipeds, and 30 minutes for mysticetes and all other odontocetes, including sperm whales, pygmy sperm whales, dwarf sperm whales, beaked whales, pilot whales, killer whales, false killer whales, and Risso's dolphins) with no further observation of the marine mammal(s).

(h) Vessel operators and crews must maintain a vigilant watch for all marine mammals and slow down, stop their vessel, or alter course, as appropriate and regardless of vessel size, to avoid striking any marine mammal. A visual observer aboard the vessel must monitor a vessel strike avoidance zone around the vessel (specific distances detailed below). Visual observers monitoring the vessel strike avoidance zone may be third-party observers (*i.e.*, PSOs) or crew members, but crew members responsible for these duties must be provided sufficient training to 1) distinguish marine mammals from other phenomena and 2) broadly to identify a marine mammal as a right whale, other whale (defined in this context as sperm whales or baleen whales other than right whales), or other marine mammal.

(i) Vessel speeds must be reduced to 10 knots or less when mother/calf pairs, pods, or large assemblages of any marine mammal are observed near a vessel.

(ii) Vessels must maintain a minimum separation distance of 500 m from North Pacific right whales and 100 m from other large whales (*i.e*., sperm whales and all other baleen whales).

(iii) The vessel must, to the maximum extent practicable, attempt to maintain a minimum separation distance of 50 m from all other marine mammals, with an understanding that at times this may not be possible (*e.g*., for animals that approach the vessel).

(iv) When marine mammals are sighted while a vessel is underway, the vessel must take action as necessary to avoid violating the relevant separation distance (*e.g.*, attempt to remain parallel to the animal's course, avoid excessive speed or abrupt changes in direction until the animal has left the area). If marine mammals are sighted within the relevant separation distance, the vessel must reduce speed and shift the engine to neutral, not engaging the engines until animals are clear of the area. This does not apply to any vessel towing gear or any vessel that is navigationally constrained.

(v) These requirements do not apply in any case where compliance would create an imminent and serious threat to a person or vessel or to the extent that a vessel is restricted in its ability to maneuver and, because of the restriction, cannot comply.

(k) Survey operations in waters shallower than 200 m between Tillamook Head, Oregon (45.9460903° N) and Barkley Sound, British Columbia (48.780291° N), and survey operations within Olympic Coast National Marine Sanctuary, must be conducted in daylight hours only (*i.e.*, from 30 minutes prior to sunrise through 30 minutes following sunset).

(j) On each day of survey operations, L-DEO must contact NMFS Northwest Fisheries Science Center (206-860-3200), NMFS West Coast Regional Office (206-526-6150), The Whale Museum (800-562-8832), Orca Network (360-331-3543), Canada's Department of Fisheries and Oceans (604-666-9965), and Olympic Coast National Marine Sanctuary (208-410-0260), to obtain any available information regarding the whereabouts of Southern Resident killer whales.

5. Monitoring Requirements

The holder of this Authorization is required to conduct marine mammal monitoring during survey activity. Monitoring must be conducted in accordance with the following requirements:

(a) The operator must provide PSOs with bigeye binoculars (*e.g*., 25 x 150; 2.7 view angle; individual ocular focus; height control) of appropriate quality solely for

PSO use. These must be pedestal-mounted on the deck at the most appropriate vantage point that provides for optimal sea surface observation, PSO safety, and safe operation of the vessel.

(b) The operator must work with the selected third-party observer provider to ensure PSOs have all equipment (including backup equipment) needed to adequately perform necessary tasks, including accurate determination of distance and bearing to observed marine mammals. Such equipment, at a minimum, must include:

(i) PAM must include a system that has been verified and tested by an experienced acoustic PSO that will be using it during the trip for which monitoring is required.

(ii) Reticle binoculars (*e.g*., 7 x 50) of appropriate quality (at least one per PSO, plus backups).

(iii) Global Positioning Unit (GPS) (plus backup).

(iv) Digital single-lens reflex cameras of appropriate quality that capture photographs and video (plus backup).

(v) Compass (plus backup).

(vi) Radios for communication among vessel crew and PSOs (at least one per PSO, plus backups).

(vii) Any other tools necessary to adequately perform necessary PSO tasks.

(c) Protected Species Observers (PSOs, Visual and Acoustic) Qualifications

(i) PSOs must have successfully completed an acceptable PSO training course appropriate for their designated task (visual or acoustic). Acoustic PSOs are required to complete specialized training for operating PAM systems and are encouraged to have familiarity with the vessel with which they will be working.

(ii) NMFS must review and approve PSO resumes.

(iii) NMFS shall have one week to approve PSOs from the time that the necessary information is submitted, after which PSOs meeting the minimum requirements shall automatically be considered approved.

(iv) One visual PSO with experience as shown in condition 4(b) of this authorization shall be designated as the lead for the entire protected species observation team. The lead must coordinate duty schedules and roles for the PSO team and serve as primary point of contact for the vessel operator. (Note that the responsibility of coordinating duty schedules and roles may instead be assigned to a shore-based, third-party monitoring coordinator.) To the maximum extent practicable, the lead PSO must devise the duty schedule such that experienced PSOs are on duty with those PSOs with appropriate training but who have not yet gained relevant experience.

(v) PSOs must successfully complete relevant training, including completion of all required coursework and passing (80 percent or greater) a written and/or oral examination developed for the training program.

(vi) PSOs must have successfully attained a bachelor's degree from an accredited college or university with a major in one of the natural sciences, a minimum of 30 semester hours or equivalent in the biological sciences, and at least one undergraduate course in math or statistics.

