NATIONAL MARINE FISHERIES SERVICE
ENDANGERED SPECIES ACT SECTION 7
BIOLOGICAL OPINION

Title:	Programmatic Biological Opinion on the National Program for the Aerial Application of Long-Term Fire Retardants
Consultation Conducted By:	Endangered Species Act Interagency Cooperation Division, Office of Protected Resources, National Marine Fisheries Service
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Approved:	DAMON RANDALL.KIMBERLY.BETH.1365821093 Digitally signed by DAMON RANDALL.KIMBERLY.BETH.1365821093 Date: 2022.02.25 15:18:06 -05'00' Kimberly Damon-Randall Director, Office of Protected Resources
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1 Introduction

The Endangered Species Act of 1973, as amended (ESA 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 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. Federal agencies must do so in consultation with the National Marine Fisheries Service (NMFS) for threatened or endangered species (ESA-listed), or designated critical habitat that are under NMFS's jurisdiction (50 CFR 402.14(a)) that may be affected by the action. 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 CFR 402.14(b)).

Section 7(b)(3) of the ESA requires that at the conclusion of formal consultation, NMFS provides a biological 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 (RPA) 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 that specifies the impact of any incidental taking and includes reasonable and prudent measures (RPMs) to minimize such impacts and terms and conditions to implement the RPMs.

The action agency for this consultation is the United States Forest Service (USFS). The action considered in this opinion is the USFS program for the aerial application of long-term fire retardants. Long-term fire retardants are typically salts, which can be applied from the air or ground, to coat the surface of fuels and slow the spread of wildfire. They are generally effective until being washed off by the next rainfall. They are the primary type of fire retardant used to fight wildfires. Long-term fire retardants are applied annually, are the only type of fire retardant considered in this consultation, and this program will continue indefinitely. This programmatic biological opinion first establishes the minimum requirements for fire retardant chemicals and safety and then assesses the risk of applying those retardants to listed species and designated critical habitat.

This consultation, biological opinion, and incidental take statement, were completed in accordance with section 7(a)(2) of the statute (16 U.S.C. 1536 (a)(2)), associated implementing regulations (50 CFR 402.01-402.16), and agency policy and guidance. This biological opinion and incidental take statement were prepared by the NMFS Office of Protected Resources Endangered Species Act Interagency Cooperation Division (NMFS ESA Interagency Cooperation Division; hereafter referred to as "we") in accordance with section 7(b) of the ESA and implementing regulations at 50 CFR 402.

This document represents the NMFS ESA Interagency Cooperation Division's biological opinion on the effects of the action on endangered and threatened marine mammals and fishes, as well as designated 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

Management of wildfires by all federal agencies had been handled as unpredictable emergency events for listed species and critical habitat prior to a September 30, 2005, ruling from the United States District Court for the District of Montana. This ruling determined that the use of fire retardant predictably occurred annually and therefore the USFS was required to initiate formal consultation with NMFS and the US Fish and Wildlife Service (USFWS). Subsequent programmatic consultations address the probability of intrusions affecting listed species and critical habitat. The term intrusion was defined for this programmatic action as "the intentional or unintentional application of aerial fire retardant into an aerial retardant avoidance area" (USDA Forest Service 2020). NMFS supports monitoring intrusions into both buffers and water, but for the purposes of this programmatic biological opinion, we will assess the effects of intrusions that enter water, whether directly through application or later via run off.

On October 9, 2007, NMFS issued a programmatic assessment of the USFS use of aerially applied long-term fire retardants. On April 2, 2008, the USFS and the Services were again sued for alleged violations of the National Environmental Policy Act (NEPA) and the ESA. On July 27, 2010, the US District Court for the District of Montana ruled against USFS and the Services, requiring new NEPA and ESA reviews prior to December 31, 2011. NMFS issued a new programmatic biological opinion on November 7, 2011 (NMFS 2011a), with a 10-year effective date to January 1, 2022 (hereafter, the "2011 fire retardant programmatic"). The 2011 programmatic action contained a number of mitigation measures not found in the 2007 action. These mitigation measures remain in effect and are discussed later.

Monitoring required by the 2011 programmatic biological opinion has resulted in improved knowledge of buffer zone effectiveness, intrusion probability, and average intrusion volumes. At that time, intrusions were called 'misapplications,' which is not always the correct phrase because retardant can be intentionally applied to buffers or streams to protect fire fighter lives. But each intrusion was monitored and reported, regardless of intent. Additionally, since 2011, the USFS has been developing a model to anticipate stream reach affected by intrusions that can be coupled with probable exposure and response of NMFS' trust resources in the exposure area (Rehmann et al. 2021).

Several regional consultations (site-specific biological opinion) have been conducted under the framework of the 2011 programmatic biological opinion where the end result is a regional component of the national ITS is superseded. In response to an intrusion on the Road 210 fire (Columbia River basin), NMFS issued a site-specific biological opinion and updated incidental take statement on May 17, 2016. Additional intrusions during the Dry Creek (Columbia River

basin), Carlton Complex (Wenatchee National Forest), Nachez (Siskiyou National Forest), and Thomas fires (Los Padres National Forest) resulted in a site-specific biological opinion issued on May 10, 2019. With the expiration of the 2011 fire retardant programmatic, the framework under which these site-specific tiered consultations were conducted, these tiered consultations have also expired. Therefore, there is a need for a new national programmatic consultation to address the risks of aerially applied long-term fire retardant usage in the future.

1.2 Consultation history

August 5, 2020: USFS provided a notice of intent to reinitiate consultation on the fire retardant programmatic action because the 2011 programmatic ITS only anticipated and exempted take through January 1, 2022.

February 8, 2021: NMFS received a draft of the programmatic fire retardant biological assessment (BA) and a request to provide comments to the USFS.

March 5, 2021: NMFS provided comments to the USFS on the draft programmatic fire retardant BA.

May 4, 2021: NMFS received a request to initiate formal consultation and programmatic consultation was initiated at that time.

2 The Assessment Framework

This biological opinion includes both a jeopardy analysis for the listed species and an adverse modification or destruction of critical habitat analysis. The two analyses occur concurrently throughout the document, as explained below.

The jeopardy analysis relies upon the regulatory definition of “jeopardize the continued existence of” a listed species, which is “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 a listed species in the wild by reducing the reproduction, numbers, or distribution of that species” (50 CFR 402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This biological opinion relies on the definition of "destruction or adverse modification," which “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 CFR 402.02). The important or essential features of critical habitat have been identified using the terms primary constituent elements (PCEs), essential features, or physical and biological features (PBFs). Critical habitat regulations define the term “physical or biological features essential to the conservation of the species” to mean “the features that occur in specific areas and that are essential to support the life-history needs of the species, including but not limited to, water characteristics, soil type, geological features, sites, prey, vegetation, symbiotic species, or other features. A feature may be a single habitat characteristic, or a more complex combination of habitat characteristics. Features may

include habitat characteristics that support ephemeral or dynamic habitat conditions. Features may also be expressed in terms relating to principles of conservation biology, such as patch size, distribution distances, and connectivity" (50 CFR 424.02). The establishment of the term, "features," does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this biological opinion, we use the term PBF to mean PCE or essential feature, as appropriate, for the specific critical habitat.

The 2019 ESA regulations define "effects of the action" to incorporate direct, indirect, interrelated, and interdependent effects into a single classification. In doing so, we also retained the concepts that the consequences of the action were attributable to the action if they were caused by or would not occur "but for" the action and were "reasonably certain to occur." This new definition did not change the standard for 7(a)(2) consultation, which remains any action which "may affect" listed species or their critical habitat. As such, this consultation considers both species "likely to be adversely affected" by the action as well as those "not likely to be adversely affected."

An ESA section 7 assessment involves the following steps:

Description of the Proposed Action (Section 3): We describe the proposed action, the legal authorities, and what guides the decision-making process when deciding whether using long-term fire retardants is appropriate 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 potential effects to ESA-listed species. Most importantly, for a mixed programmatic action such as this, this section also discusses monitoring, annual reviews, and future modifications to be coordinated with the Services.

Identification of Stressors and the Action Area (Section 4): In this section, we break the proposed action into its components and then break those components into the stressors that are likely to result. We consider the area where the stressors may be detectable above background levels to define our action area. Action Area is defined as "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action" (50 CFR 402.02).

Species in the Action Area (Section 5): We identify the ESA-listed species and designated critical habitat under NMFS jurisdiction that occur within the action area and that may be affected by the proposed action. We then identify the ESA-listed species and designated critical habitat that are not likely to be adversely affected by the proposed action. The remaining species and critical habitats in the action area are anticipated to co-occur in space and time with the stressors caused by the proposed action, which will be the subject of our jeopardy and adverse modification analyses. We then evaluate the status of those species and critical habitats.

*Environmental Baseline (*Section 6): 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" (50 CFR 402.02).

Effects of the Action (Section 7): "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" (50 CFR 402.02). These are broken into analyses of exposure, response, and risk for the species and critical habitat that are likely to be adversely affected by the action.

Cumulative Effects (Section 8): 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 CFR 402.02). Effects from future federal actions that are unrelated to the proposed action are not considered because they require a separate ESA section 7 jeopardy analysis.

Integration and Synthesis (Section 9): In this section, we complete our assessment of the effects of the action to species and critical habitat because of implementing the proposed action. We add the effects of the action (Section 7) and cumulative effects (Section 8) to the environmental baseline (Section 6), taking into account the status of the species and critical habitat (Section 5), to formulate the agency's biological opinion and determination of the effects of the action on listed resources. This final determination assesses 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 their numbers, reproduction, or distribution, and state our conclusion as to whether the action is likely to jeopardize the continued existence of such species; or

- Appreciably diminish the value of designated critical habitat as a whole 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.

Conclusion (Section 10): The conclusion section summarizes the results of our jeopardy and destruction or adverse modification analyses.

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 RPAs to the action, if any, or indicate that to the best of our knowledge there are no RPAs (50 CFR 402.14).

When an action is not likely to jeopardize listed species, destroy critical habitat, or RPAs have been identified and will be implemented by the action agency to avoid jeopardizing listed species or destroying critical habitat, we include an *Incidental Take Statement* (ITS; Section 11). The ITS specifies the life stages affected, the form of take, and establishes appropriate Reasonable and Prudent Measures (RPMs) to minimize the impact of the take, if possible. Further, it identifies the specific terms and conditions to implement each RPM (ESA section 7 (b)(4); 50 CFR 402.14(i)).

We also provide discretionary *Conservation Recommendations* that may be implemented by the action agency (Section 12) (50 CFR 402.14(j)) to further aid in the conservation of the species.

Finally, we identify the circumstances in which *Reinitiation of Consultation* (Section 13) is required (50 CFR 402.16).

To comply with our obligation to use the best scientific and commercial data available (16 U.S.C. § 1536(a)(2); 50 CFR 402.14), 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:

- Peer reviewed literature,
- Species 5-year status reviews,
- Annual monitoring reports from 2011 to present,
- Reports of fire retardant risk analyses contracted by the USFS in consultation with NMFS and the USFWS, and
- Consultations with species experts and toxicologists.

These resources were used to identify information relevant to the potential effects and associated 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 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 CFR 402.02). A mixed programmatic action means, for purposes of an ITS, a federal action that approves actions that will not be subject to further section 7 consultation, and also approves a framework for the development of future actions that are authorized, funded, or carried out at a later time and any take of a listed species would not occur unless and until those future actions are authorized, funded, or carried out and subject to further section 7 consultation (50 CFR 402.02). This analysis of the aerially applied long-term fire retardant program, a mixed programmatic action, is a programmatic consultation (50 CFR 402.02).

The aerially applied long-term fire retardant program is multifaceted. The primary objective of the program is to protect individuals and communities from threats caused by wildfires. Outside of the long-term fire retardant program, wildfires are managed by the USFS on Forest Service lands to allow them to burn in a natural mosaic pattern. When conditions threaten lives and property, the USFS will actively fight those fires and long-term fire retardants are one of the most effective tools at their disposal.

This action includes the decision-making process during firefighting operations, the factors that influence the decision of whether to use fire retardants, and operational guidance. The USFS has also established a list of mitigation measures and programs under section 7(a)(1) of the ESA to improve mitigation through time. As part of the long-term fire retardant program and an aspect of the 7(a)(1) program, the qualified products list is a constantly evolving list of approved long-term fire retardants to achieve the objectives of being continually more effective and less toxic. The success of fire retardant applications is monitored, along with any intrusions into streams and buffer zones. Finally, the program incorporates monitoring and reporting following each fire into annual coordination meetings and larger five-year program reviews.

3.1 Decision Making

There are several tiers at which decisions are made for managing wildfires and using fire retardants. At a fire management level, decisions about the use of fire retardants are made by personnel in charge of managing the wildfire attack. The management decisions for each fire are made in accordance with guidance from the USFS Washington Office, which is driven in part by annual monitoring and more substantially by 5-year reviews associated with this program.

3.1.1 Legal Authority

The legal authority under which the USFS fights wildfires using long-term fire retardants originates from the following laws and guides fire management activities for the protection of USFS lands and resources (FSM 5100 – Fire Management):

1. Organic Administration Act, June 4, 1897 (16 U.S.C. 551). This act authorizes the Secretary of Agriculture to make provisions for the protection of national forests against destruction by fire.

2. Bankhead-Jones Farm Tenant Act, July 22, 1937 (7 U.S.C. 1010, 1011). This act authorizes and directs the Secretary of Agriculture to develop a program of land conservation and land utilization to "assist in controlling soil erosion, reforestation, preserving natural resources, protecting fish and wildlife,…mitigating floods,…protecting the watersheds of navigable streams, and protecting the public lands…"

3. National Forest Management Act, October 22, 1976 (16 U.S.C. 1600 *et seq.*). This act directs the Secretary of Agriculture to specify guidelines for land management plans to ensure protection of forest resources. Regulations at Title 36, Part 19 of the Code of Federal Regulations (36 CFR 219.27) specify that, consistent with the relative resource values involved, management prescriptions in forest plans must minimize serious or long-lasting hazards from wildfire.

4. Granger-Thye Act, April 24, 1950 (16 U.S.C. 572). This act authorizes expenditure of US Department of Agriculture and USFS funds to erect buildings, lookout towers, and other federal structures on land owned by states. It provides for the procurement and operation of aerial facilities and services for the protection and management of the national forests and other lands administered by the USFS.

The USFS also has a variety of authorities that provide for cooperation with other federal land managers on all aspects of wildland fire management and some non-fire emergencies, and engagement in fire suppression actions on state, local and private lands. Pursuant to Title 41, US Code, section 1856b and agency regulations (36 CFR 211.5), the USFS, in the absence of a written reciprocal agreement with a fire organization, is permitted to render emergency assistance in suppressing wildland fires and in preserving life and property from the threat of fire within the vicinity of the agency's fire protection facilities. Assistance may be offered without reimbursement if an USFS-initiated prescribed fire escapes onto non-USFS lands; and assistance may be offered on a reimbursable basis when requested, without regard to the threat to the National Forest System (NFS) lands or resources (FSM 5132).

These policies, as well as several guidance documents on fire management that govern the USFS use of fire retardants, recognize that fires do not respect jurisdictional boundaries and that cooperative operations are necessary to respond to a wide range of emergencies. According to the wildland fire management decision process outlined in the Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy, federal wildland decisions are affected by planning direction that guides decisions, actions that are planned to occur given an ignition, and actions that are based upon the situation that exists at the time (DOA & DOI 2003). The Interagency Policy emphasizes developing quality plans to facilitate effective decision making in operational activities. In particular, the Policy emphasizes the role of the Land/Resource Management Plans and Fire Management Plans to articulate strategies and objectives for implementation of prescribed burns, appropriate Management Responses for wildland fires, including conducting situation analyses, and follow-up reviews (DOA & DOI 2003). The implementation strategy requires that "wildland fire management plans and

procedures be tied to approved Land/Resource Management Plans and that on-going evaluation is part of an iterative, improved policy." For all areas subject to wildland fires, a Fire Management Plan must be developed in compliance with the *Guidance for Implementation of Federal Wildland Fire Management Policy* (2008). The purpose of the Fire Management Plan is to formally document operational parameters for the fire manager but it does not prescribe decisions (DOA & DOI 2003). Among other things, Fire Management Plans incorporate firefighter and public safety, and environmental considerations.

The decision where and when to use fire retardant is left to the discretion of the Incident Commander (IC), Forest Supervisors, District Rangers and other USFS field personnel (FSM 5100), and is informed by policy and guidance set by the Washington Office, as well as the Regional Office. The decision to approve particular retardants as a Qualified Product and add them to the list, however, is made at the Washington Office of the USFS. Because of monitoring and research that began in 1980, the *Guidelines for Aerial Delivery of Retardant or Foam near Waterways* (2000 Guidelines) were established as interim guidelines in April 2000. These guidelines have been updated based on monitoring data collected between 2005 and 2020 to minimize the amount of fire retardant entering visible bodies of water. The most current *Implementation Guide for the Aerial Application of Fire Retardants* (Implementation Guide) is in the initiation package (USDA Forest Service 2020).

Depending on the topography, fuel amounts, fire behavior, flame lengths, and weather conditions, aerially applied fire retardants may be used in conjunction with ground support resources. Aviation use must be prioritized based on management objectives, conflicting urgency between IC needs, and the probability of successfully slowing a fire. To maximize effectiveness of fire retardant applications, direct or indirect attacks are made in front of or parallel to fires, respectively, depending on the fire's characteristics and speed. Indirect attack pre-treats fuels, which may be far removed from the main fire. Examples include safety zones, ridgelines, roads, or areas of light/sparse fuels. The use of aircraft (fixed and rotor wing) for the delivery of fire retardant is one of many methods used by fire managers. Retardant is delivered by airtankers, single engine airtankers (SEATS), and helicopters, and is an essential link in the overall suppression strategy. The main principle in the use of aerially delivered retardant is to use it early in sufficient quantity, dropped from an effective altitude with minimum time lapse between each drop.

Firefighters integrate fuel models and fuel descriptions to determine the appropriate retardant coverage level. Fuel models are classified into four fuel complex groups that include grasses, brush, timber litter, and slash (Anderson 1982). The fire behavior relates to the fuel loading expressed in tons/acre and the fuel bed depth which relates to the fuels' distribution among the fuel size classes. Anderson (1982) identified fuel load and depth as significant fuel properties for determining a fire's ignition, rate of spread, and intensity. Scott and Bergan (2005) further refined fuel models by including non-burnable fuel types (urban, ice, water, rock), and sub-

grouping the fuel complexes by adding moisture climatic condition classes to the fuel loading and distributions.

In the event that fire suppression decisions are deemed necessary, a Wildland Fire Decision Support System (WFDSS) is prepared. WFDSS is a decision support process that provides an analytical method for evaluating alternative suppression strategies that are defined by different goals and objectives, suppression costs, and impacts on the land management base. A WFDSS alternative describes a suppression strategy consistent with the "delegation of authority," (a set of instructions) communicated from a land unit administrator to an incoming IC. The "delegation" identifies what is important to protect, and may also establish cost targets. The FS 5100 Manual requires that the Agency Administrator ensures that a WFDSS is prepared during fires of sufficient severity that decisions associated with fire suppression must consider a range of objectives so that all decisions are documented.

When the USFS determines that a WFDSS is necessary, the Agency Administrator or designated staff prepare a preliminary WFDSS document. This document is reviewed and refined as necessary throughout the fire and includes concerns and constraints, such as the presence and locations of threatened or endangered species, designated critical habitat, and mapped avoidance areas (Section 3.6.2). It may also specify particular fire suppression tactics that can or cannot be used. A Resource Advisor (RA) is assigned to the fire and assists in the development of the WFDSS document. The RA also works with the IC and the Incident Management Team daily to provide information on all important resources that may be affected by the fire.

Prior to each fire season, as well as during firefighting operations, mapped avoidance areas are identified, discussed, and planned around to minimize potential exposure of sensitive resources to aerially applied fire retardants. An aerial retardant avoidance area (also referred to simply as 'avoidance area') is defined as an area in which application of aerial fire retardant is prohibited in order to avoid, limit, or mitigate potential impacts to specified resources. The term 'aquatic avoidance area' refers to any avoidance area, whether mapped or not, that is based on the presence of waterways, or as mapped to protect threatened or endangered species or critical habitat associated with waterways, waterbodies, or riparian areas. The Forest Service works cooperatively with NMFS and USFWS to annually update avoidance areas for listed species and designated critical habitat using population information in occupied sites.

3.2 Operational Guidance

The Implementation Guide (USDA Forest Service 2019) contains explicit guidance for ICs that is updated as a result of the annual review process (discussed below). This information is specific to the use of aircraft while fighting fires to ensure fire retardants do not enter mapped avoidance areas. However, the top priority with any use of aerially applied fire retardants discussed in this operational guidance is for pilots to avoid flying in a manner that endangers themselves, other aircraft, or personnel on the ground. Beyond that priority, the pilots are: 1) required to be provided maps and other information about the location of avoidance areas, 2) trained by

performing dry runs and through other methods to ensure retardant is not applied in avoidance areas, 3) provided detailed guidance on when and how to terminate and resume application of fire retardant when approaching and departing avoidance areas, and 4) given guidance on flight conditions for safe and effective use of retardant to avoid drift during application. There is additional operational guidance for sensitive species and cultural resources provided on a site-specific basis.

3.2.1 Retardant Storage and Use

Fire retardants are stored during the off-season (winter and early spring) in preparation for the upcoming fire season and purchased as needed prior to and during the season. Retardants are stored as a liquid concentrate or a dry concentrate at strategically located air bases throughout the country (Figure 1), generally within a few hours flight time from a number of national forests. These centrally located bases allow pilots to respond to requests for use of retardants quickly to fight fires in a number of different locations. Containment and wastewater treatment systems are required for retardant loading pits, mixing and pump areas, storage tanks, areas where retardant deliveries are received, and where loaded airtankers are staged for dispatch.

Fire retardants are mixed with water, diluting the concentrates, prior to loading on the airtanker. In addition to water, retardants contain retarding salts, corrosion inhibitors, thickeners, coloring agents, and performance ingredients. Some of these ingredients help prevent corrosion of the plane or base infrastructure, while others are added to increase effectiveness of the retardants at fighting fires. Airtankers are filled and launched as frequently as needed to respond to surrounding fires.

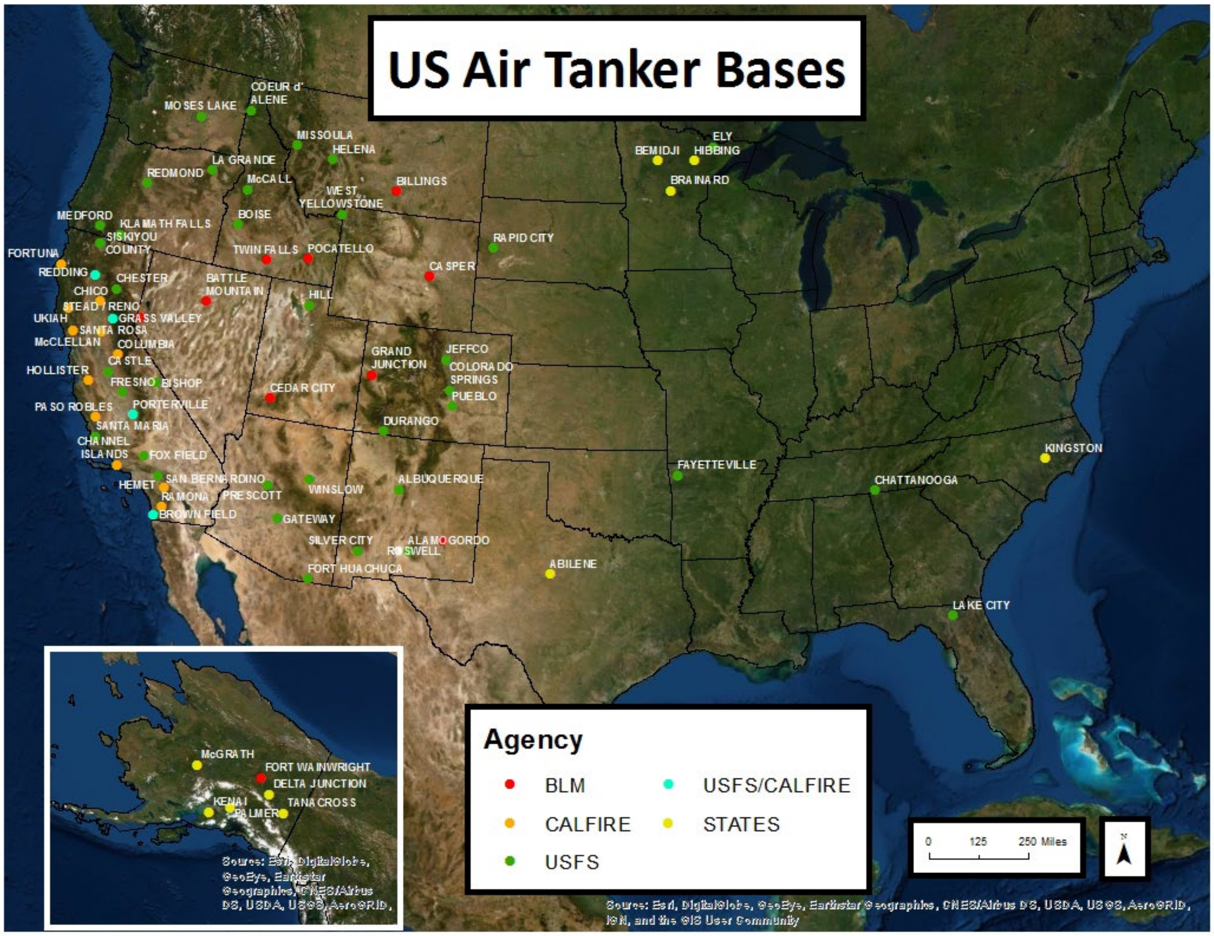

Figure 1. Air tanker bases with long-term fire retardants on site. Ownership of bases makes no difference, because during fire season, tankers are loaded with fire retardant and dispatched to the nearest application request.

Retardant is purchased from a national contract. The type of retardant a geographic region or national forest uses depends on their needs according, but not limited, to price, base location, staffing requirements, base infrastructure (is the base equipped to mix a liquid or a dry concentrate), and potential environmental concerns. ICs will request a load of fire retardant and the location of the application. Depending on the region and local policy, airtankers may either be filled and sit loaded prior to requests being received and wait for a dispatch, or an airtanker is requested and the airtanker is immediately loaded and dispatched. Any given airtanker base has the potential to serve multiple national forests as well as other jurisdictions, including state and other federal agencies. Generally, an incident will receive airtankers located closest to that incident, however, they may or may not be loaded from the nearest airtanker base. Many airtanker bases only have tankers available during periods of high activity. Airtankers are a national resource and are moved to different geographic locations or bases as needed. Furthermore, airtankers are sometimes diverted to a higher priority fire while en route to a

different fire. For these reasons, it's not logistically feasible to designate only one type of retardant to a particular forest. Therefore, this programmatic consultation will consider the effects of a maximum toxicity allowed for inclusion on the qualified products list (QPL) to assess likely effects to ESA-listed species and critical habitat in the action area even though the formulation used during a future intrusion could be less toxic.

3.2.2 Type and Purpose of Different Aircraft

As noted previously, retardant is delivered by medium/heavy airtankers, SEATS, and helicopters. The volume of retardant that can be carried and applied is directly related to the number of engines and the size of the aircraft. Medium/heavy airtankers can carry the most retardant while SEATS and helicopters carry the least.

Airtanker and helicopter types are distinguished by their retardant tank capacity (PMS 200 National Wildfire Coordinating Group Standards for Wildland Fire Resource Typing). Helicopters can deliver retardant either with a bucket or with a "fixed tank," referred to as a "helitanker." Supplying helicopters is the primary reason for setting up "portable retardant bases" (discussed below).

3.2.3 Mobile Retardant Bases

Retardant is normally stored and mixed at an airtanker base or, in some instances, on-site near a fire incident. When retardant is mixed at the incident site, a mobile retardant base (portable mixing system) is used. Water sources adjacent to portable air bases are typically municipal water supplies or a large lake or reservoir. Mobile retardant bases have a site spill containment plan, secondary containment systems, and set up at least 300 feet from any waterway, if water is present. When water withdrawal equipment is moved to different locations, the mobile bases must comply with the *Guide to Preventing Aquatic Invasive Species Transport by Wildland Fire Operations, PMS 444* (January 2017).

3.2.4 Application

Fire statistics have been maintained for many years and are a key factor in the distribution of airtankers and other aerial resources to be most accessible to fire-prone areas during the year. Potential weather events are taken into consideration, as well as fuel moisture indices and whether there are multiple geographic areas experiencing high fire activity. In evaluating fire statistics and fire history, the number of fires successfully controlled at the initial and extended attack stages averages 95 to 98 percent nationwide (USFS 2020a).

Most retardant delivery occurs on ridge tops and adjacent to human-made or natural firebreaks, such as roads, meadows, old fire scars, and rock outcrops. Occasionally, retardant is applied adjacent to aquatic environments that are being used as a natural firebreak. Applying retardant adjacent to these human-made or natural firebreaks enhances the effectiveness of firebreaks by widening them. This is especially important when applying adjacent to aquatic environments.

Fire retardants applied aerially must fall from the plane to their target area on the ground. Applications are made at roughly 280 to 370 kilometers (km) per hour, propelling the retardant forward as it is dropped and any wind force, as well as gravity, acts on the retardants as it falls. All of the different and sometimes competing forces that act on the dropped retardant can cause it to separate into smaller clumps, which eventually can cause the dropped retardant to move from its intended course. This process is called drift. The distance and volume of fire retardant that drifts depends on the height and speed of the aircraft at the time of the drop, wind direction, and wind speed. Fire retardants include a thickening agent that raises the viscosity and creates larger and more cohesive droplets to reduce drift (USDA Forest Service 2019). There are guidelines for the use of aircraft during suppression activities to ensure that operations can be conducted in a safe and effective manner (NWCG Standards for Aerial Supervision NFES 002544, February 2020). These include suspending flights during poor visibility and when wind conditions would result in unsafe or ineffective operations.