(vii) The educational requirements may be waived if the PSO has acquired the relevant skills through alternate experience. Requests for such a waiver must be submitted to NMFS and must include written justification. Requests must be granted or denied (with justification) by NMFS within one week of receipt of submitted information. Alternate experience that may be considered includes, but is not limited to (1) secondary education and/or experience comparable to PSO duties; (2) previous work experience conducting academic, commercial, or government-sponsored protected species surveys; or (3) previous work experience as a PSO; the PSO should demonstrate good standing and consistently good performance of PSO duties.

(d) Data Collection

(i) PSOs must use standardized data collection forms, whether hard copy or electronic. PSOs must record detailed information about any implementation of mitigation requirements, including the distance of animals to the acoustic source and description of specific actions that ensued, the behavior of the animal(s), any observed changes in behavior before and after implementation of mitigation, and if shutdown was implemented, the length of time before any subsequent ramp-up of the acoustic source. If required mitigation was not implemented, PSOs should record a description of the circumstances.

(ii) At a minimum, the following information must be recorded:

a. Vessel names (source vessel and other vessels associated with survey) and call signs;

b. PSO names and affiliations;

c. Date and participants of PSO briefings (as discussed in General Requirement);

d. Dates of departures and returns to port with port name;

e. Dates and times (Greenwich Mean Time) of survey effort and times corresponding with PSO effort;

f. Vessel location (latitude/longitude) when survey effort began and ended and vessel location at beginning and end of visual PSO duty shifts;

g. Vessel heading and speed at beginning and end of visual PSO duty shifts and upon any line change;

h. Environmental conditions while on visual survey (at beginning and end of PSO shift and whenever conditions changed significantly), including BSS and any other relevant weather conditions including cloud cover, fog, sun glare, and overall visibility to the horizon;

i. Factors that may have contributed to impaired observations during each PSO shift change or as needed as environmental conditions changed (*e.g.*, vessel traffic, equipment malfunctions); and

j. Survey activity information, such as acoustic source power output while in operation, number and volume of airguns operating in the array, tow depth of the array, and any other notes of significance (*i.e.*, pre-start clearance, ramp-up, shutdown, testing, shooting, ramp-up completion, end of operations, streamers, etc.).

(iii) Upon visual observation of any marine mammal, the following information must be recorded:

a. Watch status (sighting made by PSO on/off effort, opportunistic, crew, alternate vessel/platform);

b. PSO who sighted the animal;

c. Time of sighting;

d. Vessel location at time of sighting;

e. Water depth;

f. Direction of vessel's travel (compass direction);

g. Direction of animal's travel relative to the vessel;

h. Pace of the animal;

i. Estimated distance to the animal and its heading relative to vessel at initial sighting;

j. Identification of the animal (*e.g.*, genus/species, lowest possible taxonomic level, or unidentified) and the composition of the group if there is a mix of species;

k. Estimated number of animals (high/low/best);

l. Estimated number of animals by cohort (adults, yearlings, juveniles, calves, group composition, etc.);

m. Description (as many distinguishing features as possible of each individual seen, including length, shape, color, pattern, scars or markings, shape and size of dorsal fin, shape of head, and blow characteristics);

n. Detailed behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible; note any observed changes in behavior);

o. Animal's closest point of approach (CPA) and/or closest distance from any element of the acoustic source;

p. Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other); and

q. Description of any actions implemented in response to the sighting (*e.g.*, delays, shutdown, ramp-up) and time and location of the action.

(iv) If a marine mammal is detected while using the PAM system, the following information must be recorded:

a. An acoustic encounter identification number, and whether the detection was linked with a visual sighting;

b. Date and time when first and last heard;

c. Types and nature of sounds heard (*e.g*., clicks, whistles, creaks, burst pulses, continuous, sporadic, strength of signal);

d. Any additional information recorded such as water depth of the hydrophone array, bearing of the animal to the vessel (if determinable), species or taxonomic group (if determinable), spectrogram screenshot, and any other notable information.

6. Reporting

(a) L-DEO must submit a draft comprehensive report to NMFS on all activities and monitoring results within 90 days of the completion of the survey or expiration of the IHA, whichever comes sooner. A final report must be submitted within 30 days following resolution of any comments on the draft report. The draft report must include the following:

(i) Summary of all activities conducted and sightings of marine mammals near the activities;

(ii) Summary of all data required to be collected (see condition 5(d));

(iii) Full documentation of methods, results, and interpretation pertaining to all monitoring;

(iv) Summary of dates and locations of survey operations (including (1) the number of days on which the airgun array was active and (2) the percentage of time and total time the array was active during daylight vs. nighttime hours (including dawn and dusk)) and all marine mammal sightings (dates, times, locations, activities, associated survey activities);

(v) Geo-referenced time-stamped vessel tracklines for all time periods during which airguns were operating. Tracklines should include points recording any change in airgun status (*e.g*., when the airguns began operating, when they were turned off, or when they changed from full array to single gun or vice versa);

(vi) GIS files in ESRI shapefile format and UTC date and time, latitude in decimal degrees, and longitude in decimal degrees. All coordinates must be referenced to the WGS84 geographic coordinate system; and

(vii) Raw observational data.

(b) Reporting Injured or Dead Marine Mammals

(i) Discovery of Injured or Dead Marine Mammal – In the event that personnel involved in the survey activities covered by the authorization discover an injured or dead marine mammal, L-DEO must report the incident to the Office of Protected Resources (OPR) (301-427-8401), NMFS and the NMFS West Coast Regional Stranding Coordinator (866-767-6114) as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the first discovery (and updated location information if known and applicable);

b. Species identification (if known) or description of the animal(s) involved;

c. Condition of the animal(s) (including carcass condition if the animal is dead);

d. Observed behaviors of the animal(s), if alive;

e. If available, photographs or video footage of the animal(s); and

f. General circumstances under which the animal was discovered.

(ii) Vessel Strike – In the event of a ship strike of a marine mammal by any vessel involved in the activities covered by the authorization, L-DEO must report the incident to OPR, NMFS and to the West Coast Regional Stranding Coordinator as soon as feasible. The report must include the following information:

a. Time, date, and location (latitude/longitude) of the incident;

b. Species identification (if known) or description of the animal(s) involved;

c. Vessel's speed during and leading up to the incident;

d. Vessel's course/heading and what operations were being conducted (if applicable);

e. Status of all sound sources in use;

f. Description of avoidance measures/requirements that were in place at the time of the strike and what additional measures were taken, if any, to avoid strike;

g. Environmental conditions (*e.g.*, wind speed and direction, Beaufort sea state, cloud cover, visibility) immediately preceding the strike;

h. Estimated size and length of animal that was struck;

i. Description of the behavior of the marine mammal immediately preceding and following the strike;

j. If available, description of the presence and behavior of any other marine mammals immediately preceding the strike;

k. Estimated fate of the animal (*e.g.*, dead, injured but alive, injured and moving, blood or tissue observed in the water, status unknown, disappeared); and

l. To the extent practicable, photographs or video footage of the animal(s).

(c) Reporting Species of Concern – L-DEO must immediately report all observations of Southern Resident killer whales and North Pacific right whales to OPR, NMFS (301-427-8401). If Southern Resident killer whales or North Pacific right whales are observed within Olympic Coast National Marine Sanctuary, L-DEO must also immediately report the sightings to the Sanctuary (208-410-0260). The report must include the following information:

(i) Time, date, and location (latitude/longitude, water depth) of the observation;

(ii) Description of the animal(s) seen, including estimated number of animals, estimated age and sex classes observed, and distinguishing features;

(iii) Behavior observations (*e.g.*, number of blows/breaths, number of surfaces, breaching, spyhopping, diving, feeding, traveling; as explicit and detailed as possible);

(iv) Direction of vessel's travel (compass direction) and direction of animal's travel relative to the vessel; and

(v) Platform activity at time of sighting (*e.g.*, deploying, recovering, testing, shooting, data acquisition, other).

7. <u>Actions to minimize additional harm to live-stranded (or milling) marine mammals</u> – In the event of a live stranding (or near-shore atypical milling) event within 50 km of the survey operations, where the NMFS stranding network is engaged in herding or other interventions to return animals to the water, the Director of OPR, NMFS (or designee) will advise L-DEO of the need to implement shutdown procedures for all active acoustic sources operating within 50 km of the stranding. Shutdown procedures for live stranding or milling marine mammals include the following:

(a) If at any time, the marine mammal(s) die or are euthanized, or if herding/intervention efforts are stopped, the Director of OPR, NMFS (or designee) will advise L-DEO that the shutdown around the animals' location is no longer needed.

(b) Otherwise, shutdown procedures will remain in effect until the Director of OPR, NMFS (or designee) determines and advises L-DEO that all live animals involved have left the area (either of their own volition or following an intervention).

(c) If further observations of the marine mammals indicate the potential for re-stranding, additional coordination with L-DEO will be required to determine what measures are necessary to minimize that likelihood (*e.g.*, extending the shutdown or moving operations farther away) and to implement those measures as appropriate.

(d) Additional information requests – If NMFS determines that the circumstances of any marine mammal stranding found in the vicinity of the activity suggest investigation of the association with survey activities is warranted, and an investigation into the stranding is being pursued, NMFS will submit a written request to L-DEO indicating that the following initial available information must be provided as soon as possible, but no later than 7 business days after the request for information.

   (i) Status of all sound source use in the 48 hours preceding the estimated time of stranding and within 50 km of the discovery/notification of the stranding by NMFS; and

   (ii) If available, description of the behavior of any marine mammal(s) observed preceding (*i.e.*, within 48 hours and 50 km) and immediately after the discovery of the stranding.

In the event that the investigation is still inconclusive, the investigation of the association of the survey activities is still warranted, and the investigation is still being pursued, NMFS may provide additional information requests, in writing, regarding the nature and location of survey operations prior to the time period above.

8. This Authorization may be modified, suspended or withdrawn if the holder fails to abide by the conditions prescribed herein, or if NMFS determines the authorized taking is having more than a negligible impact on the species or stock of affected marine mammals.

9. Renewals - On a case-by-case basis, NMFS may issue a one-time, one-year Renewal IHA following notice to the public providing an additional 15 days for public comments when (1) up to another year of identical, or nearly identical, activities as described in the Specified Activities section of this notice is planned or (2) the activities as described in

the Specified Activities section of this notice would not be completed by the time the IHA expires and a Renewal would allow for completion of the activities beyond that described in the Dates and Duration section of this notice, provided all of the following conditions are met:

(a) A request for renewal is received no later than 60 days prior to the needed Renewal IHA effective date (recognizing that the Renewal IHA expiration date cannot extend beyond one year from expiration of the initial IHA).

(b) The request for renewal must include the following:

  (i) An explanation that the activities to be conducted under the requested Renewal IHA are identical to the activities analyzed under the initial IHA, are a subset of the activities, or include changes so minor (*e.g.*, reduction in pile size) that the changes do not affect the previous analyses, mitigation and monitoring requirements, or take estimates (with the exception of reducing the type or amount of take).

  (ii) A preliminary monitoring report showing the results of the required monitoring to date and an explanation showing that the monitoring results do not indicate impacts of a scale or nature not previously analyzed or authorized.

(c) Upon review of the request for Renewal, the status of the affected species or stocks, and any other pertinent information, NMFS determines that there are no more than minor changes in the activities, the mitigation and monitoring measures will remain the same and appropriate, and the findings in the initial IHA remain valid.

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Catherine Marzin, Date
Acting Director, Office of Protected Resources,
National Marine Fisheries Service.