3.3 Qualified Products List

Private companies submit retardants to the USFS for qualification. New products or new formulations of existing products must meet current USFS specifications for long-term retardant (US Department of Agriculture, Forest Service, Specification 5100-304 Long-term Retardant, Wildland Firefighting) to be included on the QPL.

This programmatic consultation covers all approved products as of December 1, 2021, and all potential new products with similar or lesser toxicity and effects pathways. Products will generally meet these criteria when the percentages of retardant salts, thickeners, coloring agents, and performance ingredients in the total mixed product are similar to those in products for which consultation has been completed or that are included in this consultation. The Services will be notified of additions to the QPL as they occur as part of this action.

For a product to be eligible to be included on the QPL, it must meet a two-pronged standard. The first is the amount of active ingredient is limited so as not to exceed certain amounts of chemicals applied per square foot. The second is the toxicity of the proposed formulation must have a median lethal concentration (LC_{50}) of no less than 200 milligrams per liter (mg/L) to aquatic organisms.

Retardants can be applied at different levels of thickness, depending on the fuel type and amount of retardant needed to slow the wildfire. The densest load of fire retardant used applies approximately 8 gallons per 100 square feet (gpc). Table 1 identifies the amount of active ingredient by retardant type at that 8 gpc rate. Fire retardants can be, and often are, applied at 2 to 4 gpc, meaning any intrusion at lower densities would deliver less retardant to the stream and be less toxic. The maximum allowable values of each chemical base would limit the toxicity of a retardant formulation to 200 mg/L, but all formulations on the current QPL that are evaluated in this opinion are much safer than that. The most toxic formulation included on the QPL, Phos-Chek LC-95A-R, has a mean lethal concentration of 386 mg/L.

Table 1. The anticipated amount of retardant chemicals for each retardant in pounds per square foot at 8gpc along with the calculated LC_{50} in mg/L from the QPL (Dated December 1, 2021).

Fire Retardant	LC_{50}	NH_3/ft^2	P_2O_5/ft^2	Mg/ft^2	Cl/ft^2
Phos-Chek LC-95A-R	386	0.0190	0.0602	--	--
Phos-Chek LC-95A-Fx	399	0.0191	0.0546	--	--
Phos-Chek LC-95-W	465	0.0191	0.0553	--	--
Phos-Chek MVP-Fx	2,024	0.0105	0.0399	--	--
Phos-Chek 259-Fx	860	0.0140	0.0406	--	--
Phos-Chek LCE20-Fx	983	0.0147	0.0415	--	--
Fortress FR-100	1,762	--	--	0.0185	0.0541
Maximum Allowable	200	0.02	0.07	0.02	0.06

With the exception of the Fortress product, each of the retardants identified in Table 1 meet the standards then used by the USFS to determine whether a product is eligible for the QPL that were analyzed under the 2011 fire retardant programmatic consultation. The assessment protocols for this biological opinion have changed slightly from the 2011 fire retardant programmatic consultation. The toxicity standard (LC_{50} value) analyzed in 2011 was 100 mg/L, though due to improvements in fire retardant safety, that standard has been increased to 200 mg/L and through the USFS section 7(a)(1) program, is expected to continue to become less toxic. The USFS maintains a list of unacceptable ingredients, which have been shown to increase toxicity under certain conditions. The BA (USDA Forest Service 2020) added ammonium sulfate to the unacceptable ingredients list. Items on the unacceptable ingredients list will not be authorized for use by the USFS and thus will not be subject to future consultations with NMFS.

Products or new formulations that do not meet the above criteria will require a separate consultation after which they could be included within the framework of this programmatic consultation. However, new retardants that rely on the same base chemicals but are less toxic can be added to the QPL as explained in section 3.4.3 of this programmatic biological opinion. Once the risks to ESA resources from the use and potential exposure to any new retardant chemicals has been assessed and found to have similar or lesser effects than those considered herein, they will be eligible for inclusion on the QPL.

Various combinations of di-ammonium phosphate, mono-ammonium phosphate, ammonium polyphosphate (11-37-0), or magnesium chloride retardant salts can be added to the QPL under this programmatic consultation. In addition to salts, retardants may include thickeners, coloring agents, and performance ingredients (corrosion inhibitors, stabilizers, anti-caking agents, flow conditioners, etc.).

Fire retardant composition is described by percent of ingredient in the mixed product. Composition of retardant salts has ranged from nine to 20 percent of mixed products. Mono-

ammonium phosphate and di-ammonium phosphate salts are commonly combined in the same product. Di-ammonium polyphosphate and ammonium polyphosphate are used individually. The amount (percent) of thickener in the mixed product ranges from 0.2 to 0.8 percent. Types of thickener and percent of total mixed product in previously approved products include guar (0.4 to 0.8 percent), xanthan (0.2 to 0.7 percent) and clay (0.3 to 0.5 percent). Coloring agents range from 0.1 to 0.3 percent of the total mixed product and include iron oxide, or fugitive (fading) colorant. Performance ingredients have comprised 0.1 to 0.8 percent of the mixed products.

The USFS proposes that the maximum concentrations of ammonia, phosphate, magnesium, or chloride, when delivered at 8 gallons per 100 square feet and displayed in Table 1 (last row), be used to establish the upper limit of retardant salts that can be included in newly developed retardants without the need for reinitiation of consultation. Additionally, the USFS is proposing upper limits for thickeners, coloring agents, and performance ingredients that were not considered in 2011. Thickeners cannot exceed 1% of the formulation, colorant cannot exceed 0.5% of the formulation, and performance ingredients cannot exceed 1.5% of the formulation. Upper limit values reflect small increases in constituent levels compared to existing values to allow for minor modifications in formulations, as needed by the manufacturer, without the need to reinitiate consultation. For any new formulation considered under this programmatic action, the toxicity levels must not exceed those of currently approved products. In addition, the maximum extent and duration of effects from new products cannot exceed the effects of products considered in this opinion in order to be approved without reinitiation.

3.4 Monitoring and Reporting

Since 2012, the USFS has provided a yearly summary of retardant use and reports of retardant intrusions into avoidance areas to the Services. The USFS has compiled data on aerial retardant use and fires from 2012 to 2019 (USDA Forest Service 2020) and provided a summary of the data as part of the initiation package for this consultation.

Approximately 102 million gallons of retardant (approximately 56,868 drops) were aerially applied to NFS lands in the eight years from 2012 to 2019 (USDA Forest Service 2020). It is estimated that each year between 8,586 and 22,552 acres of NFS lands receive aerial applications of fire retardants, which is further broken down by national forest in our exposure analysis. Additionally, the likelihood of an intrusion is related to the type of aircraft used to apply fire retardants. While helicopters are more accurate, they cannot carry as large a load as airtankers, and therefore are used less frequently (Table 2).

Table 2. The proportional use of airtankers and helicopters each year since 2012.

Year	Airtanker Percent	Helicopter Percent
2012	83	17
2013	75	25
2014	82	18

2015	89	11
2016	84	16
2017	81	19
2018	98	2
2019	98	2

Ultimately, the actual number of applications is more complicated to calculate than the volume of fire retardant applied each year and on each forest. Large airtankers may make multiple applications using the same load of retardant. Reporting the volume of retardant used each fire season provides a useful approximation of the number of applications made, which has helped and will continue to help track the frequency of intrusions into waterways, and whether larger avoidance areas are more protective.

On larger incidents with incident management teams, resource advisors (READs) are assigned to provide support. One of their duties is to monitor the actual locations of aerial retardant use and report any intrusions into avoidance areas. On fires with no incident management team this duty falls to the local forest resource staff. Additionally, anytime a pilot or personnel on the ground suspect an aerial application of retardant may have intruded on avoidance areas or waterways, regardless of the size of the wildfire, then the area is monitored by USFS personnel. Any evidence of intrusions is included in annual monitoring reports.

The USFS is required to conduct monitoring within 30 days of the fire being contained (USDA Forest Service 2019), as long as it is safe to do so. The sooner after the fire, the more likely USFS personnel will identify any impacts resulting from intrusions. Intrusion reports must be filled out as soon as possible, but no later than 30 days after the fire is contained.

3.4.1 Intrusions

Evaluating intrusions begins with the first report to an IC. The report of an intrusion to the IC should be accompanied by a reporting form which is provided at https://www.fs.usda.gov/managing-land/fire/chemicals, or within the online Intrusion Reporting Tool.

Monitoring of streams suspected of experiencing an intrusion follows an explicit methodology. The intent is to identify the likely area affected, assess water quality, and reach a determination about the suspected effects of the intrusion. These efforts are led by a local resource specialist such as a forest biologist. The resource specialist will visit the affected area and assess the impacts. The specialist will fill out the Aquatic Site Assessment Form and/or the Terrestrial Site Assessment Form. These forms standardize reporting between forests. The resource specialist also assesses any impacts to listed species or their habitats, including critical habitat. The USFS has developed a “spill calculator” that identifies the estimated movement of retardant in the system after an intrusion, tracking chemical concentrations throughout the waterway to understand where adverse effects likely occurred (Rehmann et al. 2021).

If adverse effects to listed species or critical habitat are identified, the resource specialist should document those and report the effects to the Washington Office. The resource specialist is also responsible for contacting other USFS units within the affected species' geographic range to ensure other forests are aware of the effects and how that affects the amount of exempted incidental take that has already occurred. If the amount of exempted take has been exceeded, the USFS should begin consultation with NMFS.

3.4.2 Annual Reports

The USFS compiles all intrusion reports into an end-of-year report. This report summarizes every intrusion into avoidance zones, as well as all intrusions that likely affected listed species or critical habitat. For intrusions into water or where runoff is suspected of entering waterways, these reports include a statement of the extent of effects. These annual reports are the foundation for the annual interagency coordination discussed in the next section (3.5).

3.4.3 Regional Species-Specific or Site-Specific Consultations

There are several mechanisms through which future site-specific consultations can be conducted under the framework of this programmatic consultation. Most common will be to include future long-term fire retardants on the QPL. In those cases, if the future chemicals are less toxic than what has been considered here, no consultation is necessary, however the USFS will provide information about the chemical to justify its inclusion within the framework of this programmatic consultation. It is also possible for future species-specific consultations to address new listed species or designated critical habitat within the framework of this programmatic consultation. And, as has happened before, it may be appropriate to conduct regional or site-specific consultations that will supersede the analyses for those regions or sites from that component of this national programmatic consultation.

3.5 Interagency Coordination

The most frequent interagency coordination occurs at the local level, when forest resource specialists work with biologists from the Services to coordinate before, during, and after fire season. These discussions are often part of larger planning meetings when a variety of proposed actions are considered to ensure all actions taken on NFS lands will be protective of listed species and their critical habitat.

As a requirement of the programmatic action, annual coordination meetings will be held in the middle of May at the national level. These meetings will focus on discussing and presenting the previous fire season and any intrusions that occurred. Participants in this meeting review the information from the previous fire season and discuss any changes to the protocols that may be appropriate. This could lead to changes to the Implementation Guide. Most often, if an unexpected number of intrusions occurred in a species' range, critical habitat, or national forest, then managers may elect to expand the size of avoidance zones. These decisions affect mapping and personnel training for the following year and must be made early enough to be implemented as fire seasons start in late May and June.

In addition to annual meetings, every five years, meetings are held to discuss the incidental take statement, incidences of incidental take over the previous five years, as detailed in the annual reports, and the statuses of the affected populations. As with annual reviews, the five-year reviews could result in modifications made to the Implementation Guide, avoidance zones, or other decisions made to manage the likelihood of incidental take.

The most important component of interagency coordination is a review of past actions to modify decision making in the future. This adaptive management process is the cornerstone of a functional aerial fire retardant program. Conservative modifications to the program can be made at any time but often occur as the result of annual and five-year meeting discussions. Any program modifications are identified in the Implementation Guide. Where possible, improvements in retardant formulations that lead to reduced toxicity will be reflected by changes to the QPL. For example, all but one retardant analyzed in the 2011 fire retardant programmatic biological opinion has been phased out. Modifications to the Implementation Guide occur regularly to include the appropriate guidance for each fire season. The Implementation Guide is nearly 100 pages long and covers nearly every aspect of aerial fire retardant attacks (USDA Forest Service 2019). For species conservation, the primary modification that can change each year is the size of the avoidance areas.

3.6 Fire Retardant Mitigation and Future ESA 7(a)(1) Program Objectives

Included in this action, the USFS has established mitigative measures to minimize the effects of the fire retardant program on ESA listed species and designated critical habitat. These measures are accompanied by a series of conservation programs with the objective of minimizing threats from the fire retardant program further through adaptive processes. These measures are: 1) mapping and guidance, 2) establishment of buffer zones, 3) provide funding for research on the effects of fire retardants on listed species and critical habitats, and 4) development and maintenance of a spill calculator to estimate the effects of fire retardant intrusions into streams.

3.6.1 Mapping and Guidance

The Implementation Guide is a 'one-stop' resource that provides forests and regions all of the information necessary to implement national direction for aerial fire retardant use as described in the *Nationwide Aerial Application of Fire Retardant on National Forest System Lands Record of Decision* (USDA Forest Service 2011). The guide provides direction for personnel, including pilots, fire management officers, ICs, resource advisors, and others involved in the use of aerial fire retardant. It details the requirements for reporting and monitoring at local and national levels, mapping avoidance areas, managing data, and coordinating and reinitiating consultation with regulatory agencies. It also describes requirements for funding of reporting and monitoring. The guide is updated as needed to include any changes required by supplemental consultations as required under section 7 of the ESA, as well as to address changes in technology, data, methodology, retardant products, or other items as appropriate.

Instruction for mapping of avoidance areas includes reminders to use the most up-to-date maps of designated critical habitat and species occurrence/habitat maps from the Services. Requirements for coordination meetings with local offices ensure that current species' information is used and that discussion of any proposed changes to buffer widths are discussed.

The Implementation Guide chapter for pilots includes direction that pilot certification should include training in the use of retardant guidelines, and that the pilots receive maps of avoidance areas and briefings on the USFS management unit in advance of retardant use. It also provides guidance about the use of "dry runs," i.e., making a pass over the target before returning for the actual application, to improve protection of avoidance areas, and about evaluation of flight conditions to ensure that safety is maintained and that retardant use guidance can be followed.

Fire operations guidance states that agency administrators will include in their delegations of authority direction and expectations for operations if the fire has the potential to include or already includes any avoidance areas. The initial incident management team briefing should address areas that have been identified as potential for high risk for public and fire fighter safety that fall within or overlap avoidance areas. The exception to apply retardant may be involved in these cases, so advance awareness of the potential safety risk(s), presence of avoidance areas, and potential need for use of the exception is critical. The guide also provides an example of documentation to provide when using the exception.

The chapter on reporting and monitoring states that intrusion reporting should occur as soon as possible after discovery, but not later than 30 days after drops have occurred. The required assessment and coordination with local Services' offices then determines what subsequent actions may occur. Water quality monitoring, where required, will be conducted to assess the extent of impacts and validate the estimates produced by the spill calculator.

The guide also provides information about annual tasks to be completed (by season), annual required training, and data reporting requirements. Specific guidance for pre-fire season requirements includes annual coordination meetings and pilot briefings, and training for fire management personnel and pilots. The guide includes direction for coordination and data reporting during the fire season, as well as guidance for completion and submission of summary reports of intrusions to the Services. Annual summary reports are generally to be submitted by April 1 of each year, and will include information on retardant use, reported intrusion rate, and a list of intrusions, by forest, that impacted threatened or endangered species. A meeting between the USFS and the Services will occur by May 15 of each year to discuss the summary reports, any changes in the program, or concerns of the agencies.

As identified in the Implementation Guide (USDA Forest Service 2019), guidance to pilots is a priority to ensure fire retardants are applied where they will be most effective and to avoid listed species and designated critical habitat. The Implementation Guide is a living document that is periodically revised based on findings from monitoring of fire seasons as new best practices are

identified. At the start of each fire season, all personnel involved in firefighting are provided with a copy of the Implementation Guide.

Avoidance areas are mapped prior to each fire season. Each year, USFS will continue to update their avoidance area maps prior to the fire season. They will provide two data layers, a hydrologic avoidance area layer and a species avoidance area layer. These layers would then be combined to develop avoidance area maps. In 2019, a summary of the percent of total NFS lands in perennial stream avoidance areas, intermittent stream avoidance areas, and threatened, endangered, proposed, candidate and sensitive species avoidance areas was completed. In total, 20 percent of NFS lands are currently included in avoidance areas. Of that, approximately 10.1 percent are perennial stream avoidance areas, 7.9 percent are intermittent stream avoidance areas, and 3.5 percent are terrestrial species avoidance areas. The individual percentages do not total to 100 percent because of overlap in the categories.

3.6.2 Avoidance Areas

The USFS established avoidance areas as protective mitigation to minimize the likelihood of intrusions in 2007 and continued them as a mitigation measure in the 2011 programmatic action. This action will require a 300-foot buffer around all streams and if some populations seem to be affected to a greater extent than others, then the USFS, voluntarily under their section 7(a)(1) program, or as part of continued annual coordination, could expand the buffers around those populations to 600 feet.

Aerial retardant drops are prohibited in aerial retardant avoidance areas, except where human life or public safety are threatened and retardant use in the aerial retardant avoidance area could be reasonably expected to alleviate the fire threat. Avoidance areas are established around waterways or their buffers, whether mapped or not, when water is present. These are aquatic avoidance areas. Avoidance areas are also established around all or part of the habitat of ESA threatened, endangered, proposed, or candidate species, or Regional Forester sensitive species, as mapped prior to fire season.

The definition of ‘aerial retardant avoidance area’ has been updated since 2011 to clarify its purpose and ensure consistency in use. An aerial retardant avoidance area is defined as an area in which application of aerial fire retardant is prohibited in order to avoid, limit, or mitigate potential impacts to specified resources. When an intrusion occurs for any reason, it would be reported, assessed for impacts, monitored, and remediated as necessary.

The USFS continues to explore and use technology to increase the precision and accuracy of retardant drops to reduce the exposure to fish. During the past eight years, USFS has electronically mapped avoidance areas in all national forests with NMFS ESA-listed species and designated critical habitat present. These maps are geo-referenced, allowing an interface with digital platforms, for use in reporting and monitoring, and use with applications on small electronic devices such as tablet computers. Maps are updated annually as needed. Some aircraft

now carry electronic devices that display electronic versions of the maps. All tanker bases have the most current maps for use by pilots.

3.6.3 Spill Calculator

The USFS has worked with the United States Geological Survey (USGS) to develop a model that calculates the distribution of retardant following an intrusion into water (Rehmann et al. 2021). Details about the model are contained in the peer-reviewed publication (Rehmann et al. 2021). The USFS Fire Retardant Misapplication Calculator was released in April of 2019. This tool is commonly referred to as the spill calculator and it replaced the previous spill calculator. It provides three results: (1) the load of tank mix delivered to the stream, (2) the probable affected reach length, and (3) the probable maximum exposure time over the specified toxicity value. The toxicity value is taken as 10 percent of the median lethal concentration for the specified retardant.

Using the area exposed to contaminant levels likely to elicit a response from ESA-listed fish (discussed in Section 7.2), it is possible to calculate the probable effects of the intrusion. The development of this tool has allowed for a more realistic estimate of effects caused by fire retardant intrusions. This is another tool that can be used in tandem with post-intrusion monitoring done by field personnel. There have been a number of iterations of this tool since its inception in 2011 and the USFS, in partnership with the USGS, will continue improving this calculator.

3.6.4 Continued Research on Fire Retardant Threats

The USFS has entered into an agreement with the USGS, Columbia Environmental Research Center, to conduct research regarding environmental impacts of firefighting chemicals. Results of multiple research studies are expected to be published over the next two years and beyond as new formulations need testing, new species are listed, or new critical habitats designated.

Research that has already been funded and carried out by the USGS on topics related to fire retardants includes:

- Determining the impacts of water temperature, pH, or presence of ash on dispersal of retardant in water;
- Studying the influence of the flow rate, water hardness, and application rate on pulsed exposure of rainbow trout to retardant chemicals;
- Studying the influence of the duration of exposure and application rate on toxicity to rainbow trout of a pulsed retardant exposure;
- Determining the 96-hour mortality to rainbow trout after a second pulsed retardant exposure;
- Studying the influence of substrate and duration of weathering on toxicity in a simulated runoff event;
- Determining the effects of ultraviolet (UV) exposure on chemical toxicity;

- Analyzing the toxicity of pulsed chemical exposure to *Ceriodaphnia* (an aquatic invertebrate); and
- Determining the concentration of chemicals lethal to rainbow trout at various times under 24-hours.

Additional studies, including repeating these studies on new retardant formulations, will occur as funds allow.

3.6.5 Reducing the Toxicity of Fire Retardant Products

The USFS maintains the QPL, a list of approved fire retardants that meet the criteria discussed in previous sections. When possible, the USFS is committed to transitioning to less toxic formulation.

In 2020, the USFS updated the specification for long-term retardant (US Department of Agriculture, Forest Service, Specification 5100-304 Long-term Retardant, Wildland Firefighting). The updated version of the retardant specification changed the allowable aquatic toxicity (Section 3.5.2.2) from a LC_{50} to rainbow trout of 100 milligrams per liter to 200 mg/L. In this case, a higher concentration of toxic chemical is a reduction in the toxicity of the chemical because it takes a higher dose of the chemical to kill 50% of the subjects. As advancements are made in the retardant industry, the USFS will consider improving the aquatic toxicity threshold in future revisions of the specifications.

4 Identification of Stressors and Action Area

The action can be broken into components. Each component of the action may produce stressors. Stressors are any physical, chemical, or biological alteration that may directly or indirectly induce a response in either an ESA-listed species or their designated critical habitat. Stressors that may result from the action are identified here. Further, to understand how the stressors are used to establish the action area for this program, as well in the exposure analysis of this opinion, we identify the timing, location, magnitude, duration, and frequency with which the stressors may be produced.

4.1 Components of the Action

Aerial use of long-term fire retardants can generate a number of stressors for listed species and their critical habitat. The aspects of this program that could produce stressors are the purchase and storage of chemicals at air bases, the operation of mobile response locations, and the aerial application of long-term fire retardants. Further, as these stressors elicit direct responses to species near intrusions, any mortality would affect food availability for species that require those resources. Some stressors may be produced by several different components of the action. Because the exposure to these stressors may occur in different locations, it is important to identify the same stressors caused by multiple action components.

4.1.1 Air Bases

Air bases are essentially staging areas for the fleet of fire-fighting aircraft and retardant chemicals. The USFS responds to fires in the order requests are received and priority of the incident. During the peak of fire season, a single air base may have planes responding to multiple fires regardless of direction from the fire. A series of airbases provides overlapping coverage of national forest land across the US. Airports house fuel needed to fly the responding aircraft and fire retardants to attack wildfires. Fuel for the planes on each base is the same, but the types of retardant housed at each base can differ. Because of this, there is a risk that fuel and retardant spills at air bases could reach nearby waterbodies.

A number of mitigation measures have been implemented to ensure any spills are contained. Containment and water treatment systems are required for retardant loading pits, mixing and pump areas, storage tanks, areas where retardant deliveries are received, and where loaded airtankers are staged for dispatch (USDA Forest Service 2020). Airports use municipal water for their water supplies.

4.1.2 Mobile Air Bases

In some cases, a mobile air base is appropriate. These situations occur in areas either too distant from established air bases or in remote locations attacking fires so large that shorter flight time between aerial applications is necessary. When retardant is mixed at the incident site, a mobile retardant base (portable mixing system) is used. The same risks exist at mobile air bases as established air bases. Fuel and retardant spills could occur in these remote areas. Additionally, water withdrawals are made to mix the retardant onsite, which could result in entrainment or impingement of aquatic species at the water intake. Finally, introducing the pump and pipe to a new waterbody could introduce non-native species.

As above, a number of mitigation measures have been established by the USFS for mobile air bases. Water sources are typically municipal water supplies or a large lake or reservoir. Pumping water for retardants requires a large, still body of water, which is not habitat for anadromous species. The contract USFS uses for mobile retardant bases requires contractors to have a site spill containment plan, secondary containment systems, and set up at least 300 feet from any waterway, if water is present. It also requires compliance with the *Guide to Preventing Aquatic Invasive Species Transport by Wildland Fire Operations, PMS 444* (January 2017, Guide).

4.1.3 Aerial Application of Fire Retardants

The application of aerially applied fire retardants poses the risk of an unintentional intrusion into waterbodies or riparian areas, which may eventually enter waterbodies through runoff. Intrusions can directly affect fish and their food resources by increasing chemicals and viscosity in the water to lethal levels. The distance intrusions may travel downstream depends on the volume of retardant that enters the stream; stream width, depth, and slope; pool frequency; and flow rates, as well as dilution from tributaries downstream of the intrusion.

The USFS, in collaboration with the USGS, developed a spill calculator to more precisely estimate the affected distance downstream from an intrusion given measurements of the relevant parameters, discussed in section 3.6.3. While the general effects of fire retardants and the chemicals that comprise the base of retardants are well-understood, NMFS and the USGS conducted a number of studies that assessed the effects of fire retardants on smolting salmonids, on brief exposures to high chemical concentrations, and on the movement of fire retardants in the stream environment (Deitrich et al. 2013,2014; Puglis 2017; Rehmann et al. 2021). This research has increased our understanding of both exposure and response of fish and habitat to intrusions over the last decade.

4.1.4 Lost Food Resources

The primary risk of fire retardants described above is the fire retardant chemicals entering riverine habitat. As discussed in this opinion, the most likely effects of fire retardant chemicals are to listed salmonids and other anadromous species. Aquatic invertebrates are an important food resource for juvenile salmonids and may be affected by exposure to fire retardants in water. In Puget Sound and Cook Inlet, salmonids provide a primary food resource for southern resident killer whales (SRKWs) and Cook Inlet beluga whales, respectively. Because of the stressors being considered for effects to salmonids, we also consider the effects of reduced food resources for these two populations of listed marine mammals.

4.2 Action Area

Action area means all areas affected directly or indirectly by the federal action and not merely the immediate area involved in the action (50 CFR 402.02). The action area for this action is all locations on and immediately downstream of NFS lands where anadromous fish are located (Figures 2 and 3). Furthermore, the action area extends into Puget Sound and Cook Inlet, where effects to food resources of ESA-listed species could be experienced (Figure 4). The national forests with NMFS-trust resources on or immediately downstream are the Bitterroot, Nez Perce-Clearwater, Boise, Payette, Salmon-Challis, Sawtooth, Cleveland, Eldorado, Klamath, Lassen, Los Padres, Mendocino, Plumas, Shasta-Trinity, Sierra, Six Rivers, Tahoe, Columbia River Gorge, Deschutes and Ochoco, Gifford Pinchot, Malheur, Mt. Hood, Mt. Baker-Snoqualmie, Olympia, Okanogan-Wenatchee, Rogue River-Siskiyou, Umatilla, Umpqua, Wallowa-Whitman, Willamette, Siuslaw, Francis Marion, Sumter, Croatan, and Ocala National Forests.

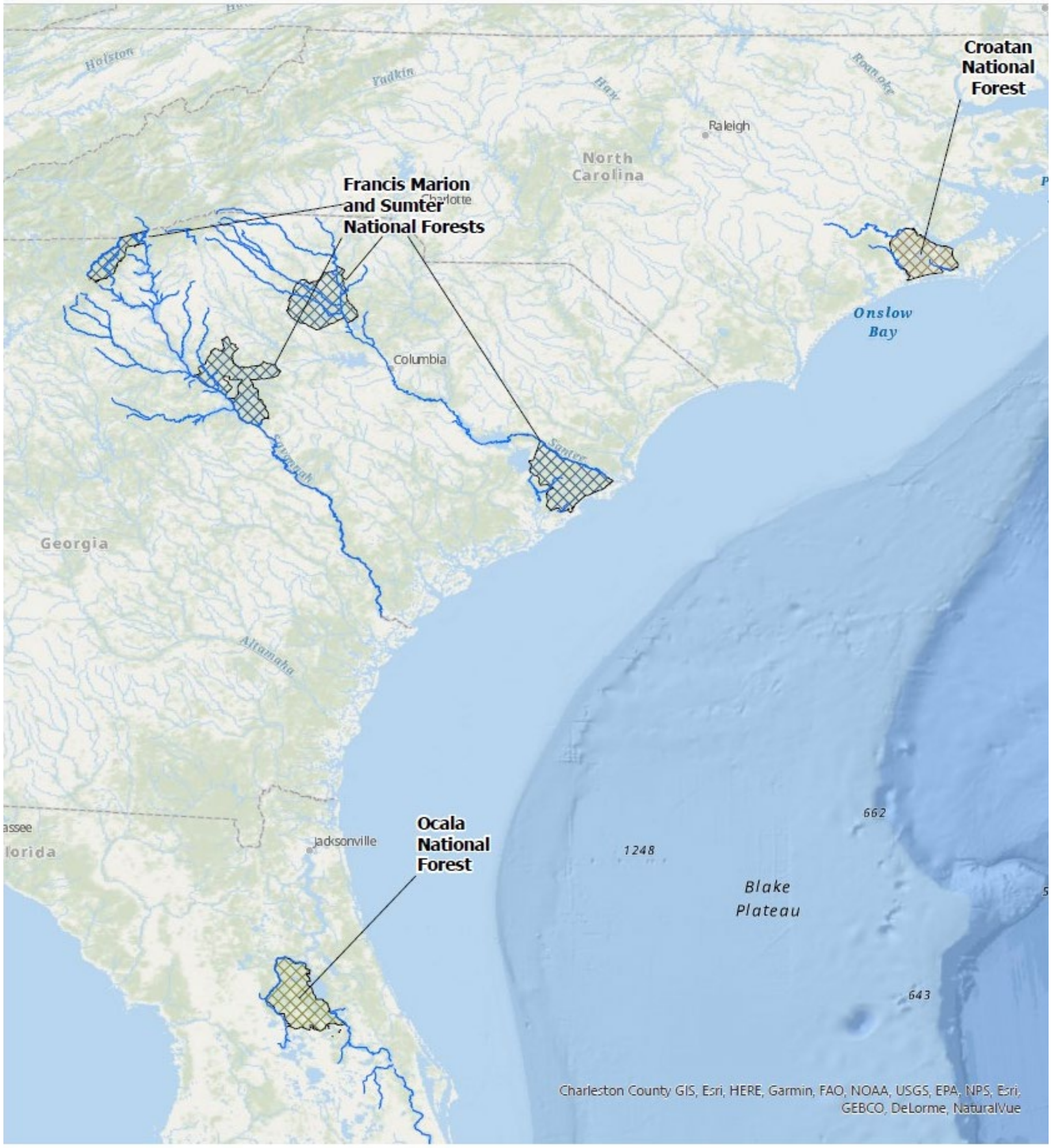

Figure 2. National forests adjacent to rivers with ESA-listed species on the East Coast of the United States.