Table 1. Numbers of Incidental Take of Marine Mammals Authorized.

Species	MMPA Stock	Authorized Take		Total Authorized Take
		Level B	Level A	
LF Cetaceans				
Humpback whale	Central North Pacific California/Oregon/Washington	112	29	141
Blue whale	Eastern North Pacific	40	11	51
Fin whale	California/Oregon/Washington Northeast Pacific	94	1	95
Sei whale	Eastern North Pacific	30	2	32
Minke whale	California/Oregon/Washington	96	7	103
Gray whale	Eastern North Pacific	43	1	44
MF Cetaceans				
Sperm whale	California/Oregon/Washington	72	0	72
Baird's beaked whale	California/Oregon/Washington	84	0	84
Small beaked whale	California/Oregon/Washington	242	0	242
Bottlenose dolphin	California/Oregon/Washington (offshore)	13	0	13
Striped dolphin	California/Oregon/Washington	46	0	46
Short-beaked common dolphin	California/Oregon/Washington	179	0	179
Pacific white-sided dolphin	California/Oregon/Washington	6084	0	6084

Northern right-whale dolphin	California/Oregon/Washington	4318	0	4318
Risso's dolphin	California/Oregon/Washington	1664	0	1664
False killer whale	Hawai'i Pelagic	5	0	5
Killer whale	Southern Resident	10	0	10
	Northern Resident	73	0	73
	West Coast Transient			
	Offshore			
Short-finned pilot whale	California/Oregon/Washington	29	0	29
HF Cetaceans				
Pygmy/dwarf sperm whale	California/Oregon/Washington	125	5	130
Dall's porpoise	California/Oregon/Washington	9762	488	10250
Harbor porpoise	Northern Oregon/Washington Coast	7958	283	8241
	Northern California/Southern Oregon			
Otariid Seals				
Northern fur seal	Eastern Pacific	4592	0	4592
	California			
Guadalupe fur seal	Mexico to California	2048	0	2048
California sea lion	U.S.	889	0	889
Steller sea lion	Eastern U.S.	7504	0	7504
Phocid Seals				
Northern elephant seal	California Breeding	2754	0	2754
Harbor seal	Oregon/Washington Coast	3887	0	3887

Table 2. Level B Harassment Zones by Water Depth

Water depth (m)	Level B harassment zone (m)
> 1000	6,733
100 – 1000	9,468
< 100	12,650

Table 3. Level A Harassment Zones by Hearing Group

Source (volume)	Threshold	Level A harassment zone (m)				
		LF cetaceans	MF cetaceans	HF cetaceans	Phocids	Otariids
36-airgun array (6,600 in^3)	SEL_{cum}	426.9	0	1.3	13.9	0
	Peak	38.9	13.6	268.3	43.7	10.6

Appendix C: Basic Data Summary Form

BASIC DATA FORM			
LDEO Project Number		MGL2201	
Seismic Contractor		LDEO	
Area Surveyed During Reporting Period		44.4045N 124.3079 W to 44.5458 N 126.1004 W	
Survey Type		2D OBN	
Vessel and/or Rig Name		R/V *Marcus G. Langseth*	
Permit Number		IHAs and BioOps issued by NMFS and FWS	
Location / Distance of Source Deployment		230 meters astern (from the NRP in the PSO tower)	
Water Depth	**Min**	50	
	Max	3000	
Dates of project		10 April 2022	Through 21 April 2022
Total time source operating – all power levels:		21:39	
Time source operating on survey lines:		19:30	
Time source operating not on a survey line:		00:55	
Amount of time single 40 in³ element operations:		00:00	
Amount of time in ramp-up:		01:14	
Number daytime ramp-ups:		3	
Number of nighttime ramp-ups:		0	
Number of ramp-ups from mitigation source:		0	
Amount of time conducted in source testing:		00:00	
Duration of visual observations:		142:15	
Duration of observations while source active:		12:13	
Duration of observation during source silence:		130:02	
Duration of acoustic monitoring:		27:12	
Duration of acoustic monitoring while source active:		21:39	
Duration of acoustic monitoring during source silence:		05:33	
Duration of simultaneous acoustic and visual monitoring:		17:25	
Lead Protected Species Observer:		Amanda Dubuque	
Protected Species Observers on the Langseth:		Eren Penfield-Espinosa, Lorena Consuelo, Marah Vital, Yesenia Balderas	
Number of Marine Mammals Visually Detected:		34	
Number of Marine Mammals Acoustically Detected:		0	
Number of Simultaneous Visual and Acoustic Detections:		0	
Number of Sea Turtles detected:		0	
Total Number of Protected Species Detections:		34	
List Mitigation Actions		2 shutdowns	
Duration of Mitigation Actions:		44 minutes	

Appendix D: Node Specifications

D.1 Node Specifications

GEOSPACE®
Technologies

OBX2-90

OCEAN BOTTOM RECORDER

- Continuous cable-free 4C autonomous recording
- Battery module: 90 days operation
- Built-in full resolution test generator
- Solid-state flash memory: 16 GB per channel
- CSAC clock
- Built-in heading sensor

Specifications subject to change at sole discretion of Geospace Technologies.

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GEOSPACE®
Technologies

OBX2-90

MECHANICAL SPECIFICATIONS (HOUSING)	METRIC	US
Length	475 mm	18.7 in.
Width	208 mm	8.2 in.
Height	106 mm	4.25 in.
Weight in Air	16.5 kg	36.4 lbs.
Weight in Seawater	9.1 kg	20.0 lbs.
Maximum Operating Pressure	34.5 MPa/345 Bar	5,000 psi
Maximum Operating Depth	3,450 M	11,316 ft.
Operating Temperature Range	-5°C to +60°C	+23°F to +140°F
Storage Temperature Range	-10°C to +60°C	+14°F to +140°F

ELECTRICAL SPECIFICATIONS	
Digitized 4C Recording Station:	4 Channel, 24 Bit A/D Digitizer 3C Orthogonal oriented GS-One OMNI 15 Hz Geophones 1 DEEPENDER Hydrophone
Digitization	24-bit Delta-Sigma
Sample Interval	0.25, 0.5, 1, 2, 4 ms
Pre-amplifier Gains	0, 6, 12, 18, 24, 30, 36 dB
Maximum Input Signal	1.8Vrms
Equivalent Input noise (@2ms sample interval)	0.17 µVrms
Gain Accuracy	Better than 1%
Anti-alias Filter	83% Nyquist
Instantaneous Dynamic Range	124dB @ 2 ms sample interval
THD	<0.2%
Distance Between Digitizer & Farthest Sensor	<18 cm
Distance Between All Sensors	<13 cm
Flash Memory	16 GB per channel
Frequency Response	1 Hz – 1650 Hz @ ¼ ms sample interval
Battery Module	90 days operation

CLOCK SPECIFICATIONS				
Days	30	60	90	100
Max Uncorrected Drift	2ms	8ms	17ms	21ms
Corrected Drift	<.25ms	<.5ms	1ms	1ms

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592-18420-01 Rev. B

Appendix E: ROV Specifications

E.1 ROV Specifications

PELAGIC
RESEARCH SERVICES

ROV ODYSSEUS

ODYSSEUS
REMOTELY OPERATED VEHICLE (ROV)

VEHICLE

DEPTH CAPABILITY:
0 to 6000 meters

DIMENSIONS WITH SCIENCE SKID:
55 1/2" (W) x 93" (L) x 83 1/4" (H)
(141 x 236 x 211.5 cm)

WEIGHT IN AIR:
4000 lbs (1814 kg) with removable science skid

REMOVABLE SCIENCE SKID:
Hydraulic activated tray for samples and/or sensors and gear—available space 47 3/4"(W) x 32"(L) x 15"(H). Extends fully in front of ROV. Entire tray is accessible to manipulators

THRU FRAME LIFTING CAPACITY
Utilizing hydraulic load release - 2000 lbs
Utilizing optional integrated lifting bridge with hydraulic stabs - 4000 lbs

SUBSEA NAVIGATION
Standard Sensor suite - IxBlue OCTANS, Tritech Altimeter and Super Seaking SONAR, Paroscientific depth sensor. (PHINNS or other INS and DVL sensors available upon request)

POWER (measured at shaft):
25 HP

HYDRAULICS
(Spare Hydraulic Circuits for tooling, etc.)
3000 psi @ 10gpm

LIGHTING:
6 to 9 Deep Sea Power and Light Model SLS 5000. Additional lights may be added

MANIPULATOR:
Standard Configuration = One 7-function Schilling Titan manipulator, one 5-function manipulator. Option to carry 2-7-function manipulators.

VOLTAGE:
24 DC, 12 DC, 5DC. (120 AC upon request)

CAMERAS

SubC Imaging 1CamAlpha HD Video and digital still camera, 6 Deep Sea Power and Light Standard Definition Color Multi – SeaCam, Color Wide-I SeaCam, Color Super Wide-I Sea Cam, BxW Wide– I SeaCam. (Additional HD, 4K and/or SD cameras are easily added.)

THRUSTERS

The vehicle has a total of 7 thrusters. 4 thrusters provide accurate control of the vehicle in the lateral and rotational axises. 3 thrusters provide vertical control of the vehicle in the water column.

042419

EXCEPTIONAL DEEP SEA RESEARCH TOOLS & SERVICES

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Appendix F: Passive Acoustic Monitoring System Specifications

F.1 Passive Acoustic Monitoring System Specifications

1.1 Heavy Tow Cable with Separate Hydrophone Array

Main tow cable serial number: SM 7353

Spare tow cable serial number: SM 7345

Mechanical Information:

Length: 230 m
Outer diameter: 16.5 mm (+/- 0.5 mm)
Ship-side connector: ITT 19-way, male
Wet-end connector: Seiche, with 36-way Lemo insert, female.
Weight: approximately 94 kg (in air)

1.2 Hydrophone Array Cable

Main array cable serial number: SM 7257

Spare array cable serial number: SM 7324

Mechanical Information:

Type: Detachable 25 m, 6-ch Array
Length: 25 m
Diameter: 17 mm (over cable), 32 mm (over mouldings), 65 mm (over connector)
Connector: Seiche connector with 36-way Lemo insert, male.
Weight: approximately 10 kg (in air)

Hydrophone elements

Array elements: four spherical hydrophones / preamplifiers, one depth sensor
Hydrophone 1: 200-200,000 Hz (-3 dB), sensitivity -201dB re 1V/uPa
Hydrophone 2: 200-200,000 Hz (-3 dB), sensitivity -201dB re 1V/uPa
Hydrophone 3: 200-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa
Hydrophone 4: 200-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa
Hydrophone 5: 2,000-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa
Hydrophone 6: 2,000-200,000 Hz (-3 dB), sensitivity -166dB re 1V/uPa
Depth sensor: 10-bar pressure rating.

1.3 Deck Cable

Main deck cable serial number: SM 7633

Spare deck cable serial number: SM 7755

Mechanical Information

Length: 100m
Diameter: 14mm cable, 45mm at male connector, 65mm at female connector
Weight: 25kg
Connectors ITT: 19 pin

Appendix G: Passive Acoustic Monitoring Hydrophone Deployment

G.1 Passive Acoustic Monitoring System Hydrophone Deployment

1.1 Overview

Two identical hydrophone cables were supplied to *R/V Langseth* for this survey. The cables consisted of a 230-meter steel reinforced tow cable with a detachable 25-meter hydrophone array. The arrays consisted of two LF hydrophones (10 Hz to 24 kHz), two MF hydrophones (200 Hz to 200 kHz), two HF hydrophone elements (2 kHz to 200 kHz) and a depth gauge (100m capacity) potted directly into the cable (Figure 1).