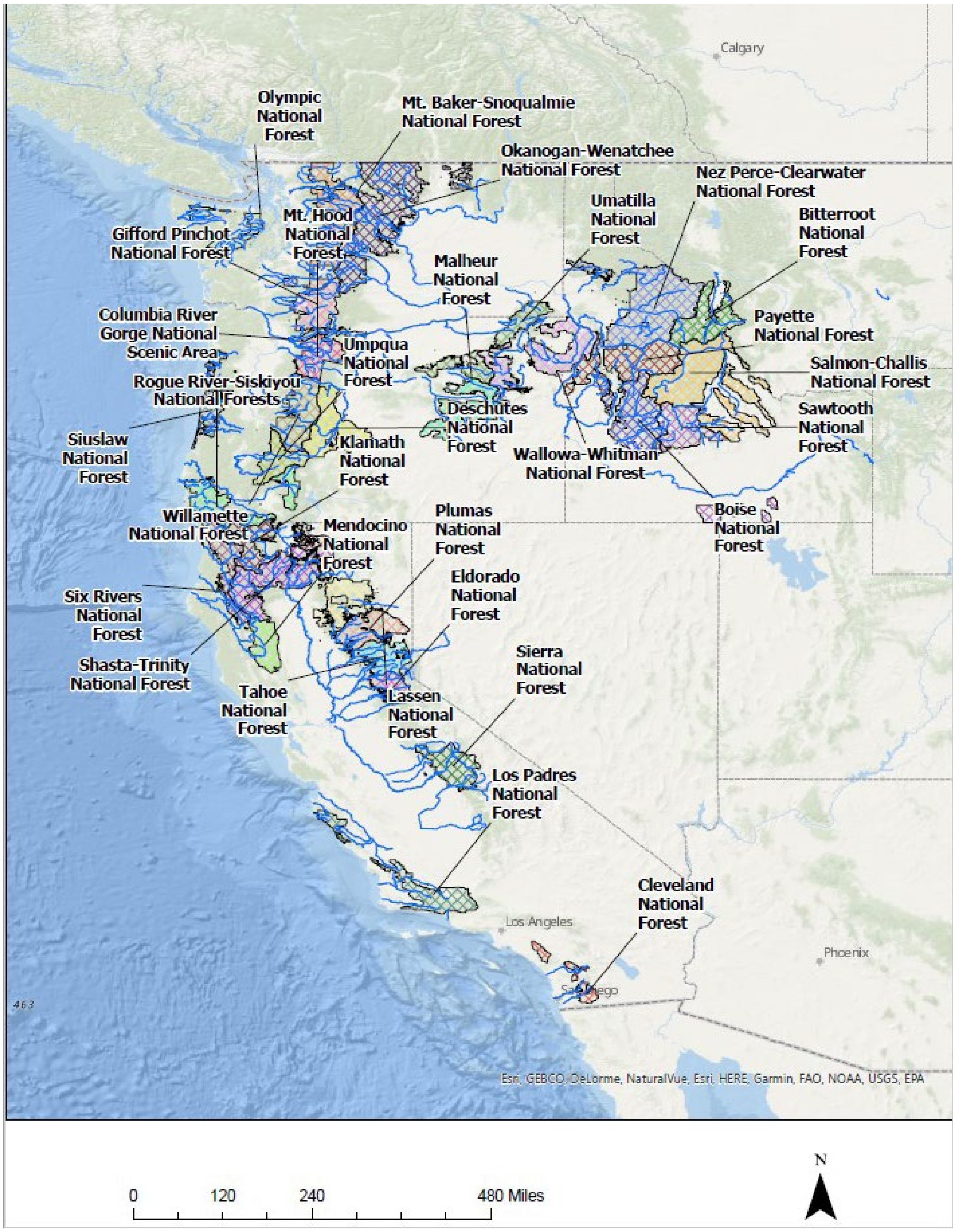

Figure 3. National forests adjacent to rivers with ESA-listed species on the West Coast of the United States.

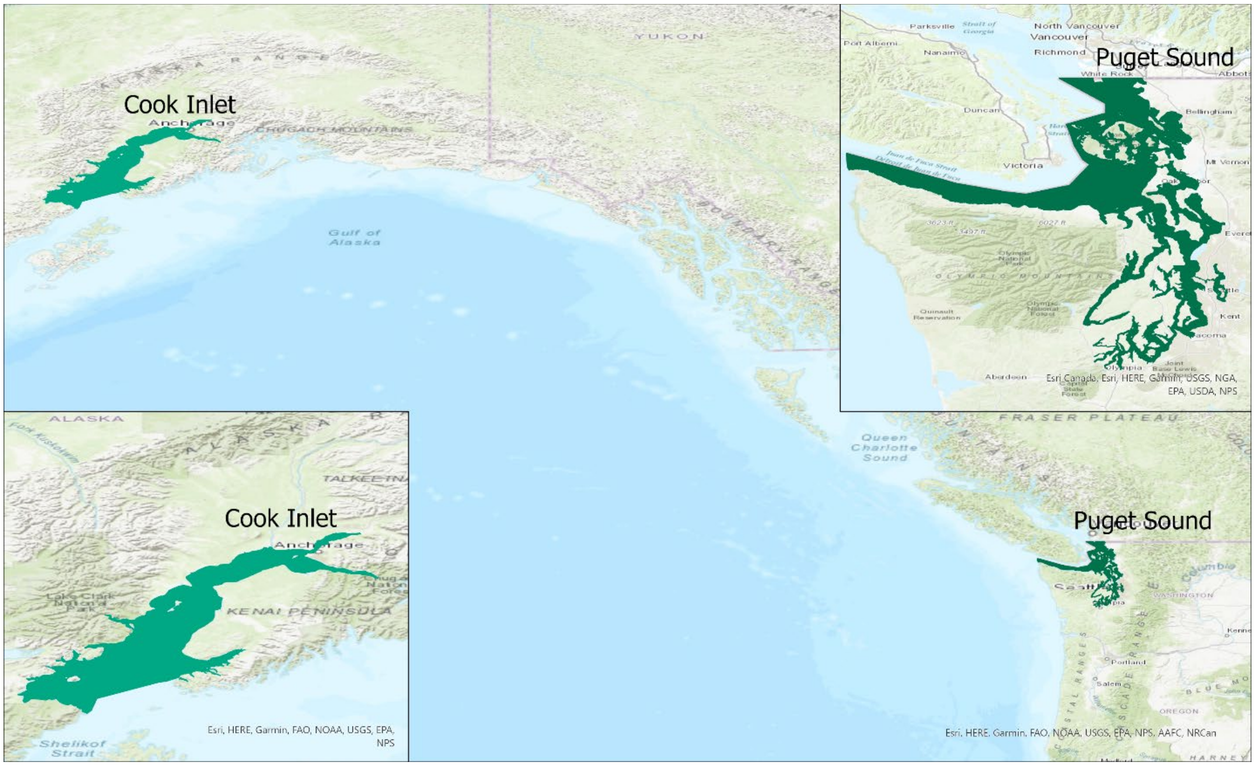

Figure 4. Puget Sound and Cook Inlet, which support ESA-listed species that require salmonids for their diets.

5 Species in the Action Area

This section identifies the ESA-listed species and designated critical habitat under NMFS jurisdiction that may occur within the action area and that may be affected by the proposed action (Table 3). Under the ESA, a distinct population segment (DPS) or evolutionarily significant unit (ESU) is a species. Within this section, we first identify the stressors (described in Section 4) that are not likely to adversely affect any species or critical habitats in the action area (Section 5.1). At the conclusion of that section, we will identify the stressors that will be the focus of all later analyses. The next step is to identify whether there are any species or critical habitat designations that are not likely to be adversely affected by the remaining stressors (Section 5.2). At the conclusion of that section, we will identify the status of the remaining species that will be the subject of the remainder of this biological opinion (Section 5.3).

Table 3. Endangered Species Act-listed threatened and endangered species and critical habitat overlapping in time and space with the action area, which, therefore, may be affected.

Species	ESA status	Critical Habitat	Recovery Plan
Killer Whale (*Orcinus orca*) – Southern Resident DPS	E – 70 FR 69903 Amendment 80 FR 7380	71 FR 69054 84 FR 99214 (proposed)	73 FR 4176 01/2008
Beluga whale (*Delphinapterus leucas*) – Cook Inlet DPS	E – 73 FR 62919	76 FR 20180	82 FR 1325

Chinook Salmon (*Oncorhynchus tshawytscha)* – California Coastal ESU	T – 70 FR 37160	70 FR 52488	81 FR 70666
Chinook Salmon (*O. tshawytscha)* – Central Valley Spring-Run ESU	T – 70 FR 37160	70 FR 52488	79 FR 42504
Chinook Salmon (*O. tshawytscha)* – Lower Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chinook Salmon (*O. tshawytscha*) – Snake River fall-run ESU	T – 70 FR 37160	58 FR 68543	80 FR 67386 (Draft)
Chinook Salmon (*O. tshawytscha*) – Snake River spring/summer run ESU	T – 70 FR 37160	64 FR 57399	81 FR 74770 (Draft) 11-2017-Final
Chinook Salmon (*O. tshawytscha*) – Sacramento Winter run ESU	E – 70 FR 37160	58 FR 33212	79 FR 42504
Chinook Salmon (*O. tshawytscha*) – Puget Sound ESU	T – 79 FR 20802	70 FR 52629	1/2007
Chinook Salmon (*O. tshawytscha*) – Upper Columbia River Spring Run ESU	E – 70 FR 37160	70 FR 52629	72 FR 57303
Chinook Salmon (*O. tshawytscha*) – Upper Willamette ESU	T – 70 FR 37160	70 FR 52629	76 FR 52317
Chum salmon (O. keta) – Columbia River ESU	T – 70 FR 37160	70 FR 52629	78 FR 41911
Chum salmon (*O. keta*) – Hood Canal summer-run ESU	T – 70 FR 37160	70 FR 52630	11/2005
Coho Salmon (*O. kisutch*) – Lower Columbia River ESU	T – 70 FR 37160	81 FR 9251	78 FR 41911
Coho Salmon (*O. kisutch*) – Southern Oregon/Northern California Coast ESU	T – 70 FR 37160	64 FR 24049	79 FR 58750
Coho Salmon (*O. kisutch*) – Oregon Coast ESU	T – 73 FR 7816	73 FR 7816	81 FR 90780
Sockeye Salmon (*O. nerka*) – Snake River ESU	E – 70 FR 37160	58 FR 68543	80 FR 32365
Sockeye Salmon (*O. nerka*) – Ozette Lake ESU	T – 79 FR 20802	70 FR 52629	5/2009
Steelhead Trout (*O. mykiss*) – California Central Valley DPS	T – 71 FR 834	70 FR 52487	79 FR 42504
Steelhead Trout (*O. mykiss*) – Lower Columbia River DPS	T – 71 FR 834	70 FR 52629	78 FR 41911

Steelhead Trout (*O. mykiss*) – Middle Columbia River DPS	T – 71 FR 834	70 FR 52629	74 FR 50165
Steelhead Trout (*O. mykiss*) – Snake River DPS	T – 71 FR 834	70 FR 52629	81 FR 74770 (draft) 11-2017 (final)
Steelhead Trout (*O. mykiss*) – Northern California DPS	T – 71 FR 834	70 FR 52487	81 FR 70666
Steelhead Trout (*O. mykiss*) – Upper Columbia River DPS	T – 71 FR 834	70 FR 52629	72 FR 57303
Steelhead Trout (*O. mykiss*) – South Central California Coast DPS	T – 71 FR 834	70 FR 52487	78 FR 77430
Steelhead Trout (*O. mykiss*) – Southern California DPS	E – 71 FR 834	70 FR 52487	77 FR 1669
Steelhead Trout (*O. mykiss*) – Upper Willamette DPS	T – 71 FR 834	70 FR 52629	76 FR 52317
Steelhead trout (*O. mykiss*) – Puget Sound DPS	T – 79 FR 20802	81 FR 9252	12/2019
Pacific Eulachon (*Thaleichthys pacificus*) – Southern DPS	T – 75 FR 13012	76 FR 65323	9/2017
Green Sturgeon (*Acipenser medirostris*) – Southern DPS	T – 71 FR 17757	74 FR 52300	2010 (Outline) 8/2018 (final)
Shortnose Sturgeon (*A. brevirostrum*)	E – 32 FR 4001	NA	63 FR 69613
Atlantic Sturgeon (*A. oxyrinchus oxyrinchus*) – Chesapeake Bay DPS	E – 77 FR 5880	79 FR 42687	NA
Atlantic Sturgeon (*A. o. oxyrinchus*) – Carolina DPS	E – 77 FR 5914	79 FR 42687	NA
Atlantic Sturgeon (*A. o. oxyrinchus*) – South Atlantic DPS	E – 77 FR 5914	79 FR 42687	NA

5.1 Stressors Not Likely to Adversely Affect Any Species or Critical Habitat

In the previous section, we identified four components of the action with associated stressors. Here, we identify which of those stressors are not likely to adversely affect any species or critical habitat. This is typically because there are best management practices in place that reduce the likelihood of adverse effects to any listed species or critical habitat in the action area. Where a stressor may affect some but not all species or critical habitat, it is not included in this section.

Mobile air bases and traditional air bases both have the potential for stored fuel and retardant spills and the operation of water pumps could result in entrainment. The risks of oil spill and fire

retardant spills are both easily preventable and appropriate mitigation can be implemented to minimize the likelihood of effects to listed species. Permanent air bases have containment and water treatment systems for retardant loading pits, designated mixing and pump areas, storage tanks, areas where retardant deliveries are received, and areas where loaded airtankers are staged for dispatch. All of these mitigation measures make the likelihood of any waterbody being affected by fuel or fire retardant spills extremely unlikely and therefore discountable.

Mobile air bases vary based on the terrain of the fire. These could pose a greater risk in terms of accidental spills, but each has a site spill containment plan, secondary containment systems, and cannot be established within 300 feet of any waterway, if water is present. Therefore, the likelihood that any waterbody would be affected by spilled fuel or fire retardant is extremely unlikely and therefore discountable. Because both of these modes of exposure are discountable, neither fuel nor fire retardant spills are likely to adversely affect any ESA-listed species.

While permanent air bases use municipal water to mix fire retardants, mobile air bases sometimes must pump water from adjacent water sources. Pumping water for retardants requires a large, still body of water, which is not habitat for anadromous species. Typically, the USFS will establish a mobile base near a reservoir or high mountain lake. Because of the requirements for obtaining water for fighting fires, we consider it extremely unlikely that ESA-listed salmonid habitat will be used for pumping water. If a reservoir is used that has ESA-listed species or critical habitat, the USFS has established screening criteria in collaboration with NMFS to minimize the risk of impingement or entrainment (NMFS 1997). Impingement is when a small fish is sucked up against a water intake screen and entrainment is when the fish is small enough to be pulled through the screen and out of the environment. Pumping water is common in salmonid habitat and protective measures have been established as standard practices (NMFS 1997) that will be followed by the USFS. It is therefore extremely unlikely that pumping will be done in waters occupied by ESA-listed species, and if it is, the likelihood of impingement or entrainment occurring will be mitigated by appropriate screening. Because of this, it is extremely unlikely that any ESA-listed species will be in the area during pumping operations, making the likelihood of exposure discountable. However, if the USFS has no choice but to pump water from occupied habitat, the mitigation detailed above will make the likelihood of impingement or entrainment discountable.

The USFS considers an intrusion to be any fire retardant application that enters a buffer area, including water, because the mitigation for this program requires no retardant to be applied within 300 feet of a waterway. However, when considering the likelihood of exposure and response of listed species an intrusion into the buffer zone would have to be flushed into the water following that intrusion. To better understand the risk of run-off, the USFS funded risk assessments of the fire retardants on the QPL to assess the risk they pose to mammals, fish, invertebrates, and plants (Auxilio 2021a, b). This assessment assumed run-off was taking place, which depends on a heavy enough rain following an intrusion to flush the retardant into water.

While it is not possible for us to estimate the frequency of heavy rains following fire retardant applications, these risk assessments do show that the risk of a response from run-off of any of these chemicals is insignificant. Because run-off of these chemicals is not expected to produce a measurable response, we have determined that run-off of these fire retardant chemicals may effect, but is not likely to adversely affect listed species.

Critical habitat for sturgeon, Pacific eulachon, and the salmonids is found in freshwater areas that could be affected by run-off. For each of these species in these locations, spawning, rearing, and migratory habitat are identified as PBFs. Because run-off poses insignificant threats to individuals, we would expect those individuals who are not likely to be adversely affected to also continue using the critical habitat that is affected for spawning, rearing, and migration. Therefore, critical habitat for the sturgeon, Pacific eulachon, and Pacific salmonids found in freshwater locations in the action area may be affected, but are not likely to be adversely affected by run-off from fire retardant intrusions into buffers.

The activities and related stressors that have the potential to adversely affect some species are the aerial application of long-term fire retardants, including salmonid mortality resulting from the aerial application of long-term fire retardants that would limit food resources for threatened or endangered predatory species. These are the stressors that will be considered further in this opinion.

5.2 Species and Critical Habitat Not Likely to be Adversely Affected

In this section, the species and critical habitats that are not likely to be adversely affected by the remaining potential stressors caused by the proposed action are identified and removed from further consideration in this biological opinion.

The USFS determined in their BA that Gulf sturgeon, central California coast coho, and central California coast steelhead may be affected, but are not likely to be adversely affected by this mixed programmatic action. However, these three species are not within the action area as described in section 4.2. Because these species are not found within the action area, they are not considered further in this consultation.

Following a review of monitoring reports submitted since the completion of the 2011 aerially applied long-term fire retardant biological opinion, the Siuslaw, Olympic, or Mt. Baker-Snoqualmie National Forests did not receive any fire retardant applications over the past decade. These are all forests in coastal Oregon and Washington, in an environment that is temperate rainforest, usually exceeding 300 inches of rain a year. It is unlikely any fire retardant will be used in the immediate future. The species found exclusively within these national forests, and, therefore, in areas that have not received any fire retardant applications in the past decade of monitoring, are Puget Sound ESU Chinook Salmon, Puget Sound DPS steelhead, Ozette Lake sockeye salmon, and Hood Canal summer-run chum salmon. If any retardants were to be applied over the next ten years in these forests, it would be very infrequent, because it hasn’t happened at

all in the last 10 years. As discussed in Section 7.1, there is a 0.21% probability nationally of a fire retardant application reaching water. When applications rarely occur in a species' habitat, the probability of an intrusion is extremely low. Intrusion likelihoods increase as applications become more common. We conclude that Puget Sound ESU Chinook Salmon, Puget Sound DPS steelhead, Ozette Lake ESU sockeye salmon, and Hood Canal summer-run ESU chum salmon, as well as their critical habitat are not likely to be adversely affected by the aerially applied long-term fire retardant program's operation.

There are also national forests in Alaska that receive very little fire retardant use. There are no listed populations of salmon or steelhead on these national forests; however, Cook Inlet beluga whales rely on the non-listed salmonids as a prey resource. Cook Inlet beluga whales could be affected by a minimized food resource, and salmonid prey are a PBF of their critical habitat. The USFS has established buffers around all waterways, regardless of presence of listed species. Because fire retardant is rarely used in Alaska and buffers are required to protect non-listed salmonids, it is unlikely that fire retardant intrusions will occur in Alaska. While there is a plausible route of effects suggesting Cook Inlet beluga whales could be exposed to a more limited prey base, given the mitigation in place (buffers) and the amount of fire retardants applied in Alaska, the probability that Cook Inlet belugas will be exposed to limited prey availability is extremely unlikely and therefore discountable. Likewise, because the PBF of Cook Inlet beluga whale critical habitat relates to food resources, any effect to critical habitat is also discountable. As this is the only stressor to which Cook Inlet belugas would be exposed, we conclude Cook Inlet beluga whales and their critical habitat may be affected, but are not likely to be adversely affected by the program's operation.

5.3 Status of Species and Critical Habitat Likely to be Adversely Affected

This opinion examines the status of each species that would likely be adversely affected by the proposed action. The status is determined by the level of extinction risk that the listed species face, based on parameters considered in documents such as status reviews, recovery plans, and listing decisions. This informs the later analysis of the species' likelihood of both survival and recovery. The species status section also helps to inform the description of the species' "reproduction, numbers, or distribution" as described in 50 CFR 402.02. The biological opinion also examines the condition of designated critical habitat, evaluates the conservation value of the various components of the habitat (e.g., watersheds, ocean basins, and coastal and marine environments) that make up the designated area, and discusses the function of the essential PBFs that inform the conservation value of the habitat.

5.3.1 Chum Salmon, Columbia River ESU

Chum salmon have the widest natural geographic and spawning distribution of the Pacific salmonids. Chum salmon have been documented to spawn from Korea and the Japanese island of Honshu, east around the rim of the North Pacific Ocean to Monterey Bay, California. Historically, chum salmon were distributed throughout the coastal regions of western Canada

and the U.S. At present, major spawning populations occur as far south as Tillamook Bay on the northern Oregon coast. On March 25, 1999, NMFS listed the Columbia River ESU (Figure 5) of chum salmon as threatened. NMFS reaffirmed the status on June 28, 2005.

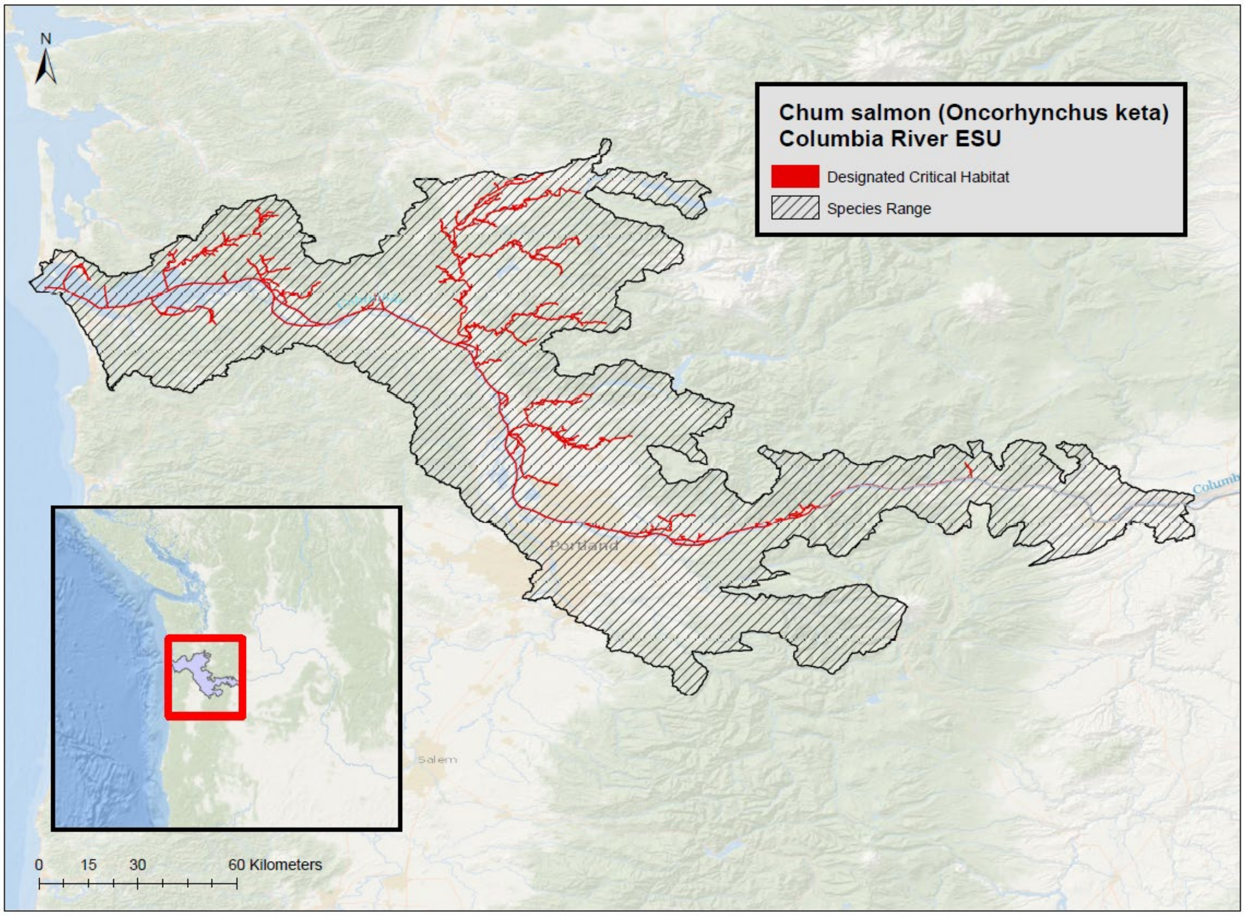

Figure 5. Chum salmon, Columbia River ESU range and designated critical habitat

5.3.1.1 Threats

The majority of the populations within the Columbia River chum salmon ESU are at high to very high risk, with very low abundances, leading to risks of extirpation due to demographic stochasticity and Allee effects (NWFSC 2015). Most of this species' habitat is downriver of national forest Lands. 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 2015). 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 (Johnson et al. 1997), but recent bycatch rates are below one percent (NWFSC 2015).

The Columbia River chum salmon ESU remains at a moderate to high risk of extinction (NWFSC 2015).

5.3.1.2 Life History

Chum salmon typically spawn in the lower reaches of rivers, with redds (gravel nests excavated by spawning females) usually dug in the mainstem or in side channels of rivers from just above the saltwater interface to 100 km from the sea. Juveniles out-migrate to seawater almost immediately after emerging from the gravel covered redds (Salo 1991).

5.3.1.3 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 2015). Ford (2011) concluded that 14 out of 17 chum populations in this ESU were either extirpated or nearly extirpated. The very low persistence probabilities or possible extirpations of most chum salmon populations are due to low abundance, productivity, spatial structure, and diversity. 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 2015).

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 (Table 4).

Table 4. Abundance estimates by life stage for Columbia River 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

5.3.1.4 Designated Critical Habitat

NMFS designated critical habitat for the Columbia River chum salmon ESU in 2005 (70 FR 52630). Sixteen of the 19 subbasins reviewed in NMFS' assessment of critical habitat for the CR chum salmon ESU were rated as having a high conservation value. The remaining three subbasins were given a medium conservation value. Washington's federal lands were rated as having high conservation value to the species. PBFs considered essential for the conservation of the Columbia River ESU of Chum salmon are shown in Table 5.

Table 5. Physical or biological features of critical habitats designated for ESA-listed salmon and steelhead species considered in the opinion (except SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, SONCC coho salmon, and Sacramento River winter-run Chinook salmon– see Table 15) and corresponding species life history events.

Physical or Biological Features Site Type	Physical or Biological Features Site Attribute	Species Life History Event
Freshwater spawning	Substrate Water quality Water quantity	Adult spawning Embryo incubation Alevin growth and development
Freshwater rearing	Floodplain connectivity Forage Natural cover Water quality Water quantity	Fry emergence from gravel Fry/parr/smolt growth and development
Freshwater migration	Free of artificial obstruction Natural cover Water quality Water quantity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Estuarine areas	Forage Free of artificial obstruction Natural cover Salinity Water quality Water quantity	Adult sexual maturation and "reverse smoltification" Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Nearshore marine areas	Forage Free of artificial obstruction Natural cover Water quantity Water quality	Adult growth and sexual maturation Adult spawning migration Nearshore juvenile rearing

The PBFs within critical habitat designated for Columbia River chum salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. Limited information exists on the quality of PBFs for Columbia River chum salmon. However, the migration PBF has been significantly impacted by dams obstructing adult migration and access to historic spawning locations. The water quality and cover for estuary and rearing PBFs have decreased in quality to the extent that the PBFs are not likely to maintain their intended function to conserve the species.

5.3.1.5 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 2013a). 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 2013a).

5.3.2 Chinook Salmon, California Coastal ESU

On September 16, 1999, NMFS listed the California Coastal (CC) ESU of Chinook salmon as a "threatened" species. On June 28, 2005, NMFS confirmed the listing of CC Chinook salmon as threatened under the ESA and also added seven artificially propagated populations from the hatcheries or programs to the listing. The CC 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).

5.3.2.1 Threats

The California Coastal Chinook salmon ESU (Figure 6) was historically comprised of 38 populations that included 32 fall-run populations and six spring-run populations across four Diversity Strata (Spence et al. 2008). All six of the spring-run populations were classified as functionally independent, but are considered extinct (Williams et al. 2011). Good et al. (2005) cited continued evidence of low population sizes relative to historical abundance, mixed trends in the few available time series of abundance indices available, low abundance, and extirpation of populations in the southern part of the ESU as significant threats to the survival of this species. In addition, the loss of the spring-run life history type throughout the entire ESU makes this species less diverse and more vulnerable to stochastic threats. The 2016 recovery plan (NMFS 2016a) 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.

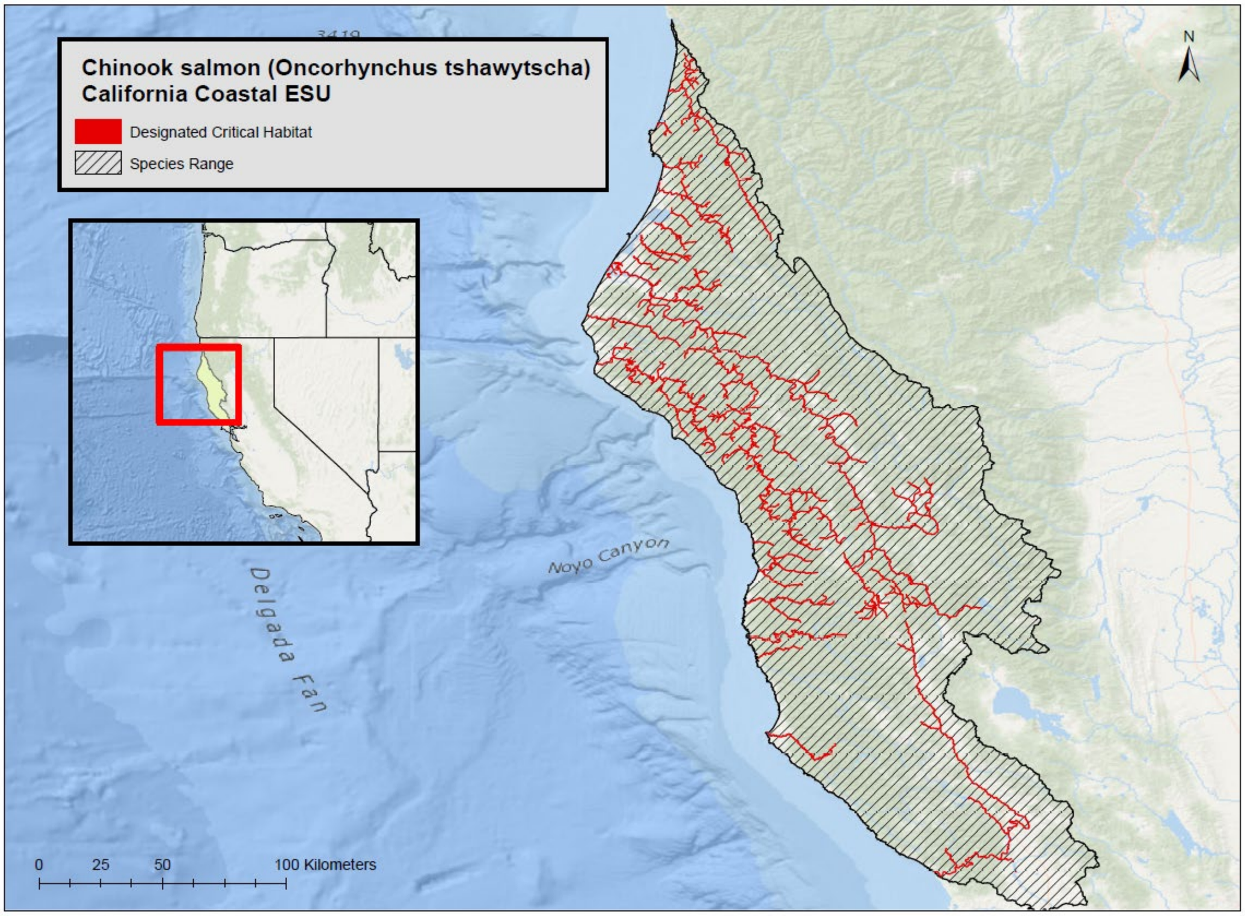

Figure 6. Chinook salmon, California coastal ESU range and designated critical habitat

5.3.2.2 Life History

California coastal Chinook salmon once displayed spring and fall runs, but due to extirpations are now a fall-run, ocean-type fish (Bjorkstedt et al. 2005). Adult returns of CC Chinook salmon depends on increased flow from fall storms, usually in November to January. Eggs will take approximately 40-60 days to hatch and up to another six weeks to emerge from the gravel as fry. Juveniles reside in freshwater for 12 to 16 months but some leave within eight months of hatching. Outmigration therefore can occur between November and June, which may be followed by an extended residency in an estuary before entering the ocean (Table 6).

Table 6. Temporal distribution of Chinook salmon, California coastal ESU.

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		Oct	Nov	Dec
Entering freshwater (adults/jacks)	Present									Present			
Spawning	Present											Present	
Incubation (eggs)	Present											Present	
Emergence (alevin to fry)		Present											
Rearing and migration (juveniles)	Present												

5.3.2.3 Population Dynamics

Comparison of historical and current abundance information indicates that independent populations are depressed in many basins (Good et al. 2005); only the Russian River currently has a run of any significance (Bjorkstedt et al. 2005). The 2000 to 2007 median observed (at Mirabel Dam) Russian River Chinook salmon run size is 2,991 with a maximum of 6,103 (2003) and a minimum of 1,125 (2008) adults (SCWA 2008).

The available data, a mixture of short-term (6-years or less) population estimates or expanded redd estimates and longer-term partial population estimates and spawner/redd indices, provide no indication that any of the independent populations 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).

5.3.2.4 Designated Critical Habitat

Designated critical habitat includes multiple CALWATER hydrological units north from Redwood Creek and south to Russian River. The total area of critical habitat includes 1,500 miles of stream habitat and about 25 square miles (mi^2) of estuarine habitat, mostly within Humboldt Bay. PBFs considered essential for the conservation of the California coastal ESU of Chinook salmon are shown in Table 5.

The PBFs within critical habitat designated for California Coastal ESU Chinook salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. There are 45 occupied California hydrologic subarea watersheds within the freshwater and estuarine range of this ESU. Eight watersheds received a low rating, 10 received a medium rating, and 27 received a high rating of conservation value to the ESU. Two estuarine habitat areas used for rearing and migration (Humboldt Bay and the Eel River Estuary) also received a high conservation value rating. Critical habitat in this ESU consists of limited quantity and quality summer and winter rearing habitat, as well as marginal spawning habitat. Compared to historical conditions, there are fewer pools, limited cover, and reduced habitat complexity. The current condition of PBFs of the California coastal Chinook salmon critical habitat indicates that the PBFs are not currently functioning or are degraded; their conditions are likely to maintain a low population abundance across the ESU.

5.3.2.5 Recovery Goals

Recovery goals, objectives and criteria for the California coastal ESU Chinook are outlined in the 2016 Recovery Plan (NMFS 2016a). Recovery plan objectives are to: 1. Reduce the present or threatened destruction, modification, or curtailment of habitat or range; 2. Ameliorate utilization for commercial, recreational, scientific, or educational purposes; 3. Abate disease and predation; 4. Establish the adequacy of existing regulatory mechanisms for protecting CC Chinook salmon now and into the future (i.e., post-delisting); 5. Address other natural or manmade factors affecting the continued existence of CC Chinook salmon; and 6. Ensure the status of CC Chinook salmon is at a low risk of extinction based on abundance, growth rate, spatial structure and diversity.

5.3.3 Chinook Salmon, Central Valley Spring-run ESU

On September 16, 1999, NMFS listed the Central Valley (CV) ESU of spring-run Chinook salmon as a “threatened” species. Historically, spring-run Chinook salmon occurred in the headwaters of all major river systems in the CV where natural barriers to migration were absent. The only known streams that currently support self-sustaining populations of non-hybridized spring-run Chinook salmon in the CV are Mill, Deer and Butte creeks. Each of these populations is small and isolated (NMFS 2014a).

5.3.3.1 Threats

The CV spring-run Chinook salmon ESU (Figure 7) 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 2014a).

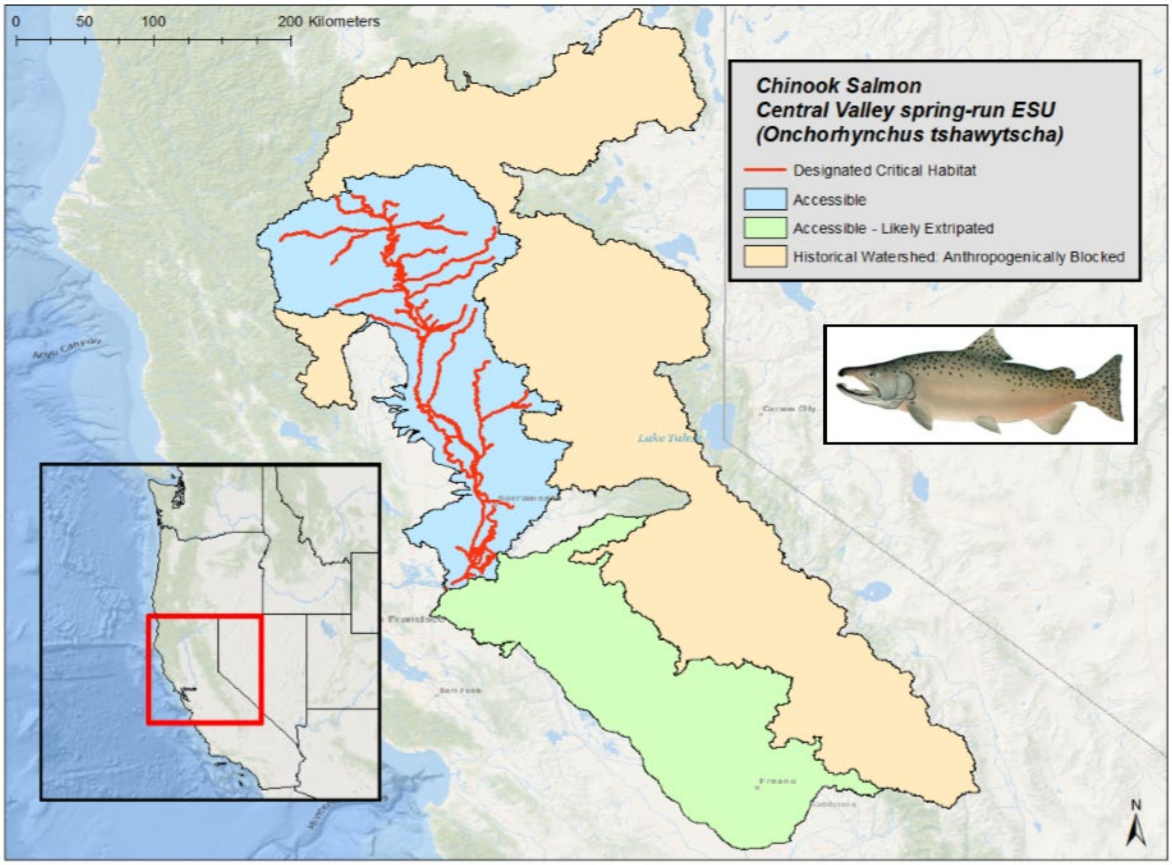

Figure 7. Chinook salmon, Central Valley spring-run ESU range and designated critical habitat

5.3.3.2 Life History

Adult CV 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 (Moyle 2002a; Yoshiyama et al. 1998). Spring-run Chinook salmon generally enter rivers as sexually immature fish and must remain in freshwater for 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 2002a). Eggs will take approximately 40-60 days to hatch and up to another six weeks to emerge from the gravel as fry. Juveniles reside in freshwater for 12 to 16 months but some leave within eight months of hatching. Outmigration therefore can occur between November and June, which may then be followed by an extended residency in an estuary before entering the ocean (Table 7).

Table 7. Temporal distribution of Chinook salmon, CV spring-run ESU.

<table>
<tr><td>Life History phase</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td></td><td></td><td colspan="5">Present</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Present</td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Present</td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.3.3 Population Dynamics

The CV 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. The only known streams that currently support self-sustaining populations of nonhybridized spring-run Chinook salmon in the CV are Mill, Deer and Butte creeks. Abundance and trend estimates for these streams as well as streams supporting dependent populations are provided in Table 8 (NMFS 2014a).

Table 8. Viability metrics for Central Valley spring-run ESU Chinook salmon populations.

Population	N	Ŝ	10-year trend (95% CI)	Recent Decline (%)
Antelope Creek	8.0	2.7	-0.375 (-0.706, -0.045)	87.8
Battle Creek	1,836	612	0.176 (0.033, 0.319)	9.0
Big Chico Creek	0.0	0.0	-0.358 (-0.880, 0.165)	60.7
Butte Creek	20,169	6,723	0.353 (-0.061, 0.768)	15.7
Clear Creek	822	274	0.010 (-0.311, 0.330)	63.3
Cottonwood Creek	4	1.3	-0.343 (-0.672, -0.013)	87.5
Deer Creek	2,272	757.3	-0.089 (-0.337, 0.159)	83.8
Feather River Fish Hatchery	10,808	3,602.7	0.082 (-0.015, 0.179)	17.1
Mill Creek	2,0910	697.0	-0.049 (-0.183, 0.086)	58.0
Sacramento River[a]	-	-	-	-
Yuba River	6,515	2,170.7	0.67 (-0.138, 0.272)	9.0

N: Total population size (N) is estimated as the sum of estimated run sizes over the most recent three years for Core 1 populations (bold) and Core 2 populations.
Ŝ: The mean population size (Ŝ) is the average of the estimated run sizes for the most recent 3 years (2012 to 2014).
Population growth/decline rate (10-year trend) is estimated from the slope of log-transformed estimated run size.
The catastrophic metric (recent decline) is the largest year-to-year decline in total population size (N) over the most recent 10 such ratios.

[a] *Beginning in 2009, estimates of spawning escapement of Upper Sacramento River spring chinook were no longer monitored.*

Cohort replacement rates (CRR) are indications of whether a cohort is replacing itself in the next generation. The majority of CV spring-run Chinook salmon are found to return as 3-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 CV 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.

Historically 18 or 19 historic independent populations of CV spring-run Chinook salmon existed. Additionally, a number of smaller dependent populations, that are distributed among four diversity groups (southern Cascades, northern Sierra, southern Sierra, and Coast Range), also existed (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, CV 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 the Mokelumne, Stanislaus, and Tuolumne Rivers.

5.3.3.4 Designated Critical Habitat

Designated critical habitat includes 1,853 km (1,158 miles) of streams and 655 km^2 (254 $miles^2$) of estuarine habitat. The PBFs considered essential for the conservation of the CV spring-run ESU of Chinook salmon are shown in Table 5.

The PBFs within critical habitat designated for CV spring-run ESU Chinook salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of the PBFs of the CV Spring-run Chinook salmon critical habitat indicates that the PBFs are not currently functioning or are degraded; their conditions are likely to maintain a low population abundance across the ESU. Spawning and rearing PBFs are degraded by high water temperature caused by the loss of access to historic spawning areas in the upper watersheds, which maintained cool and clean water throughout the summer. The rearing PBF is degraded by floodplain habitat being disconnected from the mainstem of larger rivers throughout the Sacramento River watershed, thereby reducing effective foraging. The migration PBF is degraded by a lack of natural cover along the migration corridors. Juvenile migration is obstructed by water diversions along Sacramento River and by two large state and federal water-export facilities in the Sacramento-San Joaquin Delta.

5.3.3.5 Recovery Goals

Recovery goals, objectives, and criteria for the CV spring-run ESU Chinook are fully outlined in the 2014 Recovery Plan (NMFS 2014a). The ESU delisting criteria for the spring-run Chinook are: 1) One population in the Northwestern California Diversity Group at low risk of extinction; 2) Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction; 3) Four populations in the Northern Sierra Diversity Group at low risk of extinction; 4) Two populations in the Southern Sierra Diversity Group at low risk of extinction; and 5) Maintain multiple populations at moderate risk of extinction.

5.3.4 Chinook Salmon, Lower Columbia River ESU

On March 24, 1999, NMFS listed the Lower Columbia River (LCR) ESU of Chinook salmon (Figure 8) as a "threatened" species. The listing was revisited and confirmed as "threatened" in 2005. The Lower Columbia River Chinook salmon ESU includes all naturally-spawned populations of fall-run and spring-run Chinook salmon from the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Oregon and Washington, east of the Hood River and the White Salmon River and any such fish originating from the Willamette River and its tributaries below Willamette Falls. Twenty artificial propagation programs are included in the ESU.

5.3.4.1 Threats

Low abundance, poor productivity, losses of spatial structure, and reduced diversity all contribute to the very low persistence probability for most LCR 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.

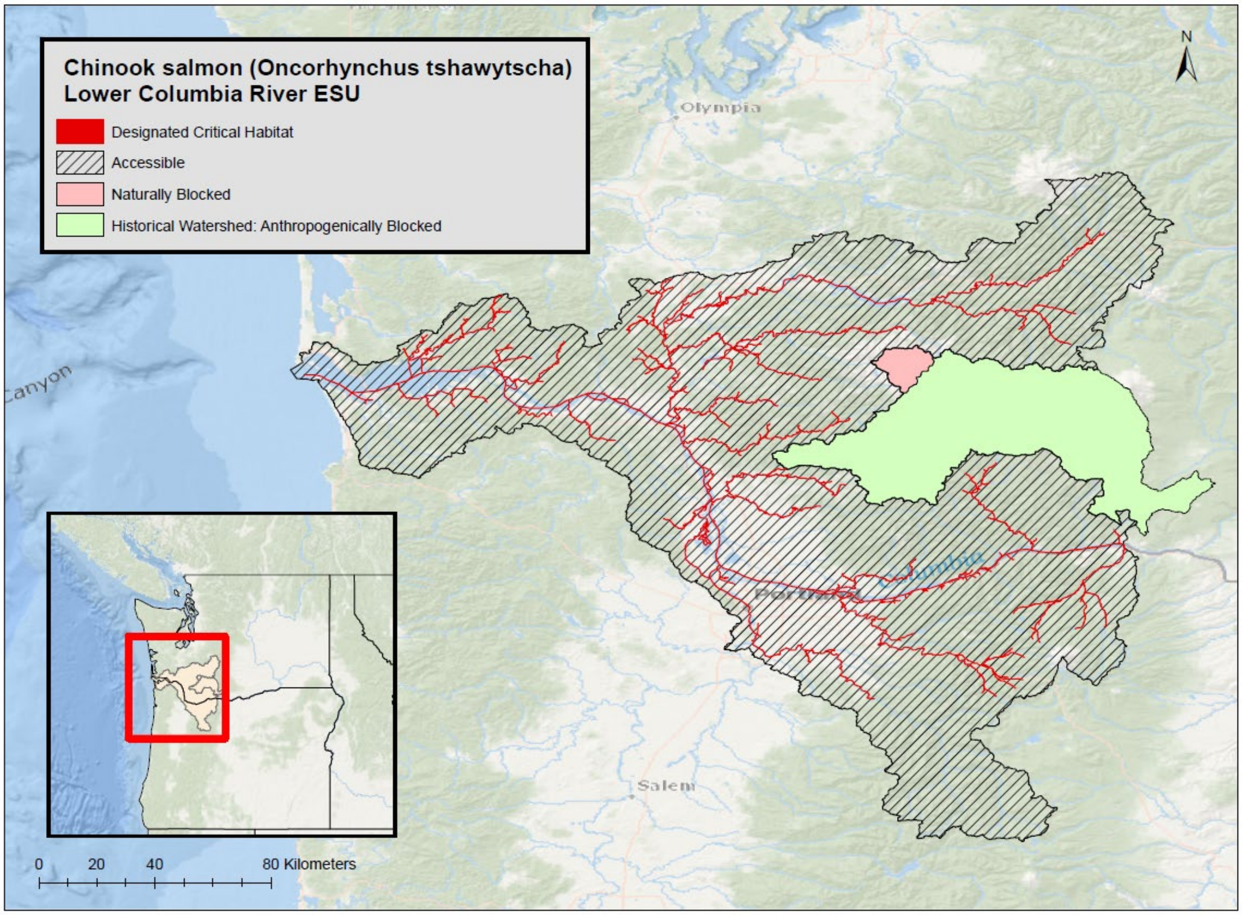

Figure 8. Chinook salmon, Lower Columbia River ESU range and designated critical habitat

5.3.4.2 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 fresh water 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 fresh water in March through June to spawn in upstream tributaries in August and September (Table 9).

Offspring of fall-run spawning may migrate as fry to the ocean soon after yolk absorption (*i.e.*, ocean-type), at 30–45 millimeter (mm) in length (Healey 1991). In the LCR system, however, the majority of fall-run Chinook salmon fry migrate either at 60-150 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 fresh water for their entire first year before emigrating. The spring-run Chinook salmon migrates to the sea as yearlings (stream-type) typically in spring.

However, the natural timing of LCR spring-run Chinook salmon emigration is obscured by hatchery releases (Myers et al. 2006).

Table 9. Temporal distribution of Chinook salmon, Lower Columbia River ESU.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td></td><td></td><td colspan="10">Present</td></tr>
<tr><td>Spawning</td><td>Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Present</td></tr>
<tr><td>Incubation (eggs)</td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td colspan="5">Present</td></tr>
<tr><td>Emergence (alevin to fry phases</td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.4.3 Population Dynamics

Populations of LCR 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 abundance (100 fish or fewer) and low probability of persistence over the next 100 years. Some of those are extirpated or nearly so. Five of the six strata fall significantly short of the recovery plan criteria for viability (Table 10). Total abundance by life stage is estimated in Table 11.

Table 10. Lower Columbia River Chinook salmon population structure, abundances, and hatchery contributions (Good et al. 2005; Myers et al. 2006).

Run	Population	Historical Abundance	Mean* Number of Spawners	Hatchery Abundance Contributions
F-R	Grays River (WA)	2,477	99	38%
	Elochoman River (WA)	Unknown	676	68%
	Mill, Abernathy, and German Creeks (WA)	Unknown	734	47%
	Youngs Bay (OR)	Unknown	Unknown	Unknown
	Big Creek (OR)	Unknown	Unknown	Unknown
	Clatskanie River (OR)	Unknown	50	Unknown
	Scappoose Creek (OR)	Unknown	Unknown	Unknown
F-R	Lower Cowlitz River (WA)	53,956	1,562	62%
	Upper Cowlitz River (WA)	Unknown	5,682	Unknown
	Coweeman River (WA)	4,971	274	0%
	Toutle River (WA)	25,392	Unknown	Unknown
	Salmon Creek and Lewis River (WA)	47,591	256	0%
	Washougal River (WA)	7,518	3,254	58%
	Kalama River (WA)	22,455	2,931	67%
	Clackamas River (OR)	Unknown	40	Unknown
	Sandy River (OR)	Unknown	183	Unknown
LF-R	Lewis R-North Fork (WA)	Unknown	7,841	13%
	Sandy River (OR)	Unknown	504	3%

Run	Population	Historical Abundance	Mean* Number of Spawners	Hatchery Abundance Contributions
S-R	Upper Cowlitz River (WA)	Unknown	Unknown	Unknown
	Tilton River (WA)	Unknown	Unknown	Unknown
	Cispus River (WA)	Unknown	1,787*	Unknown
	Toutle River (WA)	2,901	Unknown	Unknown
	Kalama River (WA)	4,178	98	Unknown
	Lewis River (WA)	Unknown	347	Unknown
	Sandy River (OR)	Unknown	3,085	3%
F-R	Upper Columbia Gorge (WA)	2,363	136	13%
	Big White Salmon R (WA)	Unknown	334	21%
	Lower Columbia Gorge (OR)	Unknown	Unknown	Unknown
	Hood River (OR)	Unknown	18	Unknown
S-R	Big White Salmon R (WA)	Unknown	334	21%
	Hood River (OR)	Unknown	18	Unknown

**Arithmetic mean*

Recent 5-year spawner abundance (up to 2001) and historic abundance over more than 20 years is given as a geometric mean, and include hatchery origin Chinook salmon.

F-R is fall run, LF-R is late fall run, and S-R is spring run Chinook salmon.

Table 11. Abundance estimates for the LCR 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 IntactAdipose	Adult	38,594
Listed Hatchery Adipose Clip	Juvenile	31,353,395

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. Trend indicators for most populations are negative. The majority of populations for which data are available have a long-term trend of less than one; indicating the population is in decline (Good et al. 2005). Only the late-fall run population in Lewis River has an abundance and population trend that may be considered viable (McElhany et al. 2007a). The Sandy River is the only stream system supporting a natural production of spring-run Chinook salmon of any amount. However, the population is at risk from low abundance and negative to low population growth rates (McElhany et al. 2007a).

5.3.4.4 Designated Critical Habitat

NMFS designated critical habitat for LCR ESU 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. The PBFs considered essential for the conservation of LCR ESU Chinook salmon are shown in Table 5.

The PBFs within critical habitat designated for LCR ESU Chinook salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. Timber harvest, agriculture, and urbanization have degraded spawning and rearing PBFs by reducing floodplain connectivity and water quality, and by removing natural cover in several rivers. Hydropower development projects have reduced the timing and magnitude of water flows, thereby altering the water quantity needed to form and maintain physical habitat conditions and support juvenile growth and mobility. Adult and juvenile migration PBFs are affected by several dams along the migration route.

5.3.4.5 Recovery Goals

NMFS has developed the following delisting criteria for the LCR Chinook salmon ESU. For a complete description of the ESU recovery goals, including complete down-listing/delisting criteria, see the 2013 recovery plan (NMFS 2013a).

1. All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:

    a. At least two populations in the stratum have at least a 95% probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the Technical Recovery Team's (TRT) scoring system).
    b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system). (See Section 2.6 for a brief discussion of the TRT's scoring system.)
    c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.

    A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

5.3.5 Chinook Salmon, Sacramento River Winter-run ESU

On January 4, 1994, NMFS listed the Sacramento River winter-run ESU of Chinook salmon (Figure 9) as endangered. 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. Winter-run Chinook salmon originally spawned in the upper Sacramento River system (Little Sacramento, Pit, McCloud and Fall rivers) and in Battle Creek (Yoshiyama et al. 1998). Currently, winter-run Chinook salmon spawning habitat is likely limited to the reach of the Sacramento River extending from Keswick Dam downstream to the Red Bluff Diversion Dam.

5.3.5.1 Threats

The Sacramento River winter-run Chinook salmon ESU is composed of just one small population that is currently under severe stress caused by one of California's worst droughts on record. The population subsists in large part due to federally-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 could have devastating impacts, possibly leading to the species' extinction. The probability of extended droughts is increasing as the effects of climate change continue (NMFS 2014a). In addition to the drought, poor ocean conditions and hatchery influence have increased the risk of extinction.

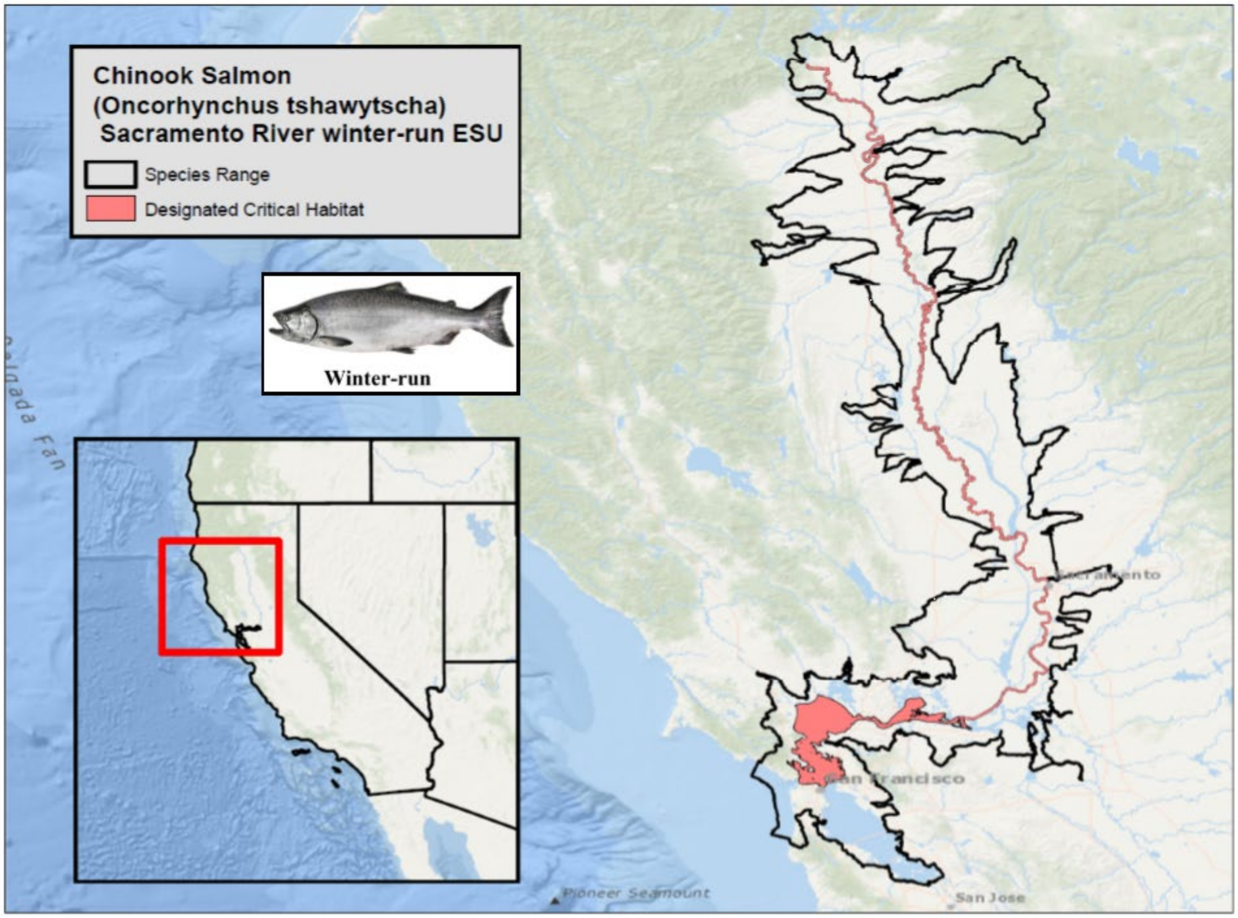

Figure 9. Chinook salmon, Sacramento winter-run ESU range and designated critical habitat

5.3.5.2 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. Winter-run Chinook salmon are sexually immature when upstream migration begins, and they must remain in freshwater 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 California Department of Fish and Wildlife (CDFW) in annual escapement surveys (2000-2006).