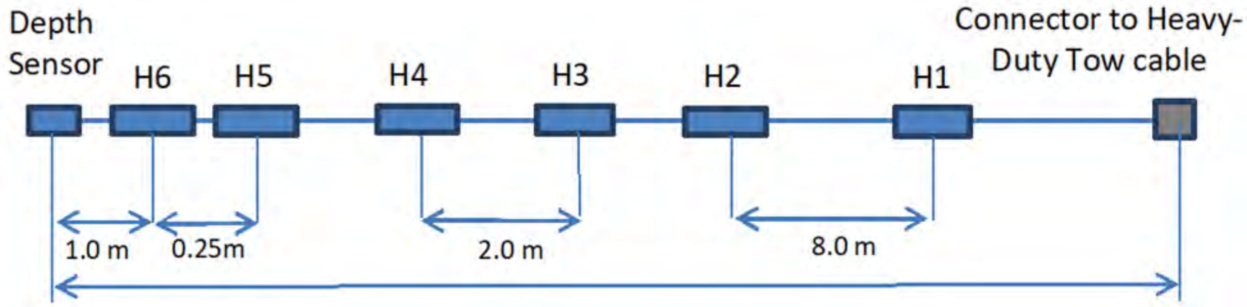

Figure 1: Two-part hydrophone cable with a 230-meter tow cable and detachable 25-meter hydrophone array.

The hydrophone cable was spooled onto a hydraulic winch located on the port stern of the vessel's aft deck. A 100-meter deck cable connected the hydrophone cable to the PAM station in the main science lab. Due to the structural design of the vessel, two 100-meter deck cables were installed prior to the project. One of the deck cables was designated as the main cable and the other acted as a spare. The main deck cable was connected to an electronic processing unit (EPU) at the PAM station in the main science lab. The rack mounted EPU was secured in the event of rough weather. A GPS feed (GNGGA string) was supplied to the system by the ships navigation Seapath 200. Additional monitoring equipment included two secured monitors supplied by the vessel, a keyboard, a mouse, and headphones for aural monitoring.

The hydrophone cable was deployed from a hydraulic winch on the port stern of the vessel's aft deck where the acoustic source arrays were deployed. Two deck cables, a main and a spare, were installed along the deck-head running from the winch to the main science lab. A Chinese finger attached to the tow cable approximately 125-meters ahead of the connector to the hydrophone array was secured to the port side boom via lifting rope. This reduced the tension on the cable remaining on the winch and served as a method to pull the cable further to port and away from the source arrays. This deployment method placed the trailing end of the hydrophone cable approximately 125 meters from the port stern of the vessel, and approximately 68 meter forward of the first elements on the acoustic source arrays. Two pieces of chain of seven kilograms each were attached and secured to the tow cable to increase tow depth and to decrease the chance of entanglement with the source arrays' umbilicals. The tow depth of the hydrophones varied between 14.4 and 34.2 meters and averaged 22.7 meters throughout the survey program.

1.2 Deployment Tasks

- Ensure that the data processing unit is powered down.
- Alert the bridge of the pending hydrophone deployment.
- Ensure that the deck cable is disconnected from the hydrophone tow cable. Do not allow connectors to rotate with the winches unless they are strapped down as they can impact or snag and snap.
- Power on the winch.
- Avoid excess tension on the cable.
- Deploy in a slow controlled manner to prevent crossover on the winch.
- Respect the cables minimum bend angles and ensure are not bent on either side of cable mouldings/pottings.
- Protect cable from abrasions and chaffing.
- Let out the proper length of hydrophone cable off the winch for the deployment method used.
- Connect the hydrophone cable to the offset rope via Chinese finger.
- Power off the winch.
- Connect the hydrophone tow cable to the deck cable.
- Power on the data processing unit.

1.3 Retrieval Tasks

- Ensure that the data processing unit is powered down.
- Alert the bridge of the pending hydrophone able retrieval.
- Disconnect the hydrophone cable from the tow cable. Tape the connectors and ensure they are stowed/secured clear of the moving winch.
- Power on the winch.
- Disconnect the Chinese fingers on the cable from the offset rope.
- Retrieve the cable in a slow controlled manner to prevent crossover on the winch.
- Power off the winch.

1.4 Health, Safety, and Environment (HSE) Requirements

Normal working deck Personal Protective Equipment (PPE) was required (hard hat, boots, gloves, eye protection). A life vest was required for any work involving items going over the side. The operation carried relatively low risk. Hazards included working close to the side of the vessel, trip hazards, and pinch points at the winch.

A Job Safety Analysis (JSA) was completed for this task. Further review of JSA was required in the event of modifications to the procedures.

Appendix H: Summary of Visual Detections of Protected Species

H.1 Summary of Visual Detections of Protected Species During the Survey.