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 Red Bluff Diversion Dam (RBDD) 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 RBDD, occurs between November and March, peaking in December, with some emigration continuing through May in some years (Table 12; Snider and Titus 2000).

Table 12. Temporal distribution of Chinook salmon, Sacramento winter-run ESU.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td colspan="6">Present</td><td></td><td></td><td></td><td></td><td colspan="2">Present</td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td colspan="5">Present</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td></td><td colspan="6">Present</td><td></td><td></td><td></td></tr>
<tr><td>Emergence (alevin to fry phases</td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Present</td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td colspan="5">Present</td></tr>
</table>

5.3.5.3 Population Dynamics

According to the NMFS 5-year species status review (NMFS 2016b) for the status of the winter-run Chinook salmon ESU, the extinction risk has increased from moderate risk to high risk of extinction since the 2007 and 2010 assessments. Between 2003 and 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 (Figure 10). Based on the Lindley et al. (2007) criteria, the population is at high extinction risk because of the hatchery influence criterion, with a mean of 66 percent hatchery origin spawners from 2016 through 2018.

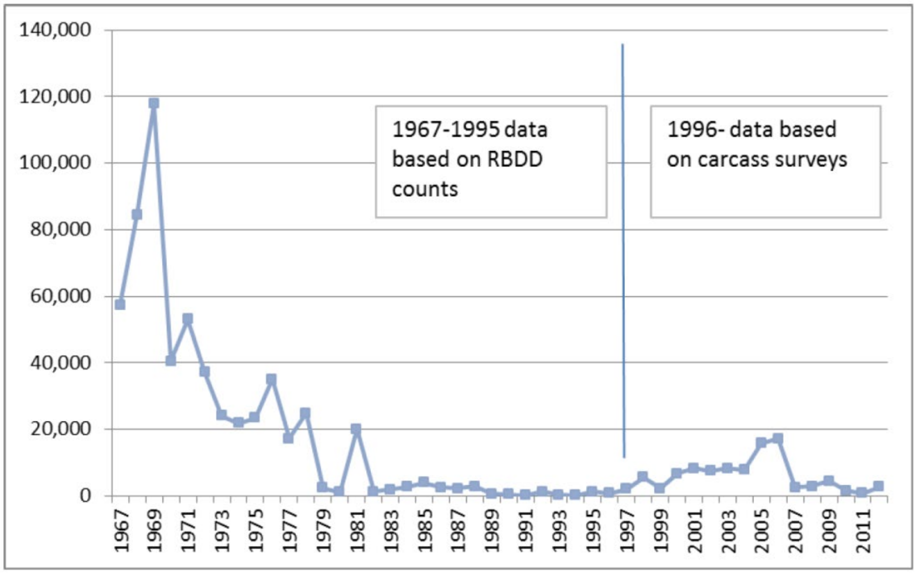

Figure 10. Estimated Sacramento River winter-run Chinook salmon run size (1967-2012).

5.3.5.4 Designated Critical Habitat

NMFS designated critical habitat for the Sacramento winter-run Chinook on June 16, 1993. It includes the Sacramento River from Keswick Dam, Shasta County (river mile 302) to Chipps Island (river mile 0) at the westward margin of the Sacramento-San Joaquin Delta, and other specified estuarine waters**.** PBFs that are essential for the conservation of Sacramento winter-run Chinook salmon, based on the best available information, include: (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River; (2) the availability of clean gravel for spawning substrate; (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles; (4) water temperatures between 42.5 and 57.5 °F (5.8 and 14.1 degrees Celsius [°C]) for successful spawning, egg incubation, and fry development; (5) habitat and adequate prey free of contaminants; (6) riparian habitat that provides for successful juvenile development and survival; and (7) access of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean. Each of these PBFs could be affected by fire retardant intrusions.

The current condition of PBFs for the Sacramento River Winter-run Chinook salmon indicates that they are not currently functioning or are degraded. These conditions are likely to maintain low population abundances across the ESU. Spawning and rearing PBFs are especially degraded by high water temperature caused by the loss of access to historic spawning areas in the upper watersheds where water maintains lower temperatures. The rearing PBF is further degraded by floodplain habitat disconnected from the mainstems of larger rivers throughout the Sacramento River watershed. The migration PBF is also degraded by the lack of natural cover along the migration corridors. Rearing and migration PBFs are further affected by pollutants from contaminated stormwater runoff, aerial drift and deposition, and point source discharges entering the surface waters and riverine sediments. Juvenile migration is obstructed by water diversions

along Sacramento River and by two large state and federal water-export facilities in the Sacramento-San Joaquin Delta.

5.3.5.5 Recovery Goals

Recovery goals, objectives and criteria for the Sacramento River winter-run Chinook are fully outlined in the 2014 Recovery Plan (NMFS 2014a). 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 are 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.

5.3.6 Chinook Salmon, Snake River Fall-run

NMFS first listed Snake River fall Chinook salmon (Figure 11) as a threatened species under the ESA on April 22, 1992. NMFS reaffirmed the listing status in June 28, 2005, and reaffirmed the status again in 2014. Snake River fall Chinook salmon historically spawned throughout the 600-mile reach of the mainstem Snake River from its mouth upstream to Shoshone Falls, a 212-foot high natural barrier near Twin Falls, Idaho (river mile 614.7). 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 2015a).

5.3.6.1 Threats

Threats posed by straying out-of-ESU hatchery fish have declined due to improved management. Still, large reaches of historical habitat remain blocked and inundated, and the mainstem Snake and Columbia River hydropower system, while less of a constraint than in the past, continues to cause juvenile and adult losses. The number of hatchery-origin fall Chinook salmon on the spawning grounds continues to threaten natural-origin fish productivity and genetic diversity. Further, the combined and relative effects of the different threats across the life cycle ─ including threats from climate change ─ remain poorly understood (NMFS 2011b, NMFS 2015a).

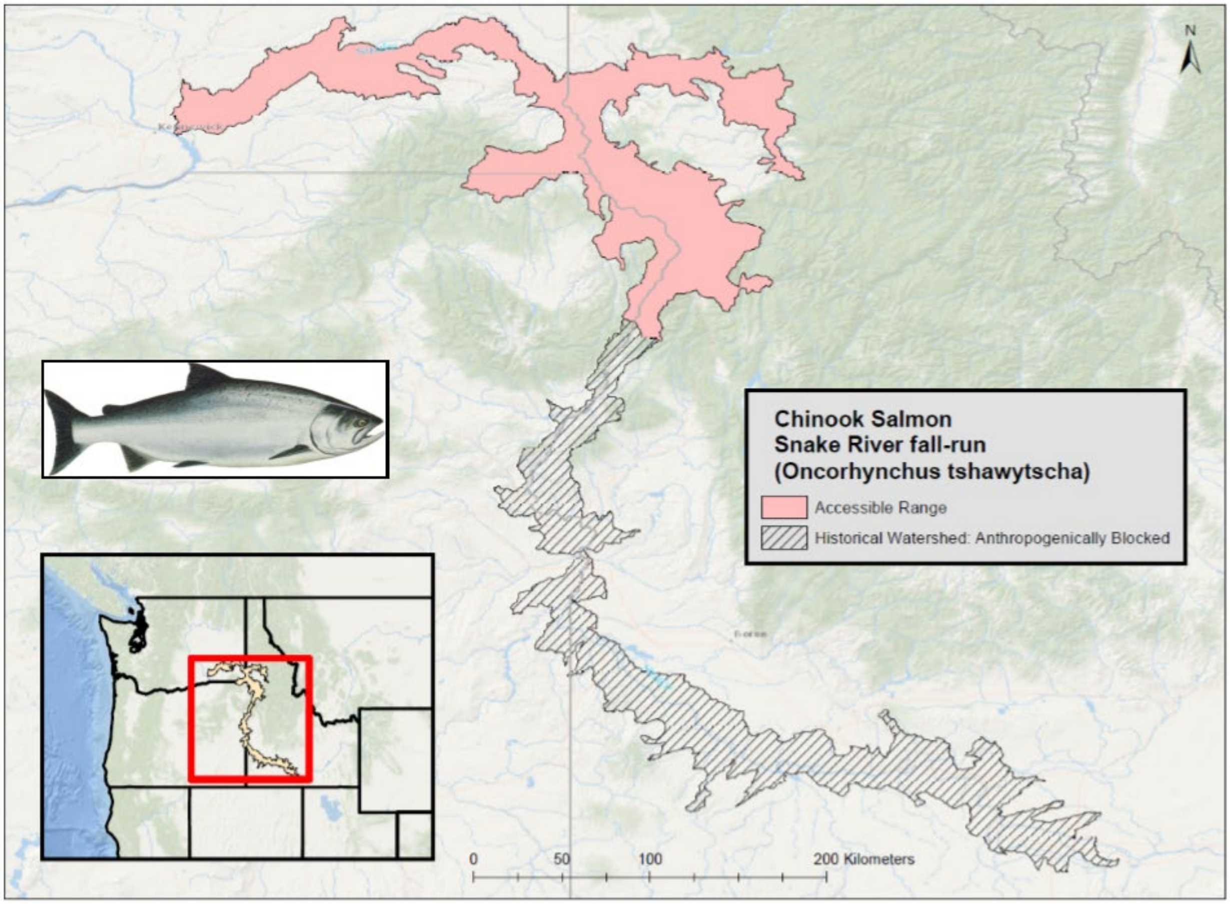

Figure 11. Chinook salmon, Snake River fall-run ESU range and designated critical habitat

5.3.6.2 Life History

Snake River fall-run Chinook return to the Columbia River in August and September, pass 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 2015a). Some fall Chinook salmon smolts sustain active migration after passing Lower Granite Dam and enter the ocean as subyearlings, whereas some delay seaward migration and enter the ocean as yearlings (Table 13; Connor et al. 2005, McMichael et al. 2008, NMFS 2015a). 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).

Table 13. Temporal distribution of Chinook salmon, Snake River fall-run ESU.

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entering Fresh Water (adults/jacks)								Present				
Spawning										Present		
Incubation (eggs)	Present									Present		
Emergence (alevin to fry phases	Present											Present
Rearing and migration (juveniles)	Present											

5.3.6.3 Population Dynamics

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 because of overfishing and other human activities, including the construction of major dams. Snake River fall Chinook salmon abundance has increased significantly since ESA listing in the 1990s. 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 for the most recent 10 years of annual spawner escapement estimates (2005-2014) is 6,418, with a standard error of 0.19 (Figure 12; NMFS 2015a). Estimates of abundance by life stage are provided in Table 14.

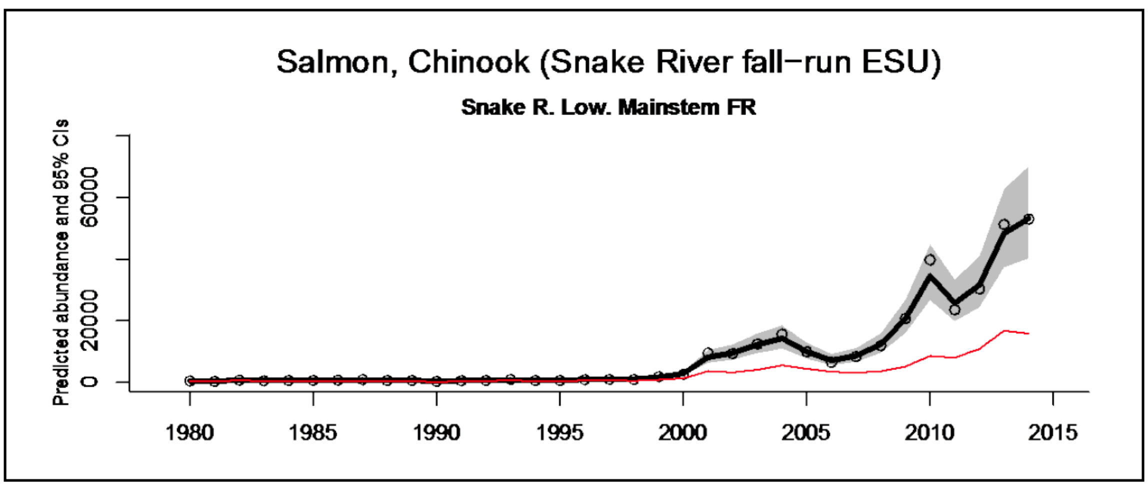

Figure 12. Smoothed trend in estimated total (thick black line) and natural (thin red line) population spawning abundance. Points show the annual spawning abundance estimates (from 2015 draft recovery plan).

Table 14. Average abundance estimates for Snake River fall-run ESU Chinook salmon (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	10,337
Natural	Juvenile	692,819

Listed Hatchery Adipose Clip	Adult	12,508
Listed Hatchery Adipose Clip	Juvenile	2,483,713
Listed Hatchery Intact Adipose	Adult	13,551
Listed Hatchery Intact Adipose	Juvenile	2,862,418

5.3.6.4 Designated Critical Habitat

NMFS designated critical habitat for SR Fall-run Chinook salmon on December 28, 1993. PBFs considered essential for the conservation of Chinook salmon, Snake River fall-run ESU are shown in Table 15.

Table 15. Essential features of critical habitats designated for SR spring/summer-run Chinook salmon, SR fall-run Chinook salmon, SR sockeye salmon, SONCC coho salmon, and corresponding species life history events.

Essential Features Site	Essential Features Site Attribute	Species Life History Event
Spawning and juvenile rearing areas	Access (sockeye) Cover/shelter Food (juvenile rearing) Riparian vegetation Space (Chinook, coho) Spawning gravel Water quality Water temp (sockeye) Water quantity	Adult spawning Embryo incubation Alevin growth and development Fry emergence from gravel Fry/parr/smolt growth and development
Adult and juvenile migration corridors	Cover/shelter Food (juvenile) Riparian vegetation Safe passage Space Substrate Water quality Water quantity Water temperature Water velocity	Adult sexual maturation Adult upstream migration and holding Kelt (steelhead) seaward migration Fry/parr/smolt growth, development, and seaward migration
Areas for growth and developmen t to adulthood	Ocean areas – not identified	Nearshore juvenile rearing Subadult rearing Adult growth and sexual maturation Adult spawning migration

The PBFs within critical habitat designated for SR Fall-run Chinook salmon that could be affected during fire retardant application include: (1) safe passage for juvenile migration, which is reduced by the presence of the Snake and Columbia River hydropower system within the lower mainstem; (2) rearing habitat water quality altered by influx of contaminants and changing seasonal temperature regimes caused by water flow management; and (3) spawning/rearing habitat PBF attributes (spawning areas with gravel, water quality, cover/shelter, riparian

vegetation, and space to support egg incubation and larval growth and development) that are reduced in quantity (80 percent loss) and quality due to the mainstem lower Snake River hydropower system.

5.3.6.5 Recovery Goals

Recovery goals, objectives and criteria for the Snake River fall-run Chinook are fully outlined in the 2015 Recovery Plan (NMFS 2015a). ESA recovery goals support conservation of natural fish and the ecosystems upon which they depend. Thus, the ESA recovery goal for Snake River fall 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.

5.3.7 Chinook Salmon, Snake River Spring/summer-run ESU

Snake River spring/summer-run Chinook salmon ESU (Figure 13) was listed as a threatened species under the ESA on April 22, 1992. NMFS reaffirmed the listing on June 28, 2005 and made minor technical corrections to the listing on April 14, 2014. 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 2016c).

5.3.7.1 Threats

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 2016c).

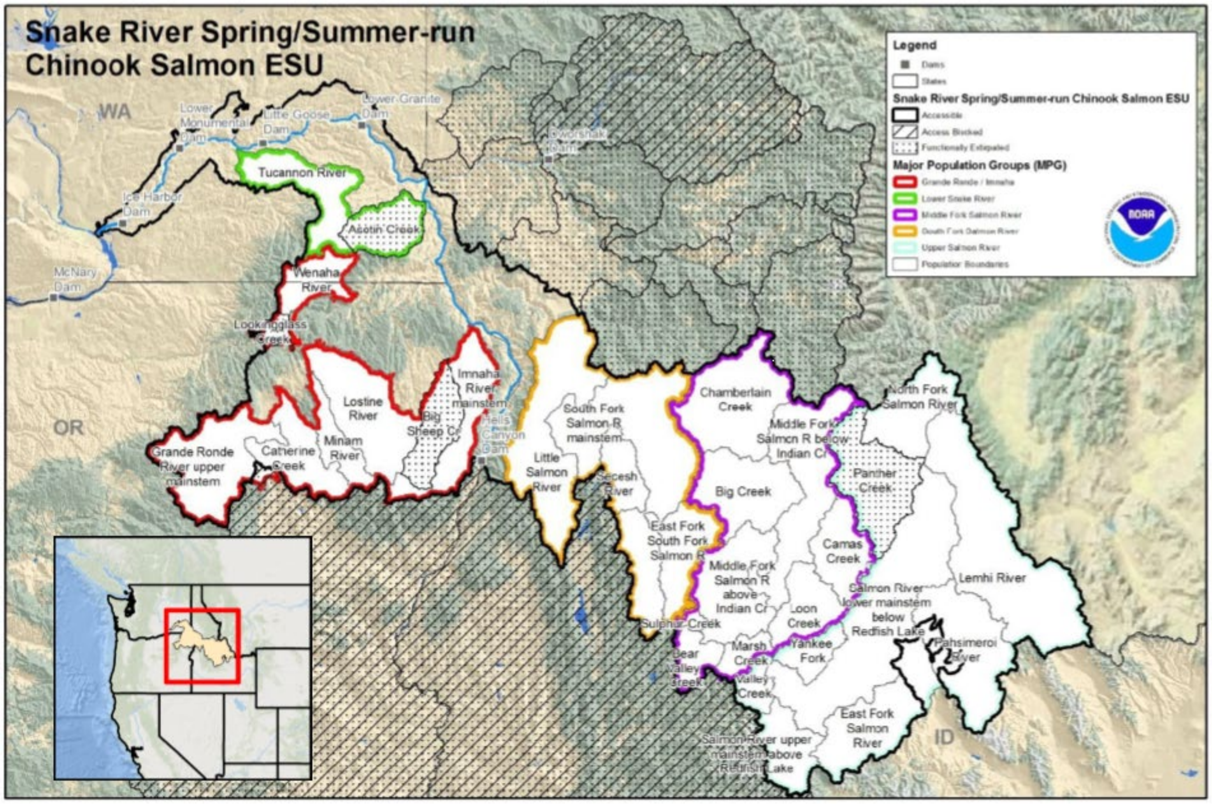

Figure 13. Chinook salmon, Snake River spring/summer-run ESU range and designated critical habitat

5.3.7.2 Life History

Annually, 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 31 (Table 16). 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 fresh water.

Table 16. Temporal distribution of Chinook salmon, Snake River spring/summer-run ESU.

<table>
<tr><td>Life History phase</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td></td><td></td><td colspan="5">Present</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Present</td><td></td></tr>
<tr><td>Emergence (alevin to fry phases</td><td>Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.7.3 Population Dynamics

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 near 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. Since then, abundance has been increasing. The Tucannon River spawning area is the only one in the Lower Snake River major spawning area (MaSA) with 10-year geometric mean abundances well below established minimum abundance thresholds. Poor natural productivity continues to be a major concern. Likewise, the Middle Fork Salmon River MaSA and Upper Salmon River MaSA have productivity estimates that are below viability objectives. The other two MaSAs have shown encouraging increases in abundance. Abundance estimates by life stage are provided in Table 17.

Table 17. Abundance estimates of Snake River spring/summer run ESU Chinook salmon (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

5.3.7.4 Designated Critical Habitat

PBFs considered essential for the conservation of Chinook salmon, Snake River spring/summer-run ESU are shown in Table 15. The PBFs within critical habitat designated for Snake River spring/summer-run Chinook salmon that could be affected during fire retardant application include: (1) safe passage for juvenile migration, which is reduced by the presence of the Snake and Columbia River hydropower system within the lower mainstem; (2) rearing habitat water quality altered by influx of contaminants and changing seasonal temperature regimes caused by water flow management; and (3) spawning/rearing habitat PBF attributes (spawning areas with gravel, water quality, cover/shelter, riparian vegetation, and space to support egg incubation and larval growth and development). Spawning and juvenile rearing PBFs are regionally degraded by changes in flow quantity, water quality, and loss of cover. Juvenile and adult migrations are

obstructed by reduced access that has resulted from altered flow regimes from hydroelectric dams. The Panther Creek population was extirpated because of legacy and modern mining-related pollutants creating a chemical barrier to fish passage (Chapman and Julius 2005).

5.3.7.5 Recovery Goals

Recovery goals, scenarios and criteria for the Snake River spring and summer-run Chinook salmon are fully outlined in the recovery plan (NMFS 2017b). The status levels targeted for populations within an ESU are referred to collectively as the "recovery scenario" for the ESU. NMFS has incorporated the viability criteria into viable recovery scenarios for each Snake River spring/summer Chinook salmon and steelhead MaSA. The criteria should be met for a spawning group to be considered viable, or low (five percent or less) risk of extinction, and thus contribute to the larger objective of ESU viability. These criteria are:

- At least one-half the populations historically present (minimum of two populations) should meet viability criteria (five percent or less risk of extinction over 100 years).
- At least one population should be highly viable (less than one percent risk of extinction).
- Viable populations within a MaSA should include some populations classified as "Very Large'" or "Large," and "Intermediate" reflecting proportions historically present.
- All major life history strategies historically present should be represented among the populations that meet viability criteria.
- Remaining populations within a MaSA should be maintained (25 percent or less risk of extinction) with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU recovery.
- For MaSAs with only one population, this population must be highly viable (less than one percent risk of extinction).

5.3.8 Chinook Salmon, Upper Columbia River Spring-run ESU

Upper Columbia River (UCR) spring-run Chinook salmon ESU (Figure 14) was listed as an endangered species under the ESA on March 24, 1999. NMFS reaffirmed the listing on June 28, 2005. This ESU includes naturally spawned spring-run Chinook salmon originating from Columbia River tributaries upstream of the Rock Island Dam and downstream of Chief Joseph Dam (excluding the Okanogan River subbasin). Also, spring-run Chinook salmon from six artificial propagation programs.

5.3.8.1 Threats

The UCR spring-run Chinook ESU includes three extant populations (Wenatchee, Entiat, and Methow), as well as one extinct population in the Okanogan subbasin (ICBTRT 2003). All three

populations continued to be rated at low risk for spatial structure but at high risk for diversity criteria. Large-scale supplementation efforts in the Methow and Wenatchee Rivers are ongoing, intended to counter short-term demographic risks given current average survival levels and the associated year-to-year variability. Under the current recovery plan, habitat protection and restoration actions are being implemented that are directed at key limiting factors. Although the status of the ESU has improved relative to measures available at the time of listing, all three populations remain at high risk (NWFSC 2015).

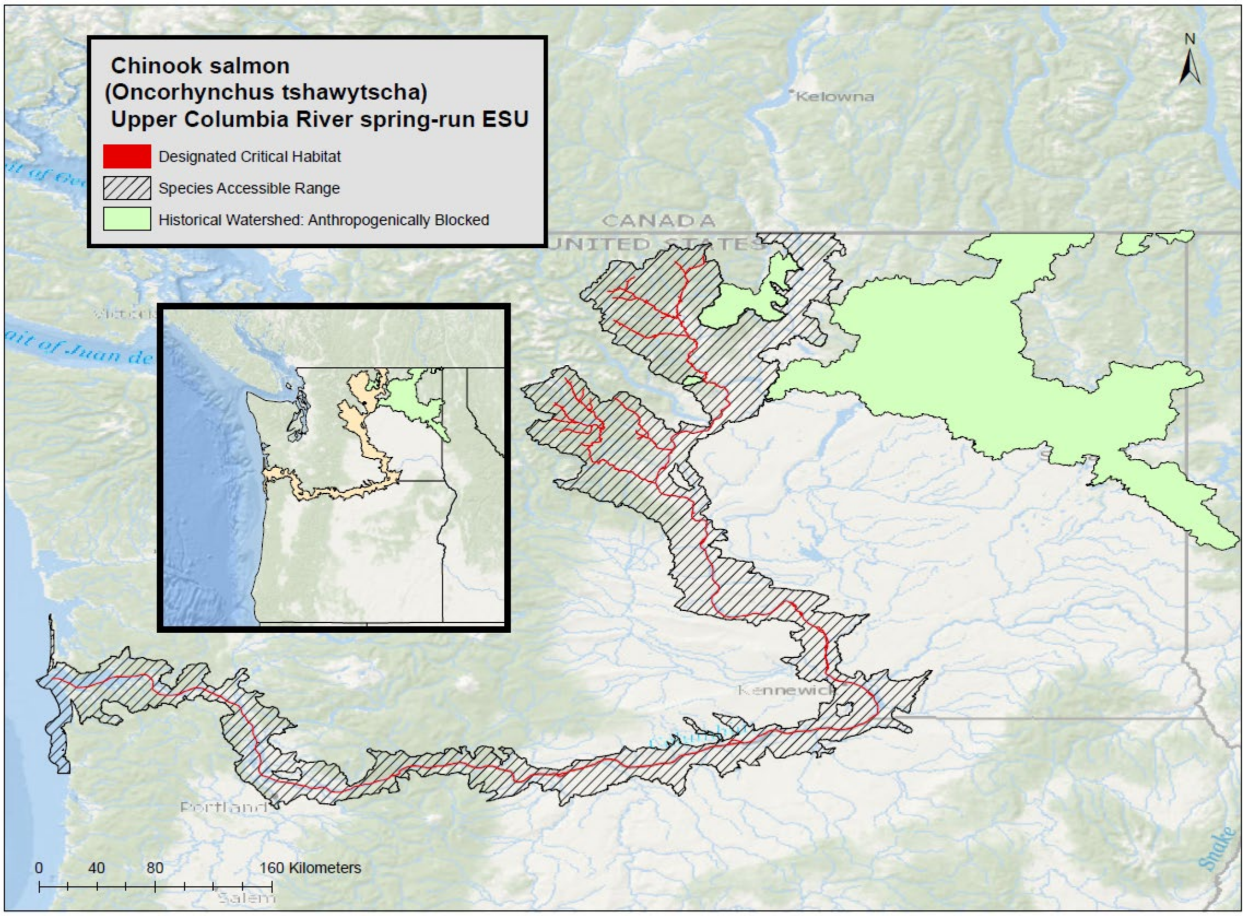

Figure 14. Chinook salmon, Upper Columbia River spring-run ESU range and designated critical habitat

5.3.8.2 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 (Table 18). 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 UCR spring Chinook salmon 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.

Table 18. Temporal distribution of Chinook salmon, Upper Columbia River spring-run ESU.

<table>
<tr><td>Life History phase</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td></td><td></td><td colspan="7">Present</td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="5">Present</td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Present</td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.8.3 Population Dynamics

For all populations, average abundance over the recent 10-year period is below the average abundance thresholds that the Interior Columbia River TRT identifies as a minimum for low risk (ICTRT 2008a; ICTRT 2008b; 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 to 15% of the minimum abundance thresholds. The five-year geometric mean remained low as of 2003.

Based on 1980-2004 returns, the population growth parameter (lambda) for this ESU is estimated at 0.93 (meaning the population is not replacing itself; Fisher and Hinrichsen 2006). The long-term trend for abundance and lambda for individual populations indicate a decline for all three populations (Good et al. 2005). Short-term lambda values indicate an increasing trend for the Methow population, but not for the Wenatchee and Entiat populations (ICTRT 2008a, ICTRT 2008b, ICTRT 2008c). Current estimates of abundance by life stage for the UCR ESU Chinook salmon are presented in Table 19.

Table 19. 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

5.3.8.4 Designated Critical Habitat

UCR spring-run Chinook salmon critical habitat includes all Columbia River estuarine areas and river reaches proceeding upstream to Chief Joseph Dam and several tributary subbasins. PBFs

considered essential for the conservation of Chinook salmon, UCR spring-run ESU are shown in Table 5.

The PBFs within critical habitat designated for UCR spring-run ESU Chinook salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. Spawning and rearing PBFs are somewhat degraded in tributary systems by urbanization in lower reaches, grazing in the middle reaches, and irrigation and diversion in the major upper drainages. These activities have resulted in excess erosion of fine sediment and silt that smother spawning gravel; reduction in flow quantity necessary for successful incubation, formation of physical rearing conditions, and juvenile mobility. Moreover, siltation further affects critical habitat by reducing water quality through contaminated agricultural runoff and removing natural cover. Adult and juvenile migration PBFs are heavily degraded by Columbia River federal dam projects, and a number of mid-Columbia River Public Utility District dam projects also obstruct the migration corridor.

5.3.8.5 Recovery Goals

Recovery goals, objectives and detailed criteria for the UCR spring-run Chinook are fully outlined in the 2016 Recovery Plan (NMFS 2016d). 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:spawner ratios and smolts/redds) 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.

5.3.9 Chinook Salmon, Upper Willamette River ESU

Upper Willamette River (UWR) Chinook salmon ESU (Figure 15) was listed as a threatened species under the ESA on March 24, 1999. NMFS reaffirmed the listing on June 28, 2005. This ESU includes naturally spawned spring-run Chinook salmon originating from the Clackamas River and from the Willamette River and its tributaries above Willamette Falls. Also, spring-run Chinook salmon from six artificial propagation programs.

5.3.9.1 Threats

Juvenile spring Chinook produced by hatchery programs are released throughout many of the subbasins and adult Chinook returns to the ESU are typically 80-90 percent hatchery origin fish. Access to historical spawning and rearing areas is restricted by large dams in the four historically most productive tributaries. In the absence of effective passage programs, Chinook 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.

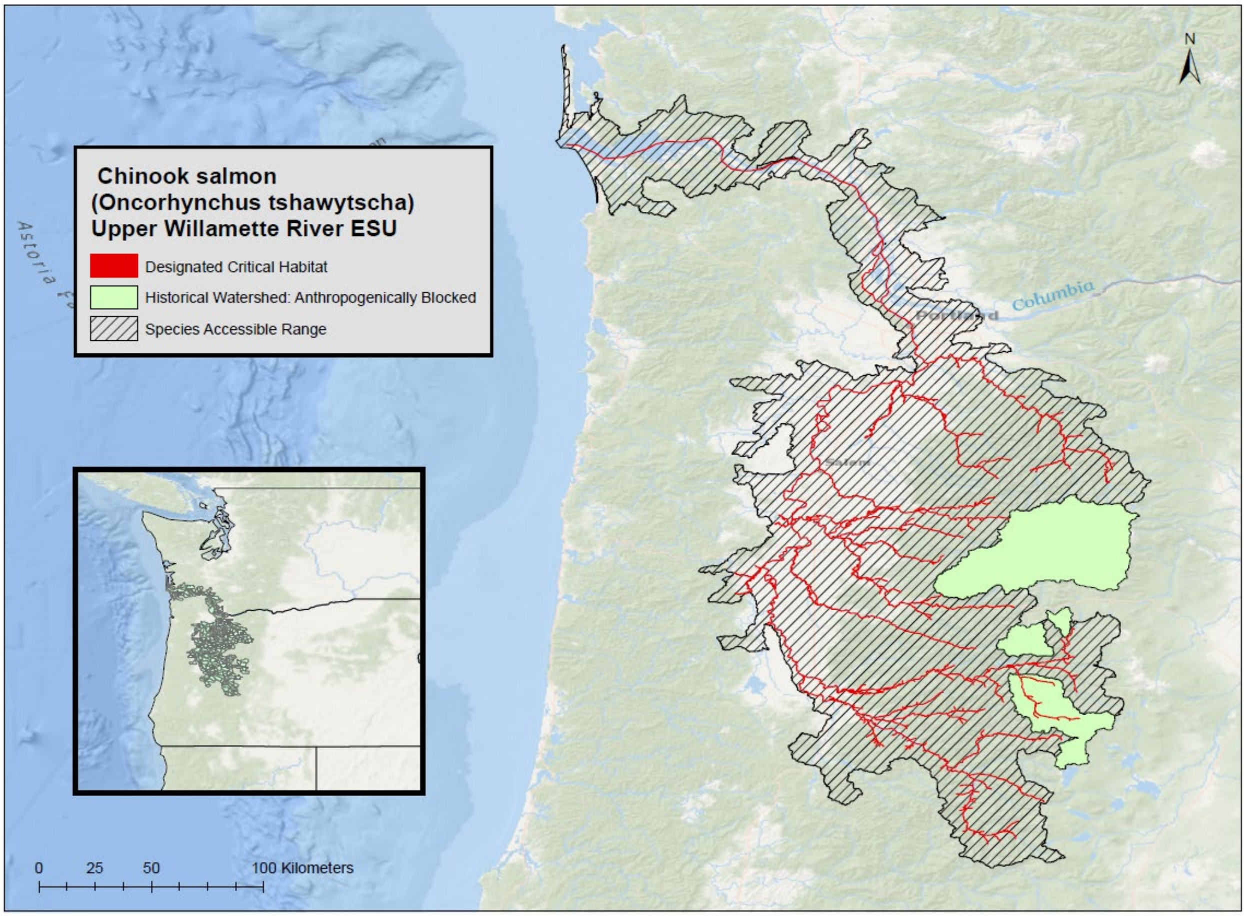

Figure 15. Chinook salmon, Upper Willamette River ESU range and designated critical habitat

5.3.9.2 Life History

UWR 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 augment river flows. Fry may emerge from January 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 yr +) migration in fall to early winter; and yearlings (1 yr +) migrating in late winter to spring (Table 20). 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.

Table 20. Temporal distribution of Chinook salmon, Upper Willamette River ESU

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
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<tr><td>Emergence (alevin to fry phases)</td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Present</td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.9.3 Population Dynamics

The UWR Chinook salmon ESU is considered to be extremely depressed, likely numbering less than 10,000 fish (Table 21) compared to a historical abundance estimate of 300,000 (Myers et al. 2006). Currently, significant natural production occurs in only the Clackamas and McKenzie populations (McElhany et al. 2007a). The spring Chinook salmon in the McKenzie River is the only remaining self-sustaining naturally reproducing independent population. The other natural-origin populations in this ESU have very low current abundances, and long- and short-term population trends are negative. Current abundance estimates are presented in Table 22.

Table 21. Upper Willamette River Chinook salmon independent populations core (C) and genetic legacy (G) populations and hatchery contributions (Good et al. 2005).

Functionally Independent Populations	Historical Abundance	Most Recent Spawner Abundance	Hatchery Abundance Contributions
Clackamas River (C)	Unknown	2,910	64%
Molalla River	Unknown	52 redds	>93%
North Santiam River (C)	Unknown	~ 7.1 rpm	>95%
South Santiam River	Unknown	982 redds	>84%
Calapooia River	Unknown	16 redds	100%
McKenzie River (C,G)	Unknown	~2,470	26%
Middle Fork Willamette River (C)	Unknown	235 redds	>39%
Total	>70,000	~9,700	Mostly hatchery

Table 22. Estimated abundance by life stage of the Upper Willamette River ESU Chinook salmon population (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	10,203
Natural	Juvenile	1,211,863
Listed Hatchery Clipped and IntactAdipose	Adult	31,476
Listed Hatchery Adipose Clip	Juvenile	4,709,045
Listed Hatchery Intact Adipose	Juvenile	157

5.3.9.4 Designated Critical Habitat

Designated critical habitat includes all Columbia River estuarine areas and river reaches proceeding upstream to the confluence with the Willamette River as well as specific stream reaches in a number of subbasins. PBFs considered essential for the conservation of Chinook salmon, UWR ESU are shown in Table 5.

The PBFs within critical habitat designated for UWR ESU Chinook salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of PBFs of the UWR ESU Chinook salmon critical habitat indicates that migration and rearing PBFs are not currently functioning or are degraded. These conditions impact their ability to serve their intended role for species conservation. The migration PBF is degraded by dams altering migration timing and water management altering the water quantity necessary for mobility and survival. Migration, rearing, and estuary PBFs are also degraded by loss of riparian vegetation and instream cover. Degraded water quality in the lower Willamette River where important floodplain rearing habitat is present affects the ability of this habitat to sustain its role to conserve the species.

5.3.9.5 Recovery Goals

Recovery goals, objectives, and detailed criteria for the UWR ESU Chinook salmon are fully outlined in the 2011 Recovery Plan (NMFS 2011c). The 2011 recovery plan outlines five potential scenario options for meeting the viability criteria for recovery. Of the five scenarios, scenario 1 reportedly represented the most balanced approach given limitations in some populations. The approach to achieve ESU delisting of UWR Chinook salmon in this Plan 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 to improve the status of the remaining populations from very high risk to high risk.

5.3.10 Coho Salmon, Lower Columbia River ESU

LCR coho salmon ESU (Figure 16) was listed as threatened under the ESA on June 28, 2005. Critical habitat has also been designated as of February 24, 2016. 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 from 21 artificial propagation programs.

5.3.10.1 Threats

Recovery efforts have likely improved the status of a number of coho salmon ESUs, abundances are still at low levels and the majority of the ESUs 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 2015).

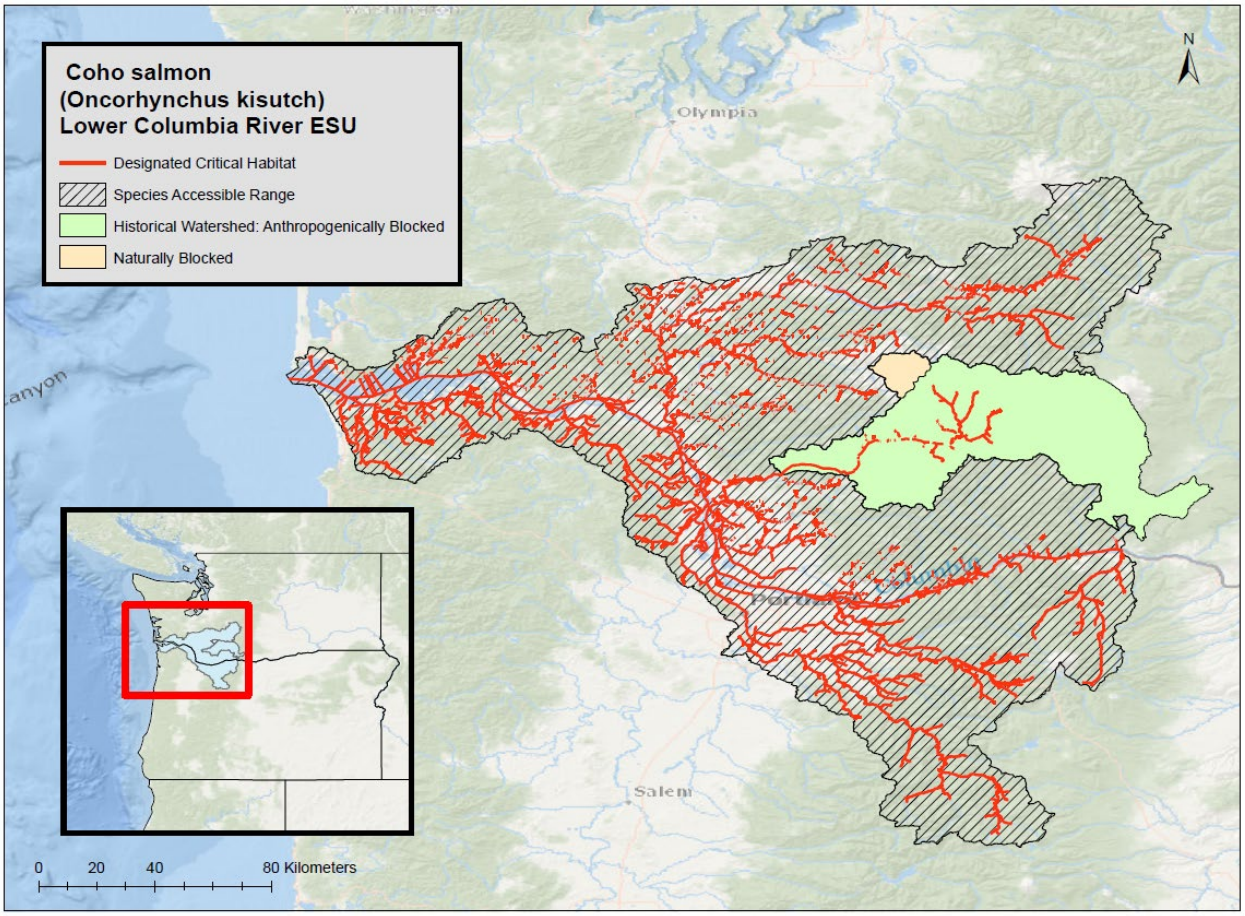

Figure 16. Coho salmon, lower Columbia River ESU range and designated critical habitat

5.3.10.2 Life History

LCR 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 2010b).

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 2013a). 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 2010b).

Most juvenile coho salmon migrate seaward as smolts in April to June, typically during their second year (Table 23). Salmon that have stream-type life histories, such as coho, typically do not linger for extended periods in the Columbia River estuary. Juvenile coho salmon are present in the Columbia River estuary from March to August. Most coho salmon sexually mature at age three, except for a small percentage of males (called "jacks") that return to natal waters at age two, after only five to seven months in the ocean (LCFRB 2010b).

Table 23. Temporal distribution of Coho salmon, lower Columbia River ESU.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
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<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.10.3 Population Dynamics

Although poor data quality prevents precise quantification, most populations are believed to have very low abundance of natural-origin spawners (50 fish or fewer, compared to historical abundances of thousands or tens of thousands).

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 one, 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. More recent spawning surveys indicate short-term increases in natural production in the Clatskanie, Scappoose, and Mill/Abernathy/Germany populations (Ford 2011, ODFW 2010).

5.3.10.4 Designated Critical Habitat

For this species, PBFs considered essential for their conservation are shown in Table 5. The PBFs within critical habitat designated for LCR ESU coho salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. Reduced complexity, connectivity, quantity, and quality of habitat used for

spawning, rearing, foraging, and migrating continues to be a concern for all four lower Columbia River listed species. Loss of habitat from conversion to agricultural or urbanized uses continues to be a particular concern throughout the LCR region, especially the loss of habitat complexity in the lower tributary/mainstem Columbia River interface, and concomitant changes in water temperature (LCFRB 2010b, NMFS 2013a, ODFW 2010). A growing concern is the introduction or toxic contaminants through the production, use, and disposal of numerous chemicals from multiple sources including industrial, agricultural, medical and pharmaceutical, and common household uses that enter the Columbia River in wastewater treatment plant effluent, stormwater runoff, and from nonpoint sources.

5.3.10.5 Recovery Goals

NMFS has developed the following delisting criteria for the LCR coho salmon ESU (2013a):

> All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:
>
> a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system. See Section 2.6 for a brief discussion of the TRT's scoring system.
> b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system).
> c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.
> d. A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

5.3.11 Coho Salmon, Oregon Coast ESU

Oregon coast coho salmon ESU (Figure 17) was listed as threatened under the ESA on August 10, 1998. The listing was revisited and confirmed as threatened on June 20, 2011. NMFS designated critical habitat for Oregon Coast coho salmon on February 11, 2008. This ESU includes naturally spawned coho salmon originating from coastal rivers south of the Columbia River and north of Cape Blanco, and coho salmon from one artificial propagation program: Cow Creek Hatchery Program.

5.3.11.1 Threats

The ESU is improving, due in large part to management decisions to reduce harvest and hatchery releases (NWFSC 2015a). It determined that Oregon coast coho salmon abundance remains strongly correlated with marine survival rates. 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 (ODF 2007).

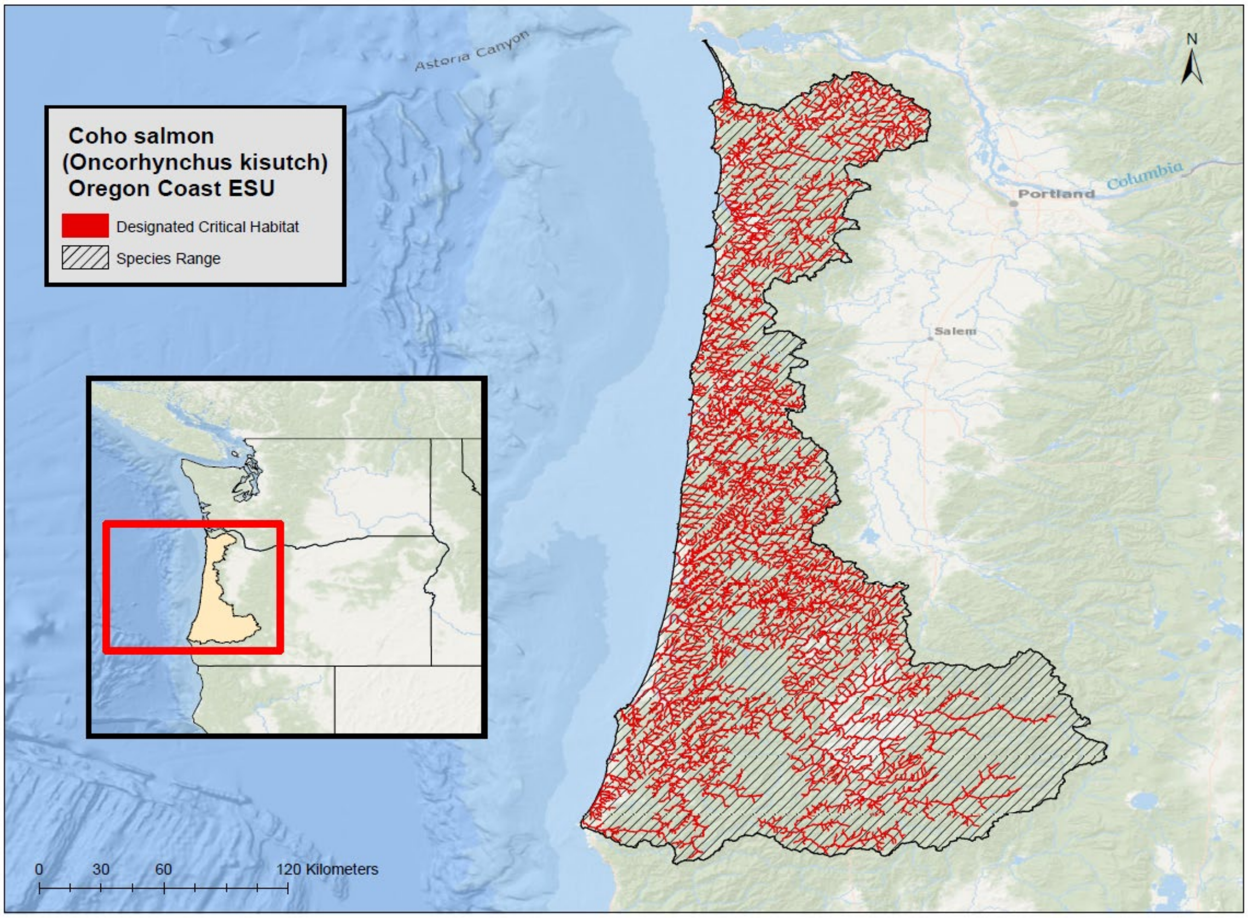

Figure 17. Coho salmon, Oregon coast ESU range and designated critical habitat

5.3.11.2 Life History

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 (Table 24). Research shows that substantial numbers of coho fry emigrate downstream from natal streams into tidally-influenced lower river wetlands and estuarine habitat (Bass 2010, Chapman 1962, Koski 2009). 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.

Table 24. Temporal distribution of Coho salmon, Oregon coast ESU.

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entering Fresh Water (adults/jacks)	Present									Present		
Spawning	Present									Present		
Incubation (eggs)	Present									Present		
Emergence (alevin to fry phases)	Present											Present
Rearing and migration (juveniles)	Present											

5.3.11.3 Population Dynamics

Results from the NWFSC status 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 of the last five years (NWFSC 2015).

Most independent populations in the ESU showed an overall increasing trend in abundance with synchronously high abundances in 2002-2003, 2009-2011, 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 2015).

5.3.11.4 Designated Critical Habitat

PBFs considered essential for the conservation of Oregon Coast ESU coho salmon are shown in Table 5. The PBFs within critical habitat designated for Oregon Coast ESU coho salmon that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The spawning PBF has been impacted in many watersheds from the inclusion of fine sediment into spawning gravel from timber harvest and forestry related activities, agriculture, and grazing. These activities have also diminished the channels' rearing and overwintering capacity by reducing the amount of large woody debris in stream channels, removing riparian vegetation, disconnecting floodplains from stream channels, and changing the quantity and dynamics of stream flows. The rearing PBF has been degraded by elevated water temperatures in 29 of the 80 HUC 5 watersheds; rearing PBF within the Nehalem, North Umpqua, and the inland watersheds of the Umpqua subbasins have elevated stream temperatures. Water quality is impacted by contaminants from agriculture and urban areas in low-lying areas in the Umpqua subbasins, and in coastal watersheds within the Siletz/Yaquina, Siltcoos, and Coos subbasins. Reductions in water quality have been observed in 12 watersheds due to contaminants and excessive nutrients The migration PBF has been impacted throughout the ESU by culverts and road crossings that restrict passage. As described above, the PBFs vary widely throughout the critical habitat area designated for Oregon Coast coho salmon, with many watersheds heavily impacted with low quality PBFs while habitat in other coho salmon-bearing watersheds have sufficient quality for supporting the conservation value of designated critical habitat.

5.3.11.5 Recovery Goals

See the 2016 Recovery Plan for detailed descriptions of the recovery goals and delisting criteria (NMFS 2016d). 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.

5.3.12 Coho Salmon, Southern Oregon/Northern California Coast ESU

Southern Oregon / Northern California Coast (SONCC) coho salmon ESU (Figure 18) was listed as threatened under the ESA on May 6, 1997. The listing was revisited and confirmed as threatened on June 28, 2005. NMFS designated critical habitat for the SONCC coho salmon on May 5, 1999. This ESU includes naturally spawned coho salmon originating from coastal streams and rivers between Cape Blanco, Oregon, and Punta Gorda, California, as well as coho salmon from three artificial propagation programs.

5.3.12.1 Threats

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).

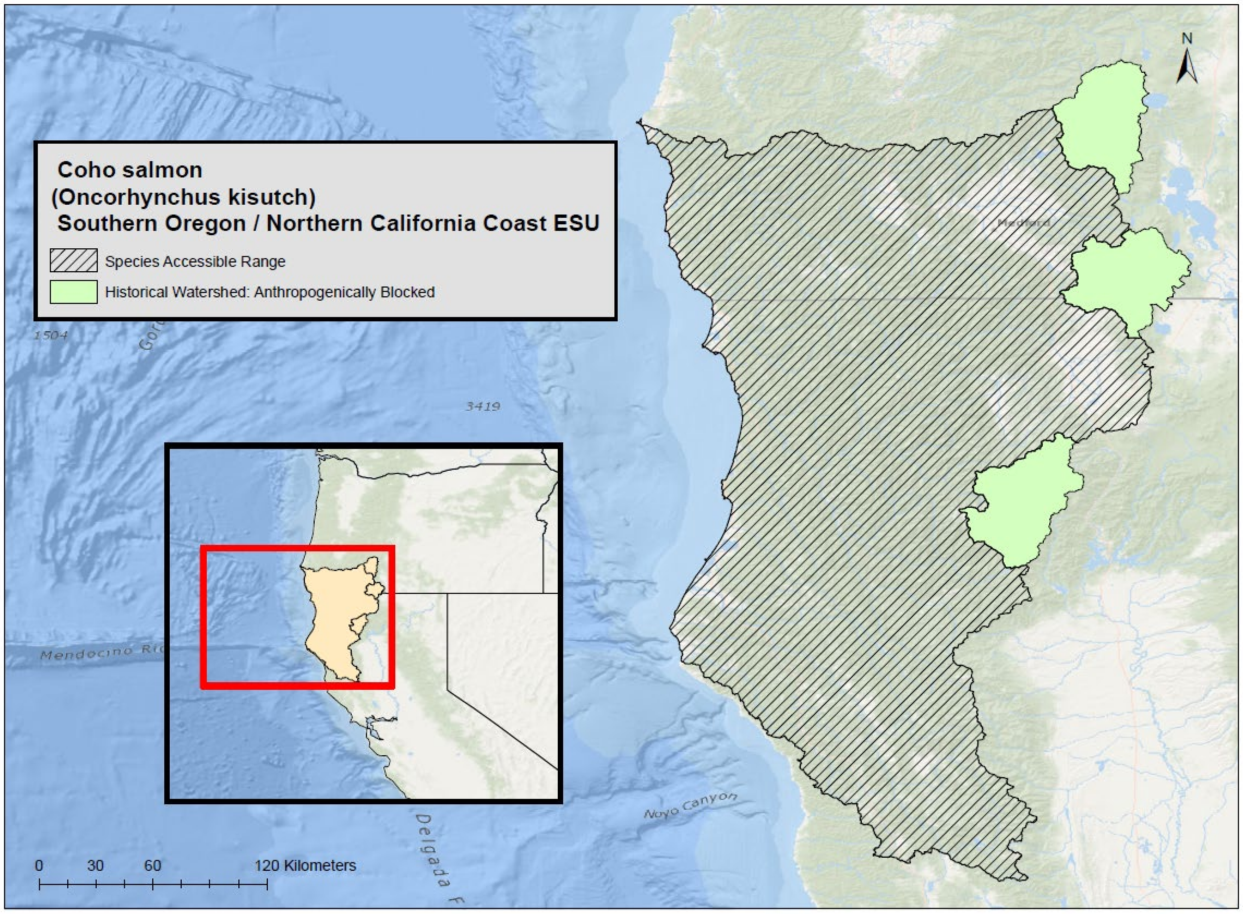

Figure 18. Coho salmon, Southern Oregon/Northern California ESU range and designated critical habitat

5.3.12.2 Life History

Coho salmon is an anadromous fish species that generally exhibits a relatively simple three-year life cycle (Table 25). 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 four months before hatching. Once most of the yolk sac is absorbed, the 30 to 35 mm fish 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 mm, and both stages are collectively referred to as "young of the year." Juveniles begin partitioning available instream habitat through aggressive agonistic interactions with other juvenile fish (Quinn 2005). Juveniles rear in fresh water for up to 15 months, then migrate to the ocean as smolts in the spring. Coho salmon return to their natal stream to spawn as three-year-olds. Some precocious males, called jacks, return to spawn after only six months at sea (NMFS 2014b).

Table 25. Temporal distribution of Coho salmon, Southern Oregon/Northern California ESU

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entering Fresh Water (adults/jacks)									Present	Present	Present	Present
Spawning										Present	Present	Present
Incubation (eggs)	Present									Present	Present	Present
Emergence (alevin to fry phases)	Present	Present	Present									Present
Rearing and migration (juveniles)	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present

5.3.12.3 Population Dynamics

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 (NMFS 2014b). Based on 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.

Available data show that the 95 percent confidence intervals for the slope of the regression line include zero for many populations, indicating that whether the slope is negative or positive cannot be determined. However, there is 95 percent confidence that the slope of the regression line is negative, indicating a decreasing trend, for Mill Creek in the Smith River and Freshwater Creek in Humboldt Bay Tributaries. In contrast, there is 95 percent confidence that the slope of the regression line is positive, indicating an increasing trend, at Gold Ray Dam in the Upper Rogue River (NMFS 2014b).

5.3.12.4 Designated Critical Habitat

PBFs considered essential for the conservation of the SONCC coho salmon ESU are shown in Table 15. The PBFs within critical habitat that could be affected during fire retardant application include: (1) safe passage for juvenile migration,; (2) rearing habitat water quality altered by influx of contaminants and changing seasonal temperature regimes caused by water flow management; and (3) spawning/rearing habitat PBF attributes (spawning areas with gravel, water quality, cover/shelter, riparian vegetation, and space to support egg incubation and larval growth and development). Critical habitat designated for the SONCC coho salmon is generally of good quality in northern coastal streams. The spawning PBF has been degraded throughout the ESU by logging activities that have increased fines in spawning gravel. The rearing PBF has been considerably degraded in many inland watersheds from the loss of riparian vegetation, resulting in unsuitably warm water temperatures. Rearing and juvenile migration PBFs have been reduced from the disconnection of floodplains and off-channel habitat in low gradient reaches of streams, consequently reducing winter rearing capacity.

5.3.12.5 Recovery Goals

See the 2014 recovery plan for complete down listing/delisting criteria for this ESU (Table 26; NMFS 2014b).

Table 26. Biological recovery objectives and criteria for SONCC coho salmon. All Biological criteria must be met in a recovered ESU. Taken from (NMFS 2014b).

VSP Parameter	Population Role	Biological Recovery Objective	Biological Recovery Criteria[1]
Abundance	Core	Achieve a low risk of extinction[2]	The geometric mean of wild adults over 12 years meets or exceeds the "low risk threshold" of spawners for each core population[2,3,4]
	Non-Core 1	Achieve a moderate or low risk of extinction[2]	The annual number of wild adults is greater than or equal to four spawners per IP-km for each non-core population[2]
Productivity	Core and Non-Core 1	Population growth rate is not negative	Slope of regression of the geometric mean of wild adults over the time series ≥ zero[4]
Spatial Structure	Core and Non-Core 1	Ensure populations are widely distributed	Annual within-population juvenile distribution ≥ 80%[4] of habitat[5,6] (outside of a temperature mask[7])
	Non-Core 2 and Dependent	Achieve inter- and intra-stratum connectivity	≥ 80% of accessible habitat[4] is occupied in years[8] following spawning of cohorts that experienced high marine survival[9]
Diversity	Core and Non-Core 1	Achieve low or moderate hatchery impacts on wild fish	Proportion of hatchery-origin adults (pHOS) < 0.05
	Core and Non-Core 1	Achieve life-history diversity	Variation is present in migration timing, age structure, size and behavior. The variation in these parameters[10] is retained.