Movement Codes: **TV**: towards vessel; **AV**: away from vessel; **PV/SD**: parallel vessel, same direction; **PV/OD**: parallel vessel, opposite direction; **PE (AH/BH):** perpendicular (crossing ahead or behind); **MI**: milling; **SA**: stationary; **V:** variable, **UN**: unknown**; OM**: other movement

Behavioral Codes: **NS**: normal swimming; **FT**: fast travel; **ST**: slow travel; **PO**: porpoising; **SS**: swimming below surface; **MI**: milling: **BR**: bow/wake riding; **BA**: resting/basking at surface; **FL:** floating; **SA: surface** active (lob tailing/pectoral slapping, full/partial breaching)**; R:** rolling; **DI**: dive; **DF**: dive with fluke; **FF**: feeding/foraging; **SB**: social behavior; **MT**: mating behavior; **BV**: blow visible (whale); **SV**: only splashes visible (dolphins); **DV**: dorsal fin visible; **OB**: other behavior

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement	Behavior	CPA Source/ Source Activity	Mitigation Action	Comments
1	2022-04-10	21:01	Unidentifiable Whale	1	44.50242°N 125.31438°W	Source Not Deployed	PV/OD, AV	BV	N/A	None	Vessel in transit back to port, no gear deployed.
2	2022-04-10	22:30	Humpback Whale	2	44.52550°N 125.01167°W	Source Not Deployed	PV/OD, AV	BV, SA	N/A	None	Vessel in transit back to port, no gear deployed.
3	2022-04-10	23:24	Humpback Whale	1	44.54600°N 124.75533°W	Source Not Deployed	PV/OD	BV	N/A	None	Vessel in transit back to port, no gear deployed.
4	2020-04-12	16:18	Steller Sea Lion	2	44.62617°N 124.05273°W	Source Not Deployed	PV/OD, TV	NS, SS	N/A	None	Vessel in transit within port heading back to survey site, no gear deployed.
5	2020-04-12	16:46	Steller Sea Lion	1	44.59955°N 124.11490°W	Source Not Deployed	SA	OB	N/A	None	Vessel in transit just outside of port heading back to survey site, no gear deployed.
6	2020-04-13	16:36	Unidentifiable Whale	1	44.48633°N 125.40333°W	Source Not Deployed	UN	BV	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
7	2020-04-13	17:39	Unidentifiable Whale	1	44.48567°N 125.39350°W	Source Not Deployed	AV	BV	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
8	2020-04-13	19:32	Steller Sea Lion	1	44.48473°N 125.38074°W	Source Not Deployed	AV, PV/OD	SS, DI, BA	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
9	2020-04-13	21:24	Steller Sea Lion	1	44.48417°N 125.37433°W	Source Not Deployed	PV/SD; AV	SS, DI, BA	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
10	2020-04-14	01:04	Steller Sea Lion	2	44.48317°N 125.36167°W	Source Not Deployed	V, TV	SS, DI, BA	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
11	2020-04-15	17:53	Humpback Whale	3	44.46308°N 125.10216°W	Source Not Deployed	MI, AV	BV, DF, SA	N/A	None	Vessel in survey area with ROV in the water deploying nodes. Includes one juvenile.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement	Behavior	CPA Source/ Source Activity	Mitigation Action	Comments
12	2020-04-15	23:31	Steller Sea Lion	1	44.45868°N 125.04665°W	Source Not Deployed	AV	ST, SS	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
13	2020-04-16	00:36	Humpback Whale	3	44.45766°N 125.03378°W	Source Not Deployed	AV	BV, DF	N/A	None	Vessel in survey area with ROV in the water deploying nodes. Includes one juvenile.
14	2020-04-16	13:30	Steller Sea Lion	2	44.44741°N 124.90568°W	Source Not Deployed	PV/SD; TV	ST, SS	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
15	2020-04-16	15:46	Steller Sea Lion	2	44.44520°N 124.87840°W	Source Not Deployed	TV, AV	ST, SS	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
16	2020-04-16	16:35	Steller Sea Lion	2	44.44434°N 124.86773°W	Source Not Deployed	PV/OD; TV	ST, SS, BA, MI	N/A	None	Vessel in survey area with ROV in the water deploying nodes.
17	2022-04-17	01:52	Humpback Whale	2	44.44267°N 124.42250°W	Source Deployed and Silent	PV/SD, PV/OD	BV, SA, DI	1,885m/ Silent	None	Source was silent during deployment of the arrays.
18	2022-04-17	14:16	Humpback Whale	1	44.47842°N 125.29522°W	Reduced Volume Online	PV/OD, AV	BV, DI	2,614m/ Active	None	Potential Level B take.
19	2022-04-17	20:38	Northern Fur Seal	1	44.52229°N 125.88187°W	Reduced Volume Online	TV	FT, SR	240m/ Active and 193m/ Silent	Shutdown	Potential Level B take. Mitigation action totaled 17 minutes, but source silent for 01:36 as vessel circled around. Last sighted within 500m EZ.
20	2022-04-17	21:05	Northern Fur Seal	1	44.53680°N 125.91536°W	Source Deployed and Silent	PV/SD	FT, DI	277m/ Silent	None	Source was silent after previous detections shutdown. No further delay for this sighting as ramp-up was already delayed while the vessel circled around. Last sighted within 500m EZ.
21	2022-04-18	23:55	Northern Fur Seal	1	44.52533°N 125.92633°W	Reduced Volume Online	PV/OD, PV/SD	FT, SA, DI	247m/ Active and 200m/ Silent	Shutdown	Potential Level B take. Mitigation action totaled 27 minutes, but source was silent for 29 minutes. Last sighted within 500m EZ.
22	2022-04-18	14:20	Northern Fur Seal	1	44.32995°N 125.81565°W	Source Not Deployed	TV	FT, DI	N/A	None	Vessel on weather standby between end of acoustic source operations and start of node retrieval operations. All equipment silent and onboard.