[1] All applicable criteria must be met for each population in order for the ESU to be viable.
[2] See Table 4-2 for specific spawner abundance requirements needed to meet this objective.
[3] In the Shasta River, Upper Trinity River, and Upper Rogue River populations, IP above some anthropogenic dams was excluded from the spawner target, so the low-risk threshold for these populations is based on the IP downstream of those dams.
[4] Assess for at least 12 years, striving for a coefficient of variation (CV) of 15% or less at the population level (Crawford and Rumsey 2011).
[5] Based on available rearing habitat within the watershed (Wainwright et al. 2008). For purposes of these biological recovery criteria, "available" means accessible. 80% of habitat occupied relates to a truth value of +1.0,(true: juveniles occupy a high proportion of the available rearing habitat within the watershed (p. 56, Wainwright et al. 2008).
[6] The average for each of the three year classes over the 12 year period used for delisting evaluation must each meet this criterion. Strive to detect a 15% change in distribution with 80% certainty (Crawford and Rumsey 2011).
[7] Williams et al. (2008) identified a threshold air temperature, above which juvenile coho salmon generally do not occur, and identified areas with air temperatures over this threshold. These areas are considered to be within the temperature mask.
[8] If young-of-year are sampled, sampling would occur the spring following spawning of the cohorts experiencing high marine survival. If 1+ juveniles are sampled, sampling would occur approximately 1.5 years after spawning of the cohorts experiencing high marine survival, but before outmigration to the estuary and ocean.
[9] High marine survival is defined as 10.2% for wild fish and 8% for hatchery fish; Sharr et al. 2000. If marine survival is not high, then this criterion does not apply.
[10] This variation is documented in the population profiles in Chapters 7 to 46 of this plan.

5.3.13 Sockeye Salmon, Snake River ESU

On November 20, 1991, NMFS listed the Ozette Lake sockeye salmon ESU (Figure 19) as endangered and reaffirmed the ESU's status as endangered on June 28, 2005. NMFS designated critical habitat for Snake River sockeye salmon on December 28, 1993. This ESU includes naturally spawned anadromous and residual sockeye salmon originating from the Snake River basin, and sockeye salmon from one artificial propagation program: Redfish Lake Captive Broodstock Program.

5.3.13.1 Threats

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). 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). 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 2015).

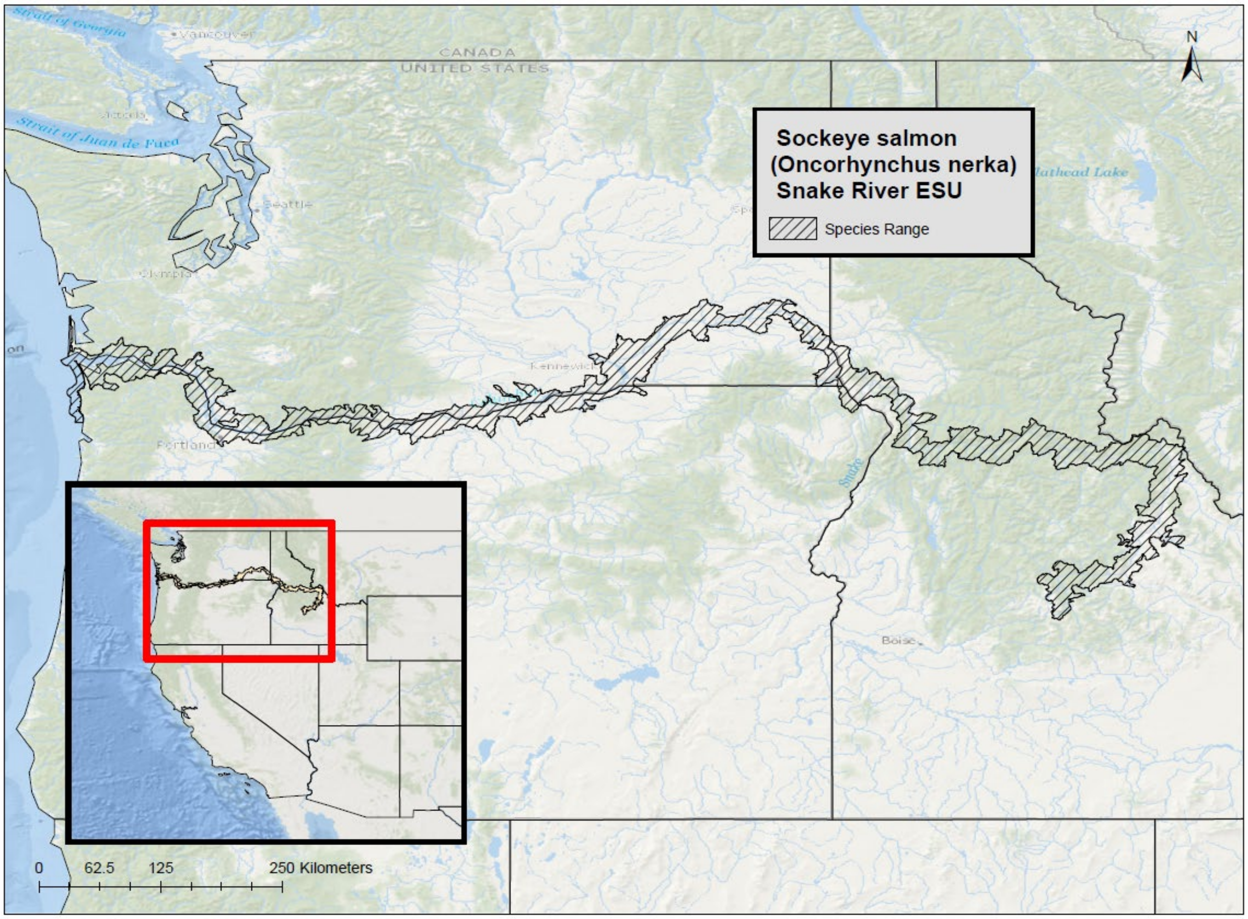

Figure 19. Sockeye salmon, Snake River ESU range and designated critical habitat

5.3.13.2 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 100-200 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. Juveniles will remain in lakes for one to three years after emergence. 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 (Table 27).

Table 27. Temporal distribution of Sockeye salmon, Snake River ESU

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td colspan="12">Present</td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td><td></td></tr>
<tr><td>Incubation (eggs)</td><td>Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="4">Present</td></tr>
<tr><td>Emergence (alevin to fry phases</td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Present</td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.13.3 Population Dynamics

For the Snake River ESU, the only extant population at the time of listing occurred in Redfish Lake. Adult returns to Redfish Lake during the period 1954 through 1966 ranged from 11 to 4,361 fish (Bjornn et al. 1968). In 1985, 1986, and 1987, 11, 29, and 16 sockeye, respectively, were counted at the Redfish Lake weir. Since 1987, only 18 natural-origin sockeye salmon have returned to the Stanley Basin. The first adult returns from the captive broodstock program returned to the Stanley Basin in 1999. From 1999 through 2005, 345 captive brood adults that had migrated to the ocean returned to the Stanley Basin, and returns increased to over 600 in 2008 and more than 700 returning adults in 2009. Annual adult releases during 2011-2014 averaged over 1,200; almost double the average for the prior five-year period (NWFSC 2015). 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. The captive brood program has been successful in providing substantial numbers of hatchery-produced sockeye for use in supplementation efforts. While increased abundance of hatchery-reared Snake River sockeye salmon has reduced the risk of loss, levels of naturally-produced sockeye salmon returns have remained extremely low (Ford 2011, NWFSC 2015). Substantial increases in survival rates across life history stages must occur to re-establish sustainable natural production (Hebdon et al. 2004, Keefer et al. 2008). Current abundance estimates by life stage are provided in Table 28.

Table 28. Current abundance estimates by life stage of 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

5.3.13.4 Designated Critical Habitat

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). Specific PBFs are shown in Table 15. The PBFs within critical habitat that could be affected during fire retardant application include: (1) safe passage for juvenile migration, which

is reduced by the presence of the Snake and Columbia River hydropower system within the lower mainstem; (2) rearing habitat water quality altered by influx of contaminants and changing seasonal temperature regimes caused by water flow management; and (3) spawning/rearing habitat PBF attributes (spawning areas with gravel, water quality, cover/shelter, riparian vegetation, and space to support egg incubation and larval growth and development).

5.3.13.5 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.

5.3.14 Steelhead Trout, California Central Valley DPS

On March 19, 1998, NMFS listed the California Central Valley (CCV) DPS of steelhead (Figure 20) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. NMFS designated critical habitat for CCV steelhead on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) 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. This DPS includes steelhead from two artificial propagation programs.

5.3.14.1 Threats

At the time of listing, the major threats were long-term declines in abundance, low abundance, and interbreeding with hatchery-origin fish natal to other regions. Additionally, when listed, lost habitat, degraded habitat, water diversions, reduced water quality, and other factors affecting abundance were identified as threats. Many watersheds in the Central Valley still experience decreased abundance of CCV steelhead. Dam removal and habitat restoration efforts in Clear Creek appear to be benefiting CCV 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 returning to most hatcheries, domination by hatchery fish, and relatively sparse monitoring makes the continued existence of naturally reproduced steelhead a concern.

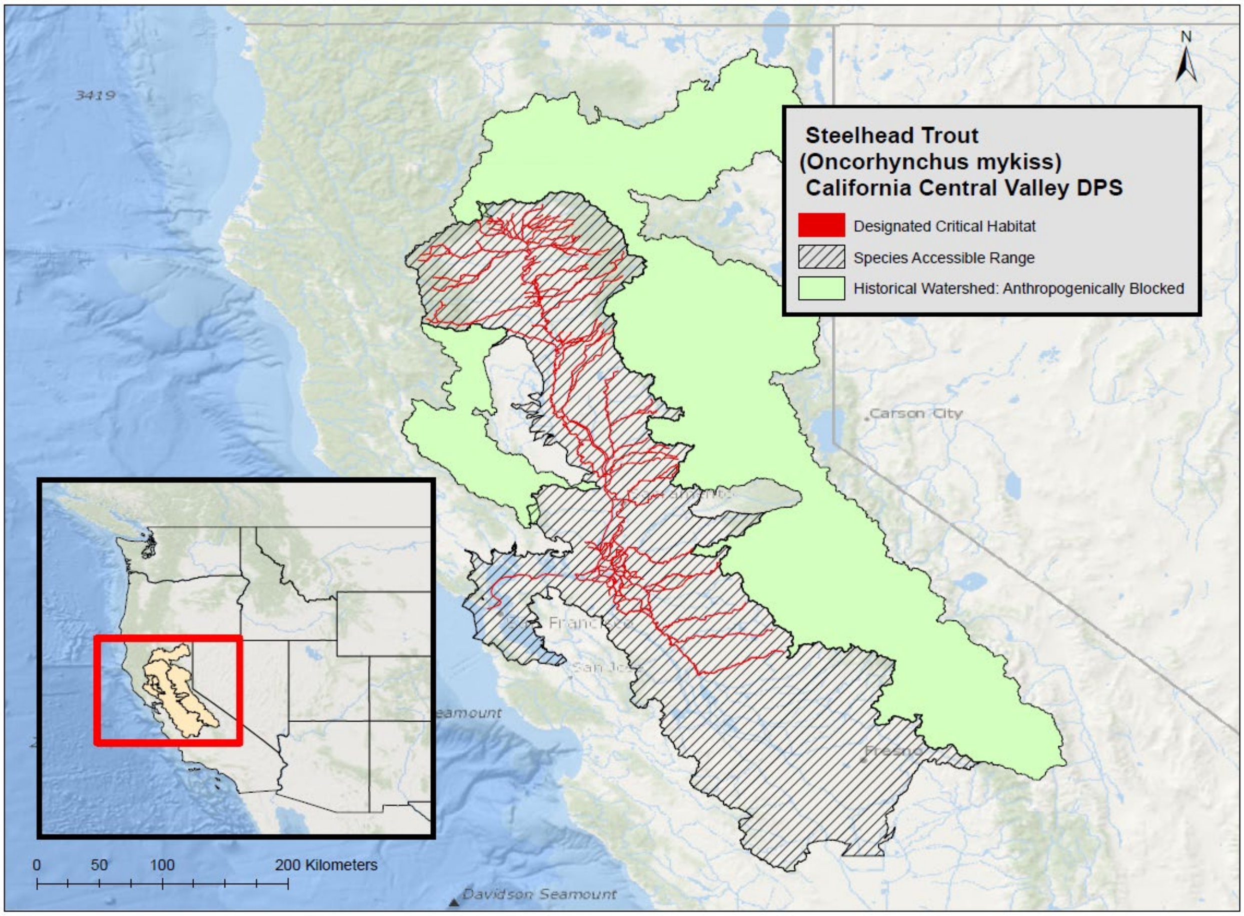

Figure 20. Steelhead, California Central Valley DPS range and designated critical habitat

5.3.14.2 Life History

Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. The eggs hatch about three to four weeks after spawning at 50°F to 59°F. 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 common in riffles, intermediate size fish in runs, and larger fish in pools.

Steelhead typically migrate to marine waters after spending two years in fresh water. 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, CCV steelhead are considered "ocean-maturing" (also known as winter) steelhead, although summer steelhead may have been

present prior to construction of large dams. Ocean-maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. California Central Valley steelhead enter fresh water from August through April (Table 29). 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).

Table 29. Temporal distribution of Steelhead, California Central Valley DPS

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td colspan="5">Present</td><td></td><td colspan="6">Present</td></tr>
<tr><td>Spawning</td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Present</td></tr>
<tr><td>Incubation (eggs)</td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Present</td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.14.3 Population Dynamics

Historic CCV 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. Hallock et al. (1961) estimated an average of 20,540 adult steelhead in the Sacramento River, upstream of the Feather River, through the 1960s. Steelhead were counted at the Red Bluff Diversion Dam (RBDD) up until 1993. Counts at the dam declined from an average of 11,187 for the period of 1967 to 1977, to an average of approximately 2,000 through the early 1990s. An estimated total annual run size for the entire Sacramento-San Joaquin system was no more than 10,000 adults during the early 1990s (McEwan and Jackson 1996, McEwan 2001). Based on catch ratios at Chipps Island in the Delta and using some generous assumptions regarding survival, the average number of CCV 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).

CCV steelhead lack annual monitoring data for calculating trends and lambda. However, the RBDD 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 2014a). The current abundance estimates of each life stage are presented in Table 30.

Table 30. Current abundance estimates for the CCV DPS steelhead by life stage (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

5.3.14.4 Designated Critical Habitat

Physical and biological features considered essential for the conservation of CCV DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for CCV DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of CCV steelhead critical habitat is degraded, and does not provide the conservation value necessary for species recovery. In addition, the Sacramento-San Joaquin River Delta, as part of CCV steelhead designated critical habitat, provides very little function necessary for juvenile CCV steelhead rearing and physiological transition to salt water.

The spawning PBF is subject to variations in flows and temperatures, particularly over the summer months. Some complex, productive habitats with floodplains remain in the system and flood bypasses (*i.e.*, Yolo and Sutter bypasses). However, the rearing PBF is degraded by the channelized, leveed, and riprapped river reaches and sloughs that are common in the Sacramento-San Joaquin system and which typically have low habitat complexity, low abundance of food organisms, and offer little protection from either fish or avian predators. Stream channels commonly have elevated temperatures.

The current conditions of migration corridors are substantially degraded. Both migration and rearing PBFs are affected by dense urbanization and agriculture along the mainstems and in the Delta that contribute to reduced water quality by introducing several contaminants. In the Sacramento River, the migration corridor for both juveniles and adults is obstructed by the RBDD gates, which are down from May 15 through September 15. The migration PBF is also obstructed by complex channel configurations, making it more difficult for CCV steelhead to migrate successfully to the western Delta and the ocean. In addition, the state and federal government pumps and associated fish facilities change flows in the Delta, which impedes and obstructs a functioning migration corridor that enhances migration. The estuarine PBF, which is present in the Delta, is affected by contaminants from agricultural and urban runoff and release of wastewater treatment plant effluent.

5.3.14.5 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 2014a). 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; and
- Maintain multiple populations at moderate risk of extinction.

5.3.15 Steelhead Trout, Lower Columbia River DPS

On March 19, 1998, NMFS listed the LCR DPS of steelhead (Figure 21) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. Critical habitat was designated for the LCR steelhead on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (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 UWR basin above Willamette Falls. This DPS includes steelhead from seven artificial propagation programs.

5.3.15.1 Threats

The LCR steelhead had 17 historically independent winter steelhead populations and six independent summer steelhead populations (McElhany et al. 2003, Myers et al. 2006). All historic LCR 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 2015). Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. Summer-run steelhead 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 spawning groups meet the criteria for viability. The DPS therefore continues to be at moderate risk (NWFSC 2015).

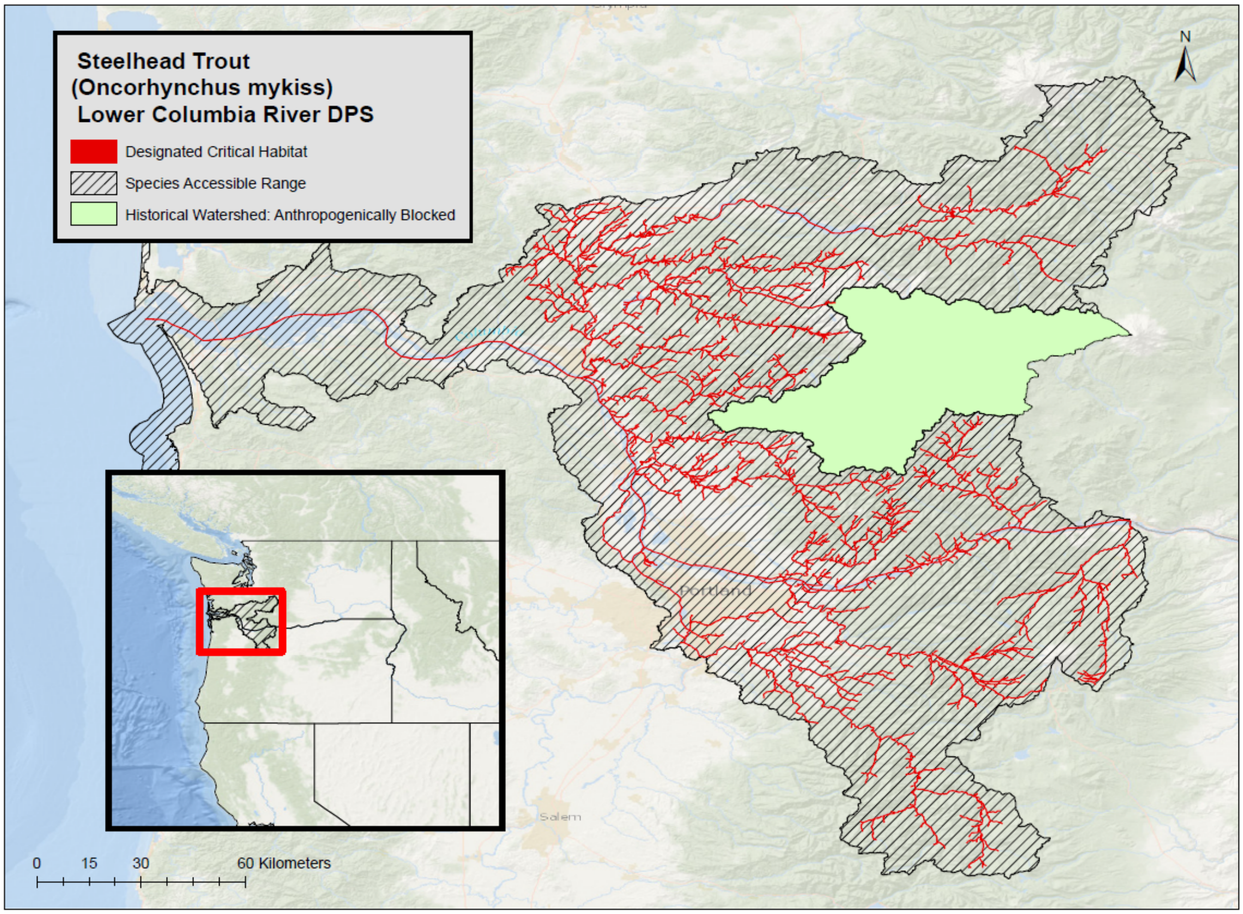

Figure 21. Steelhead, Lower Columbia River DPS range and designated critical habitat

5.3.15.2 Life History

The LCR 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 fresh water prior to spawning (Table 31). Winter-run steelhead enter fresh water 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 majority of juvenile LCR 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.

Table 31. Temporal distribution of Steelhead, Lower Columbia River DPS.

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entering Fresh Water (adults/jacks)	Present											
Spawning			Present									
Incubation (eggs)			Present									
Emergence (alevin to fry phases					Present							
Rearing and migration (juveniles)	Present											

5.3.15.3 Population Dynamics

All LCR steelhead populations declined from 1980 to 2000, with sharp declines beginning in 1995. Historical counts in some of the larger tributaries (Cowlitz, Kalama, and Sandy Rivers) suggest the population probably exceeded 20,000 fish. During the 1990s, fish abundance dropped to 1,000 to 2,000 fish. Recent abundance estimates of natural-origin spawners range from completely extirpated for some populations above impassable barriers to over 700 fishes for the Kalama and Sandy winter-run populations. A number of the populations have a substantial fraction of hatchery-origin spawners in spawning areas. Many of the long-and short-term trends in abundance of individual populations are negative.

There is a difference in population stability between winter- and summer-run LCR steelhead. The winter-run steelhead in the Cascade region has the highest likelihood of being sustained as it includes a few populations with moderate abundance and positive short-term population growth rates (Good et al. 2005, McElhany et al. 2007a). The Gorge summer-run steelhead is at the highest risk over the long-term and the Hood River population is at high risk of being lost (McElhany et al. 2007a). Current abundance estimates by life stage are presented in Table 32.

Table 32. Abundance estimates by life stage for the LCR DPS steelhead (NMFS 2020).

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

5.3.15.4 Designated Critical Habitat

PBFs considered essential for the conservation of LCR DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for LCR DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. Critical habitat is impaired by reduced quality of rearing and juvenile migration PBFs within the lower portion and alluvial valleys of many watersheds; contaminants from agriculture affect both water quality and food production in these reaches of tributaries and in the mainstem Columbia River. Several dams affect the adult migration PBF by obstructing the migration corridor. Watersheds that consist of a large proportion of federal lands such as is the case with the Sandy River watershed, have relatively healthy riparian corridors that support attributes of the rearing PBF such as cover, forage, and suitable water quality.

5.3.15.5 Recovery Goals

NMFS has developed the following delisting criteria for the LCR steelhead DPS (NMFS 2013a):

> All strata that historically existed have a high probability of persistence or have a probability of persistence consistent with their historical condition. High probability of stratum persistence is defined as:
>
> a. At least two populations in the stratum have at least a 95 percent probability of persistence over a 100-year time frame (i.e., two populations with a score of 3.0 or higher based on the TRT's scoring system. See Section 2.6 for a brief discussion of the TRT's scoring system).
> b. Other populations in the stratum have persistence probabilities consistent with a high probability of stratum persistence (i.e., the average of all stratum population scores is 2.25 or higher, based on the TRT's scoring system).
> c. Populations targeted for a high probability of persistence are distributed in a way that minimizes risk from catastrophic events, maintains migratory connections among populations, and protects within-stratum diversity.
> d. A probability of persistence consistent with historical condition refers to the concept that strata that historically were small or had complex population structures may not have met Criteria A through C, above, but could still be considered sufficiently viable if they provide a contribution to overall ESU viability similar to their historical contribution.

5.3.16 Steelhead Trout, Middle Columbia River DPS

On March 25, 1999, NMFS listed the Middle Columbia River (MCR) DPS of steelhead (Figure 22) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. Critical habitat was designated for this species on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (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. This DPS includes steelhead from seven artificial propagation programs.

5.3.16.1 Threats

There are 16 extant populations in four major population groups (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 major population group. Historic threats of overfishing, hydropower, migration disruption, loss of spawning habitat, and urbanization are still affecting this DPS. Present population structure is delineated largely on geographical proximity, topography, distance, ecological similarities or differences. Using criteria for abundance and productivity, a gap analysis for each of the four population groups in this DPS

under three different ocean conditions and a base hydrologic condition (most recent 20-year survival rate) was developed (ICTRT 2003). The results showed that none of the population groups would be able to achieve a five 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.

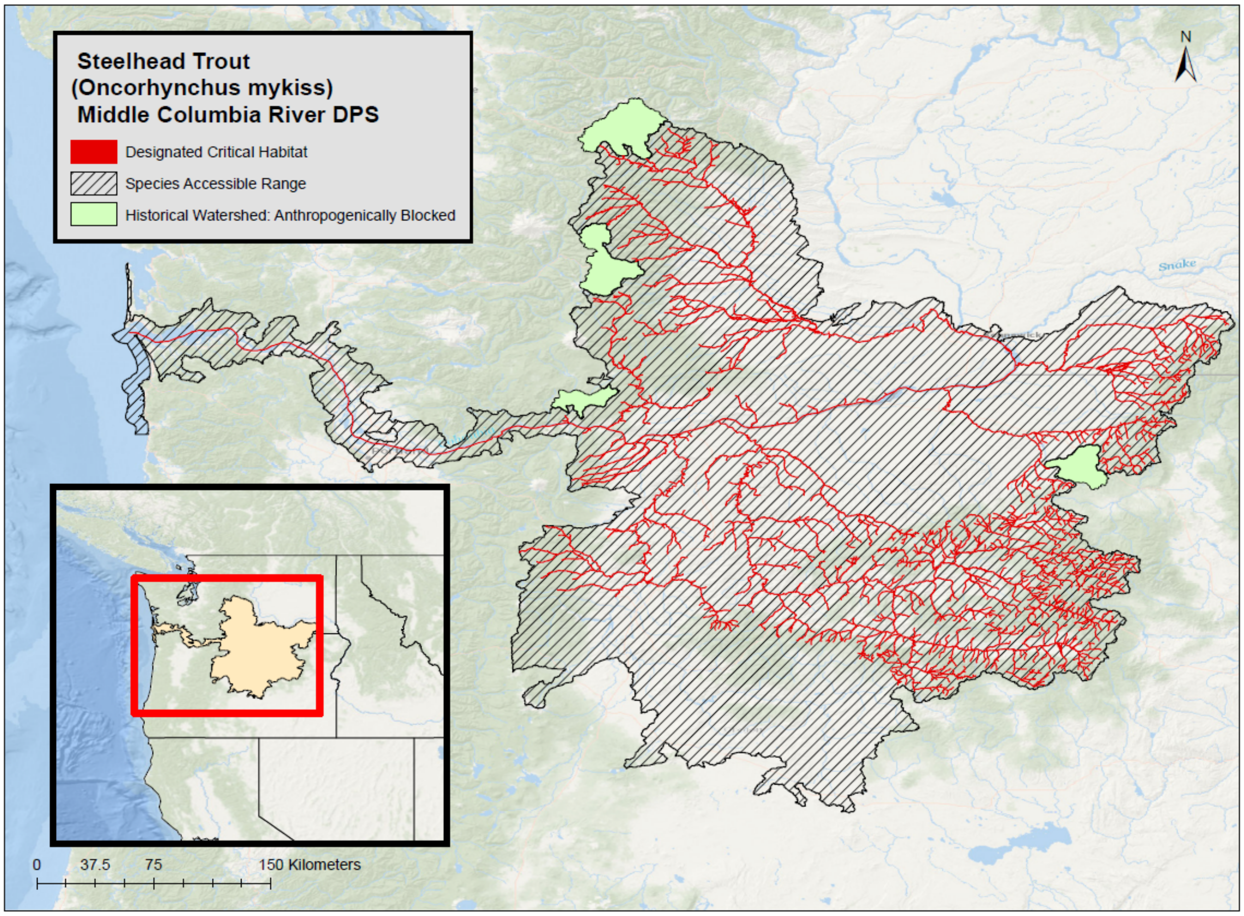

Figure 22. Steelhead, Middle Columbia River DPS range and designated critical habitat

5.3.16.2 Life History

MCR steelhead populations are mostly of the summer-run type. Adult steelhead enter fresh water from June through August. The only exceptions are populations of inland winter-run steelhead that occur in the Klickitat River and Fifteenmile Creek (Busby et al. 1996). The majority of juveniles smolt and outmigrate 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 and 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 (Table 33; Busby et al. 1996). Adults may hold in the river up to a year before spawning.

Table 33. Temporal distribution of Steelhead, Middle Columbia River DPS.

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entering Fresh Water (adults/jacks)	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present
Spawning	Present	Present	Present	Present	Present	Present	Present					
Incubation (eggs)	Present	Present	Present	Present	Present	Present	Present					
Emergence (alevin to fry phases)				Present	Present	Present	Present	Present				
Rearing and migration (juveniles)	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present	Present

5.3.16.3 Population Dynamics

Historic run estimates for the Yakima River imply that annual species abundance may have exceeded 300,000 returning adults (Busby et al. 1996). The five-year average (geometric mean) return of natural MCR steelhead for 2015 to 2019 was at every spawning location (except the Klickitat River) compared to 2010-2014. The geometric mean estimate for 2015 to 2019 was 14,311, which is much more similar to the mean return estimate for 2005 to 2009 (15, 137) than 2014 to 2014 (26,224). The recent estimates of mean spawner abundance represent the lowest levels observed since 2000. Despite that, viability probability remains unchanged since 2000. Current abundance estimates by life stage are presented in Table 34.

Table 34. Abundance estimates by life stage of Middle Columbia River DPS steelhead (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

5.3.16.4 Designated Critical Habitat

PBFs considered essential for the conservation of MCR DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for MCR DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of critical habitat designated for the MCR steelhead is moderately degraded. Critical habitat is affected by the reduced quality of juvenile rearing and migration PBFs within many watersheds; contaminants from agriculture affect both water quality and food production in several watersheds and in the mainstem Columbia River. Loss of riparian vegetation to grazing has resulted in high water temperatures in the John Day basin. The reduced quality of the rearing PBF has diminished its contribution to the conservation value necessary for the recovery of the species. Several dams affect the adult migration PBF by obstructing the migration corridor.