Record No.	Date	Time (UTC)	Species	Group Size	Vessel Position	Source Activity Initial Detection	Movement	Behavior	CPA Source/ Source Activity	Mitigation Action	Comments
23	2022-04-19	15:15	Unidentifiable Whale	3	44.48470°N 125.38060°W	Source Not Deployed	UN, AV	BV, MI, DI	N/A	None	Vessel retrieving nodes with ROV in the water.
24	2022-04-19	17:36	Humpback Whale	1	44.48303°N 125.35876°W	Source Not Deployed	PE(AH)	BV	N/A	None	Vessel retrieving nodes with ROV in the water.
25	2022-04-19	18:04	Unidentifiable Whale	2	44.48267°N 125.35533°W	Source Not Deployed	AV, PE(BH)	BV	N/A	None	Vessel retrieving nodes with ROV in the water.
26	2022-04-19	18:28	Humpback Whale	3	44.48267°N 125.35533°W	Source Not Deployed	PE(BH), AV	BV, SA, DF	N/A	None	Vessel retrieving nodes with ROV in the water.
27	2022-04-19	22:12	Humpback Whale	2	44.48226°N 125.34900°W	Source Not Deployed	TV, AV	BV, MI, DF	N/A	None	Vessel retrieving nodes with ROV in the water.
28	2022-04-19	23:15	Humpback Whale	4	44.48175°N 125.34231°W	Source Not Deployed	V, PV/OD	BV, SS, MI, DF	N/A	None	Vessel retrieving nodes with ROV in the water. Simultaneous detection of humpback and fin whales.
28	2022-04-19	23:15	Fin Whale	3	44.48175°N 125.34231°W	Source Not Deployed	V, PV/OD	BV, FT, DI	N/A	None	Vessel retrieving nodes with ROV in the water. Simultaneous detection of humpback and fin whales.
29	2022-04-20	01:37	Unidentifiable Whale	1	44.48066°N 125.32822°W	Source Not Deployed	AV	BV	N/A	None	Vessel retrieving nodes with ROV in the water.
30	2022-04-20	15:01	Steller Sea Lion	1	44.47658°N 125.28375°W	Source Not Deployed	TV	SH, SS	N/A	None	Vessel on weather standby with all equipment silent and onboard.
31	2022-04-20	17:24	Northern Fur Seal	1	44.47044°N 125.26568°W	Source Not Deployed	TV	SS, SA	N/A	None	Vessel on weather standby with all equipment silent and onboard.
32	2022-04-20	19:29	Steller Sea Lion	1	44.46723°N 125.26481°W	Source Not Deployed	PV/SD	SS, SH	N/A	None	Vessel on weather standby with all equipment silent and onboard.
33	2022-04-20	22:07	Steller Sea Lion	1	44.44791°N 125.26585°W	Source Not Deployed	UN	SS	N/A	None	Vessel on weather standby with all equipment silent and onboard.
34	2022-04-21	01:06	Humpback Whale	2	44.50822°N 124.82279°W	Source Not Deployed	PE(AH), AV	BV, NS, DF	N/A	None	Vessel in transit back to port.

Appendix I: Photographs of Detected Protected Species

Figure 1: Visual Detection #4 - Steller sea lion - 12 April 2022

Figure 2: Visual Detection #5 - Steller sea lion - 12 April 2022

Figure 3: Visual Detection #8 - Steller sea lion - 13 April 2022

Figure 4: Visual Detection #9 - Steller sea lion - 13 April 2022

Figure 5: Visual Detection #10 - Steller sea lion - 14 April 2022

Figure 6: Visual Detection #11 - Humpback whales - 15 April 2022

Figure 7: Visual Detection #12 - Steller sea lion - 15 April 2022

Figure 8: Visual Detection #13 - Humpback whale - 16 April 2022

Figure 9: Visual Detection #14 - Steller sea lion - 16 April 2022

Figure 10: Visual Detection #15 - Steller sea lion - 16 April 2022

Figure 11: Visual Detection #16 - Steller sea lion - 16 April 2022

Figure 12: Visual Detection #17 - Humpback whale - 17 April 2022

Figure 13: Visual Detection #19 - Northern fur seal - 17 April 2022

Figure 14: Visual Detection #21 - Northern fur seal - 18 April 2022

Figure 15: Visual Detection #27 - Humpback whale - 19 April 2022

Figure 16: Visual Detection #28 - Fin whales - 19 April 2022

Figure 17: Visual Detection #28 - Humpback whales - 19 April 2022

Figure 18: Visual Detection #31 - Northern fur seal - 20 April 2022

Appendix J: Birds and Other Wildlife Observed

J.1 Species of Birds and Other Wildlife Observed During the Survey

Birds: Common Name	Taxonomic Identification	Approximate Number Individuals Observed	Approximate Number of Days Species Was Observed
Black-footed albatross	*Diomedea nigripes*	233	10
Black-legged Kittiwake	*Larus tridactyla*	27	5
Brand's cormorant	*Phalacrocorax penicillatus*	4	1
Brant	*Branta bernicla*	13	1
California Gull	*Larus californicus*	2	1
Common loon	*Gavia immer*	5	1
Common murre	*Alcidae uria aalge*	2	1
Fork-tailed storm petrel	*Oceanodroma furcata*	16	4
Harlequin Duck	*Histrionicus histrionicus*	5	1
Herring gull	*Larus argentatus*	56	8
Laysan Albatross	*Diomedea immutabilis*	5	4
Leach's storm-petrel	*Oceanodroma leucorhoa*	1	1
Northern Fulmar	*Fulmarus glacialis*	5	4
Pelagic Cormorant	*Phalacrocorax pelagicus*	5	1
Pigeon Guillemot	*Cepphus columba*	4	1
Pomarine Skua	*Stercorarius pomarinus*	1	1
Red-necked Grebe	*Podiceps grisegena*	6	1
Ring-billed gull	*Larus delawrensis*	60	4
Sabine's Gull	*Larus sabini*	1	1
Short-tailed shearwater	*Puffinus tenuirostris*	1	1
Western Gull	*Larus occidentalis*	22	4
Western Meadowlark	*Sturnella neglecta*	2	2

Invertebrates: Common Name	Taxonomic Identification	Approximate Number Individuals Observed	Approximate Number of Days Species Was Observed
Moon Jellyfish	*Aurelia aurita*	2	2