5.3.16.5 Recovery Goals

See the 2016 recovery plan for the MCR steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2016d). This species ranges through Oregon and Washington on either side of the Columbia River and is therefore managed by multiple groups for the same outcome. The goal is to recover the major population groups within the DPS to a point where:

1. At least one-half of the populations historically within the major population group (MPG; with a minimum of two populations) should meet viability standards.
2. At least one population should be classified as "Highly Viable."
3. Viable populations within an MPG should include some populations classified (based on historical intrinsic potential) as "Very Large," "Large," or "Intermediate," generally reflecting the proportions historically present within the MPG. In particular, Very Large and Large populations should be at or above their composite historical fraction within each MPG.
4. All major life history strategies (e.g. spring and summer-run timing) that were present historically within the MPG should be represented in populations meeting viability requirements.
5. Remaining MPG populations should be maintained with sufficient abundance, productivity, spatial structure, and diversity to provide for ecological functions and to preserve options for ESU/DPS recovery.

By achieving these goals, the minimum abundance and productivity of the populations will fit in the following size categories (Table 35):

Table 35. Middle Columbia River DPS steelhead recovery criteria.

Major Population Group	Population	Population Size	Abundance Threshold	Productivity Threshold
Cascades Eastern Slope Tributaries	White Salmon R	Basic	500	1.56
	Klickitat R	Intermediate	1000	1.35
	Fifteenmile Cr	Basic	500	1.56
	Deschutes R East	Intermediate	1000	1.35
	Deschutes R West	Large	1500	1.26
	Rock Creek	Basic	500	1.56
	Crooked R	Very Large	2250	1.19
John Day River	Lower mainstem John Day	Very Large	2250	1.19
	North Fork John Day	Large	1500	1.26
	Middle Fork John Day	Intermediate	1000	1.35
	South Fork John Day	Basic	500	1.56
	Upper mainstem John Day	Intermediate	1000	1.35
Umatilla/Walla Walla Rivers	Umatilla R	Large	1500	1.26
	Walla Walla R	Intermediate	1000	1.35
	Touchet R	Intermediate	1000	1.35
	Willow Cr	Intermediate	1000	1.35
Yakima River	Satus Cr	Intermediate	1000	1.35
	Toppenish Cr	Basic	500	1.56

Group	Naches R	Large	1500	1.26
	Upper Yakima	Large	1500	1.26

5.3.17 Steelhead Trout, Northern California DPS

On June 7, 2000, NMFS listed the Northern California (NC) DPS of steelhead (Figure 23) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. NMFS designated critical habitat for NC steelhead on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers in California coastal river basins from Redwood Creek to and including the Gualala River.

5.3.17.1 Threats

Northern California DPS steelhead face threats from habitat impediments (dams), habitat degradation, habitat loss, commercial and recreational fishing, and climate change. Habitat impediments have restricted access to historic spawning habitat. Habitat degradation and loss have restricted the spawning and rearing habitat still available. Commercial and recreational fisheries reduce survival rates and limit the number of adults returning to spawn. Steelhead are sensitive to warm waters and survival is strongly correlated with size. Climate change increases water temperatures and increases stress on juveniles and smolts, causing them to be more vulnerable upon entering the ocean environment.

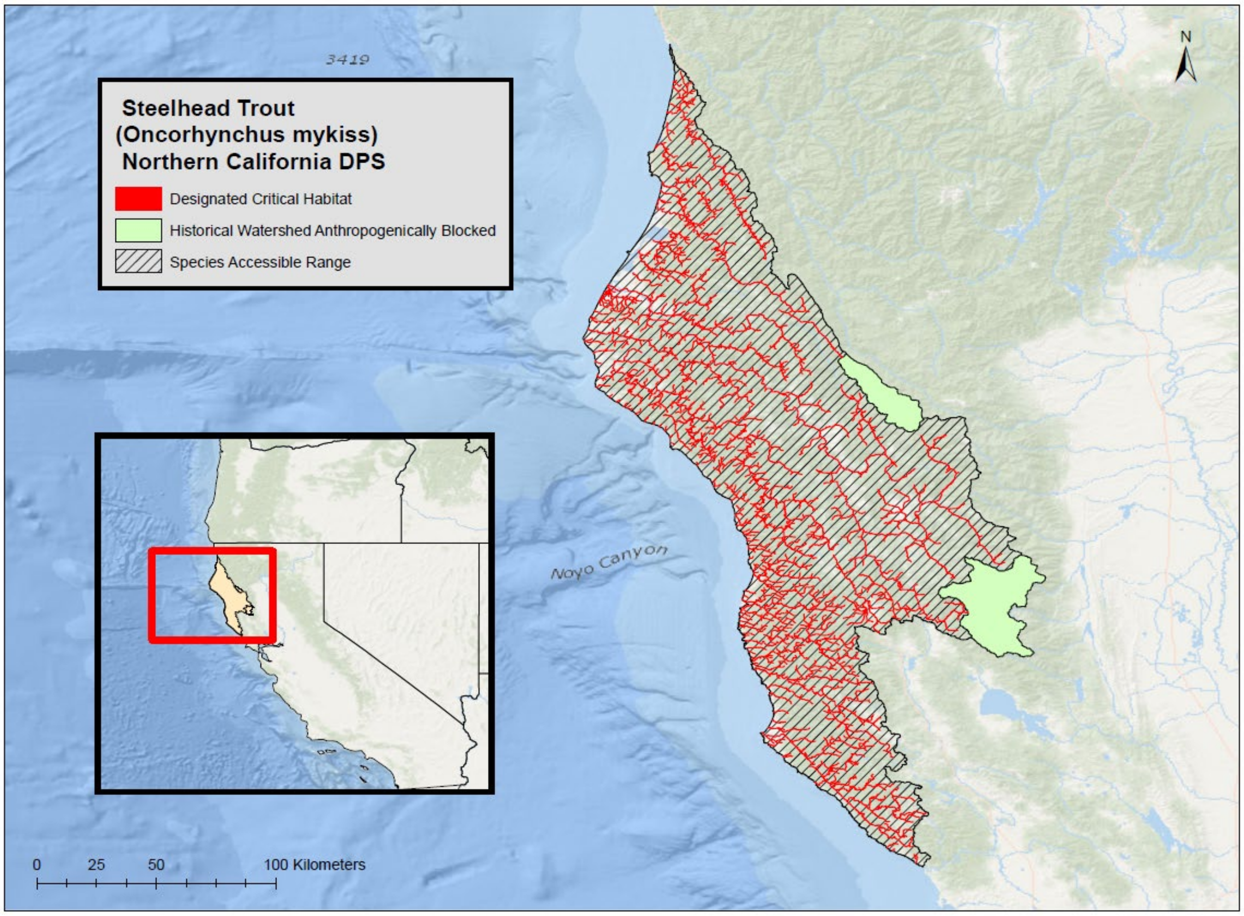

Figure 23. Steelhead, Northern California DPS range and designated critical habitat

5.3.17.2 Life History

This DPS includes both winter- and summer –run steelhead. In the Mad and Eel Rivers, immature steelhead may return to fresh water as "half-pounders" after spending only two to four months in the ocean. Generally, a half-pounder will overwinter in fresh water and return to the ocean 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 fresh water (Table 36; Busby et al. 1996). Smolts range from 14-21 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 1954a, Zedonis 1992).

Table 36. Temporal distribution of Steelhead, Northern California DPS.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Present</td></tr>
<tr><td>Spawning</td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Present</td></tr>
<tr><td>Incubation (eggs)</td><td></td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emergence (alevin to fry phases</td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.17.3 Population Dynamics

The available data for winter-run populations— predominantly in the North Coastal, North-Central Coastal, and Central Coastal strata— indicate that all populations are well below viability targets, most being between five and 13 percent of these goals. Populations appear to be small, but there is no strong evidence of increasing or decreasing trends. Northern California steelhead historic functionally independent populations and their abundances and hatchery contributions are provided in Table 37. Abundance estimates by life stage are presented in Table 38.

Table 37. Northern California DPS steelhead historic and recent spawner abundance.

Population	Historical Abundance	Recent Spawner Abundance	Hatchery Abundance Contributions
Mad River (S)	6,000	162-384	2%
MF Eel River (S)	Unknown	384-1,246	0%
NF Eel River (S)	Unknown	Extirpated	N/A
Mattole River (S)	Unknown	9-30*	Unknown
Redwood Creek (S)	Unknown	6*	Unknown
Van Duzen (W)	10,000	Unknown	Unknown
Mad River (W)	6,000	Unknown	Unknown
SF Eel River (W)	34,000	2743-20,657	Unknown
Mattole River (W)	12,000	Unknown	Unknown
Redwood Creek (W)	10,000	Unknown	Unknown
Humboldt Bay (W)	3,000	Unknown	Unknown
Freshwater Creek (W)		25-32	
Ten Mile River (W)	9,000	Unknown	Unknown
Noyo River (W)	8,000	186-364*	Unknown
Big River (W)	12,000	Unknown	Unknown
Navarro River (W)	16,000	Unknown	Unknown
Garcia River (W)	4,000	Unknown	Unknown
Gualala River (W)	16,000	Unknown	Unknown
Total	198,000	Unknown	

**From Spence et al. (2008). Redwood Creek abundance is the mean count over four generations. Mattole River abundances from surveys conducted between 1996 and 2005. Noyo River abundances from surveys conducted since 2000.*
Summer –run steelhead is noted with a (S) and winter-run steelhead with a (W)

Table 38. Current abundance estimates of adults and juveniles of the Northern California DPS steelhead (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	7,221
Natural	Juvenile	821,389

Good et al. (2005) estimated lambda at 0.98 with a 95% confidence interval of 0.93 and 1.04. The result is an overall downward trend in both the long- and short-term. Juvenile data were also recently examined. Both upward and downward trends were apparent (Good et al. 2005).

Reduction of summer-run steelhead populations has significantly reduced current DPS diversity compared to historic conditions. Of the 10 summer-run steelhead populations, only four are extant. Of these, only the Middle Fork Eel River population is at moderate risk of extinction, the remaining three are at high risk (Spence et al. 2008). Hatchery influence has likely been limited.

5.3.17.4 Designated Critical Habitat

PBFs considered essential for the conservation of Steelhead, Northern California DPS are shown in Table 5. The PBFs within critical habitat designated for Northern California DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of critical habitat designated for the NC steelhead is moderately degraded. Nevertheless, it does provide some conservation value necessary for species recovery. Within portions of its range, especially the interior Eel River, rearing PBF quality is affected by elevated temperatures by removal of riparian vegetation. Spawning PBF attributes such as the quality of substrate supporting spawning, incubation, and larval development have been generally degraded throughout designated critical habitat by silt and sediment fines in the spawning gravel. Bridges and culverts further restrict access to tributaries in many watersheds, especially in watersheds with forest road construction, thereby reducing the function of the adult migration PBF.

5.3.17.5 Recovery Goals

See the 2016 recovery plan for the Northern California steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2016d). The biological recovery criteria for these populations are:

- 27 essential independent populations attaining low extinction risk criteria (i.e., Garcia River, Gualala River, Navarro River, Chamise Creek, Outlet Creek, Tomki Creek, Woodman Creek, Larabee Creek, Middle Fork Eel River, North Fork Eel River, Upper Mainstem Eel River, Van Duzen River, Big River, Noyo River, Ten Mile River, Usal Creek, Wages Creek, Maple Creek/Big Lagoon, Bear River, Humboldt Bay Tributaries, Little River [Humboldt County], Mattole River, South Fork Eel River, Mad River [Upper], Mad River [Lower], and Redwood Creek [Upper] and Redwood [Lower Humboldt County]);

- Ten supporting independent populations attaining moderate extinction risk criteria (i.e., Brush Creek, Elk Creek, Bell Springs, Bucknell Creek, Dobbyn Creek, Garcia Creek, Jewett River, Albion River, Cottaneva Creek and Pudding Creek);
- 14 dependent populations contributing to redundancy and occupancy (i.e., Schooner Gulch, Soda Creek, Caspar Creek, Guthrie Creek, Oil Creek, Big Creek, Big Flat Creek, Howe Creek, Jackass Creek, Lower Mainstem Eel River, McNutt Gulch, Shipman Creek, Spanish Creek, and Telegraph Creek); and
- Ten independent summer-run steelhead populations expected to meet effective population size criteria (Redwood Creek, Mad River, South Fork Eel River, Mattole River, Van Duzen River, Larabee Creek, North Fork Eel River, Upper Middle Mainstem Eel River, Middle Fork Eel River, and Upper Mainstem Eel River).

5.3.18 Steelhead Trout, Snake River Basin

On August 18, 1997, NMFS listed the Snake River Basin DPS of steelhead (Figure 24) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. Critical habitat was designated for this species on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Snake River basin, and steelhead from six artificial propagation programs.

5.3.18.1 Threats

Snake River DPS steelhead face threats from habitat impediments (dams), habitat degradation, habitat loss, commercial and recreational fishing, and climate change. Habitat impediments have restricted access to historic spawning habitat. Habitat degradation and loss have restricted the spawning and rearing habitat still available. Commercial and recreational fisheries reduce survival rates and limit the number of adults returning to spawn. Steelhead are sensitive to warm waters and survival is strongly correlated with size. Climate change increases water temperatures and increases stress on juveniles and smolts, causing them to be more vulnerable upon entering the ocean environment.

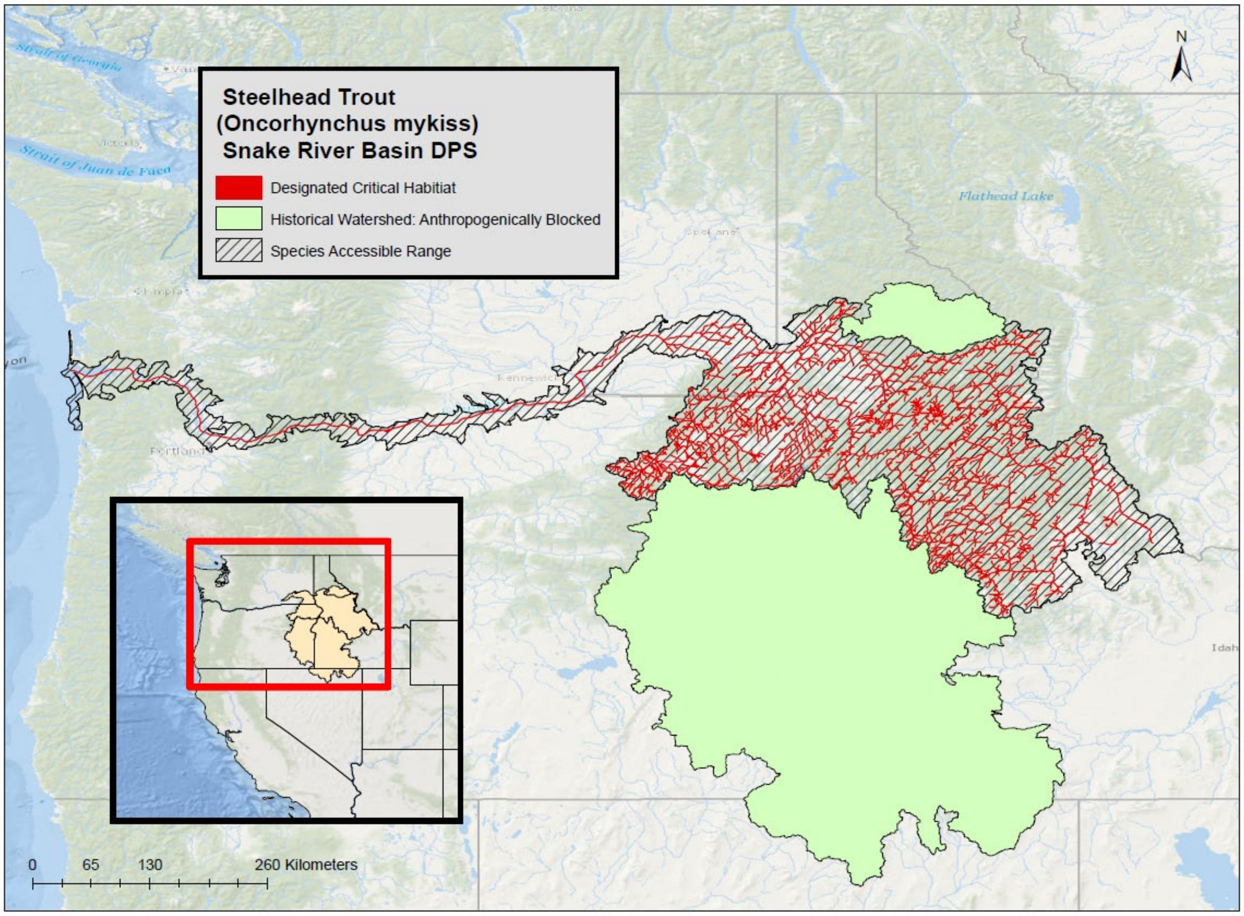

Figure 24. Steelhead, Snake River Basin DPS range and designated critical habitat

5.3.18.2 Life History

Snake River basin steelhead are generally classified as summer-run fish. They enter the Columbia River from late June to October (Table 39). 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 fresh water 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.

Table 39. Temporal distribution of Steelhead, Snake River Basin DPS.

<table>
<tr><td>Life History phase</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td><td>Dec</td></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td></td><td></td><td></td><td></td><td colspan="6">Present</td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td></td><td></td><td></td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.18.3 Population Dynamics

Recent declines of approximately 50% for all spawning populations in the past five years has resulted in essentially no change in abundance in the past 15 years. Hatchery origin spawners for this DPS are still low. Overall, the abundances remain well below interim recovery criteria. The five-year trends for each spawning population declined during each of those five years, resulting in lambda values below one for every spawning population. Current abundance estimates by life stage are presented in Table 40.

Table 40. Abundance estimates of adults and juveniles of the Snake River DPS steelhead population (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

5.3.18.4 Designated Critical Habitat

PBFs considered essential for the conservation of Snake River Basin DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for Snake River Basin DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of critical habitat designated for Snake River basin steelhead is moderately degraded. Critical habitat is affected by reduced quality of juvenile rearing and migration PBFs within many watersheds; contaminants from agriculture affect both water quality and food production in several watersheds and in the mainstem Columbia River. Loss of riparian vegetation to grazing has resulted in high water temperatures in the John Day basin. These factors have substantially reduced the rearing PBFs contribution to the conservation value necessary for species recovery. Several dams affect adult migration PBF by obstructing the migration corridor.

5.3.18.5 Recovery Goals

See the 2017 ESA Recovery Plan for Snake River Spring/Summer Chinook Salmon and Snake River Basin Steelhead for recovery goals, as well as the delisting criteria for this species (NMFS 2017b).

5.3.19 Steelhead Trout, South-Central California Coast DPS

On August 18, 1997, NMFS listed the South-Central California Coast (SCCC) DPS of steelhead (Figure 25) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. Critical habitat was designated for this species on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Pajaro River to (but not including) the Santa Maria River.

5.3.19.1 Threats

Human abundance increases after World War II and the associated land and water development within coastal drainages (particularly major dams and water diversions) leading to steelhead abundance rapidly declining. Populations were extirpated from many watersheds and only sporadic and remnant populations were left in the remaining, more highly modified watersheds such as the Salinas River and Arroyo Grande Creek watersheds (Boughton et al. 2007, Good et al. 2005). A substantial portion of the upper watersheds, which contain the majority of historical spawning and rearing habitats for anadromous *O. mykiss*, remain intact but inaccessible to anadromous fish because of dams.

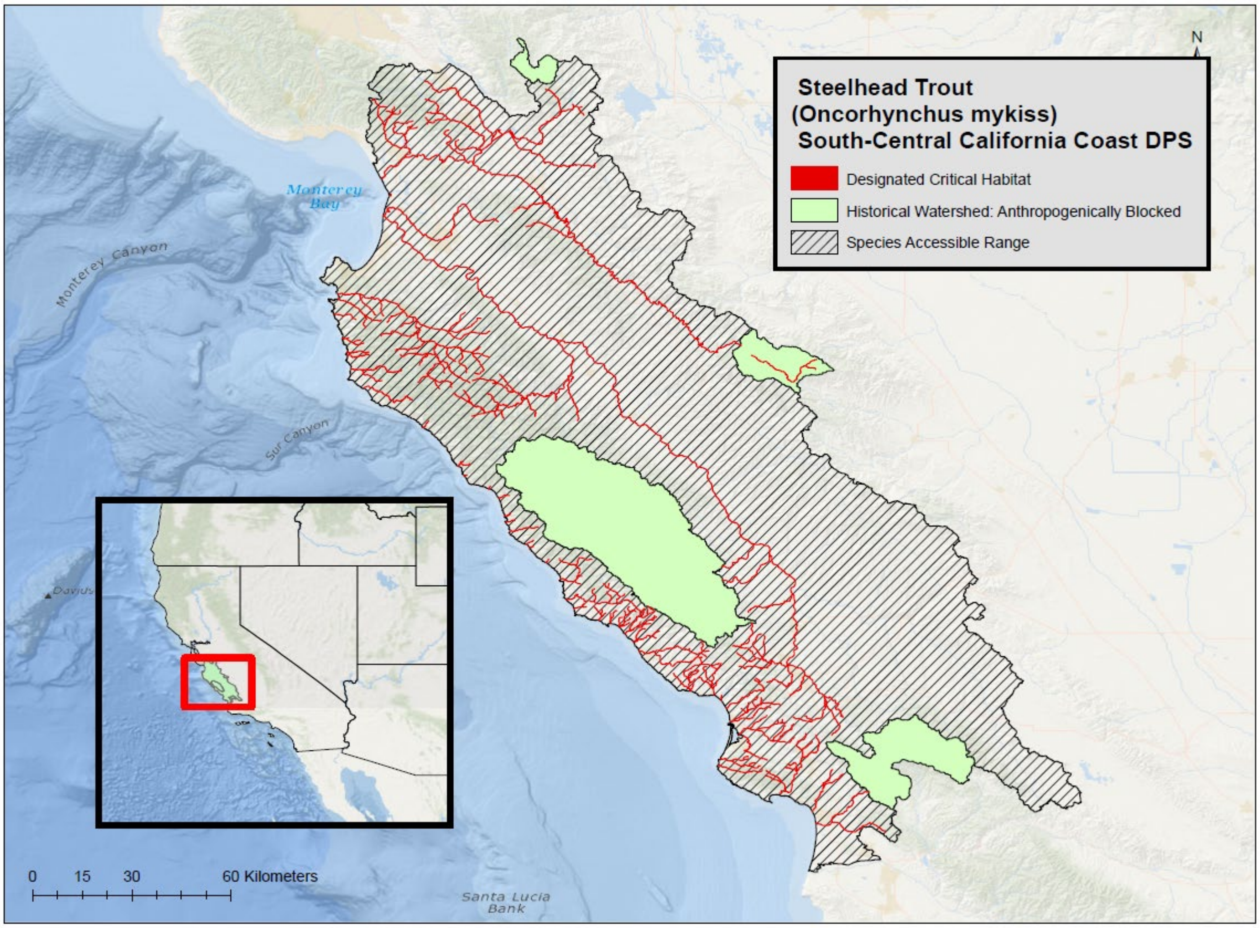

Figure 25. Steelhead, South-Central California Coast DPS range and designated critical habitat.

5.3.19.2 Life History

Only winter steelhead are found in this DPS. Migration and spawn timing are similar to adjacent steelhead populations (Table 41). There is limited life history information for steelhead in this DPS.

Table 41. Temporal distribution of Steelhead, South-Central California Coast DPS.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td></td><td></td><td></td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.19.3 Population Dynamics

The data 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. These runs are interrupted in years when the mouth of the coastal estuaries fail to open to the ocean due to low flows (Williams et al. 2011). Estimates of abundance by life stage for the SCCC DPS steelhead are presented in Table 42.

The Carmel River population was impaired by the San Clemente Dam, but supported returns of just under 400 adults each year until the fish ladder was removed and the river was routed around the dam to allow passage to historic spawning habitat (Figure 26). It is expected the river can support approximately 2,000 adults with access to spawning habitat.

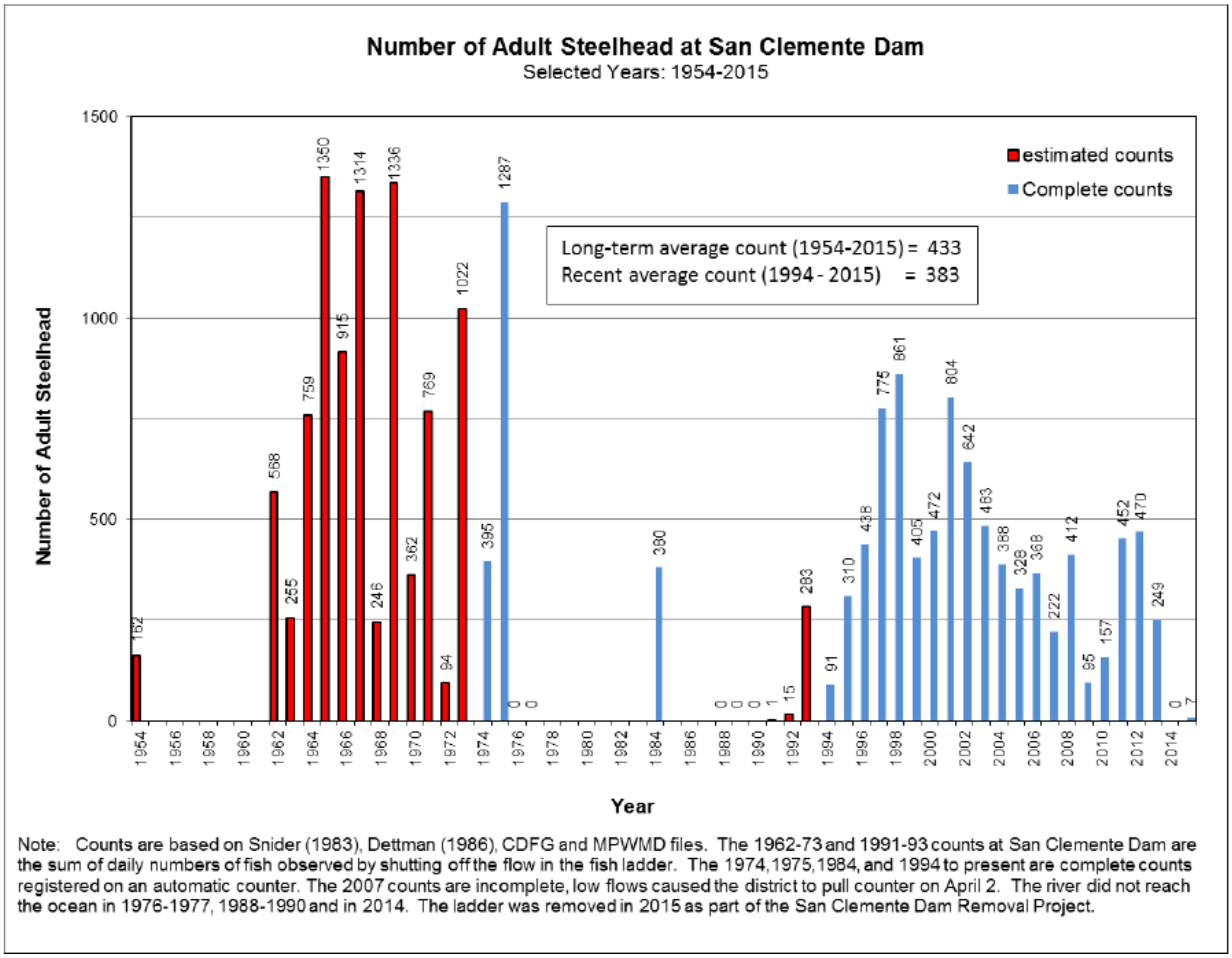

Figure 26. Carmel River steelhead counts from ladder passage over the San Clemente Dam.

Table 42. Abundance estimates by life stage of adults and juveniles in the South-Central California DPS steelhead population (NMFS 2020).

Production	Life Stage	Abundance
Natural	Adult	695
Natural	Juvenile	79,057

5.3.19.4 Designated Critical Habitat

PBFs considered essential for the conservation of SCCC DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for SCCC DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. Migration and rearing PBFs are degraded throughout critical habitat by elevated stream temperatures and contaminants from urban and agricultural areas. The estuarine PBF is impacted by most estuaries being breached, removal of structures, and contaminants.

5.3.19.5 Recovery Goals

See the 2013 recovery plan for the SCCC steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2013b). Recovery of the SCCC DPS will require the protection, restoration, and maintenance of habitats of sufficient quantity, quality, and natural complexity throughout their range. To achieve this, the following objectives were identified:

- Prevent steelhead extinction by protecting existing populations and their habitats;
- Maintain current distribution of steelhead and restore distribution to some previously occupied areas;
- Increase steelhead abundance 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 viable populations;
- Maintain and restore suitable habitat conditions and characteristics to support all life history stages of viable populations; and
- Conduct research and monitoring necessary to refine and demonstrate attainment of recovery criteria.

5.3.20 Steelhead Trout, Southern California DPS

On August 18, 1997 NMFS listed the Southern California DPS of steelhead (Figure 27) as endangered and reaffirmed the DPS's status as endangered on January 5, 2006. Critical habitat was designated for this species on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Santa Maria River to the U.S.-Mexico Border.

5.3.20.1 Threats

Southern California DPS steelhead face threats from habitat impediments (dams), habitat degradation, habitat loss, commercial and recreational fishing, and climate change. The extended drought and the recent genetic data documenting the high level of introgression and extirpation of native *O. mykiss* stocks in the southern portion of the DPS has elevated the threats level to the already endangered populations. The drought, and the lack of comprehensive monitoring, has also limited the ability to fully assess the status of individual populations and the DPS as a

whole. The systemic anthropogenic threats identified at the time of the initial listing have remained essentially unchanged over the past five years, though there has been significant progress in removing fish passage barriers in a number of the smaller and mid-sized watersheds. Threats to the Southern California Steelhead DPS posed by environmental variability resulting from projected climate change are likely to exacerbate the factors affecting the continued existence of the DPS.

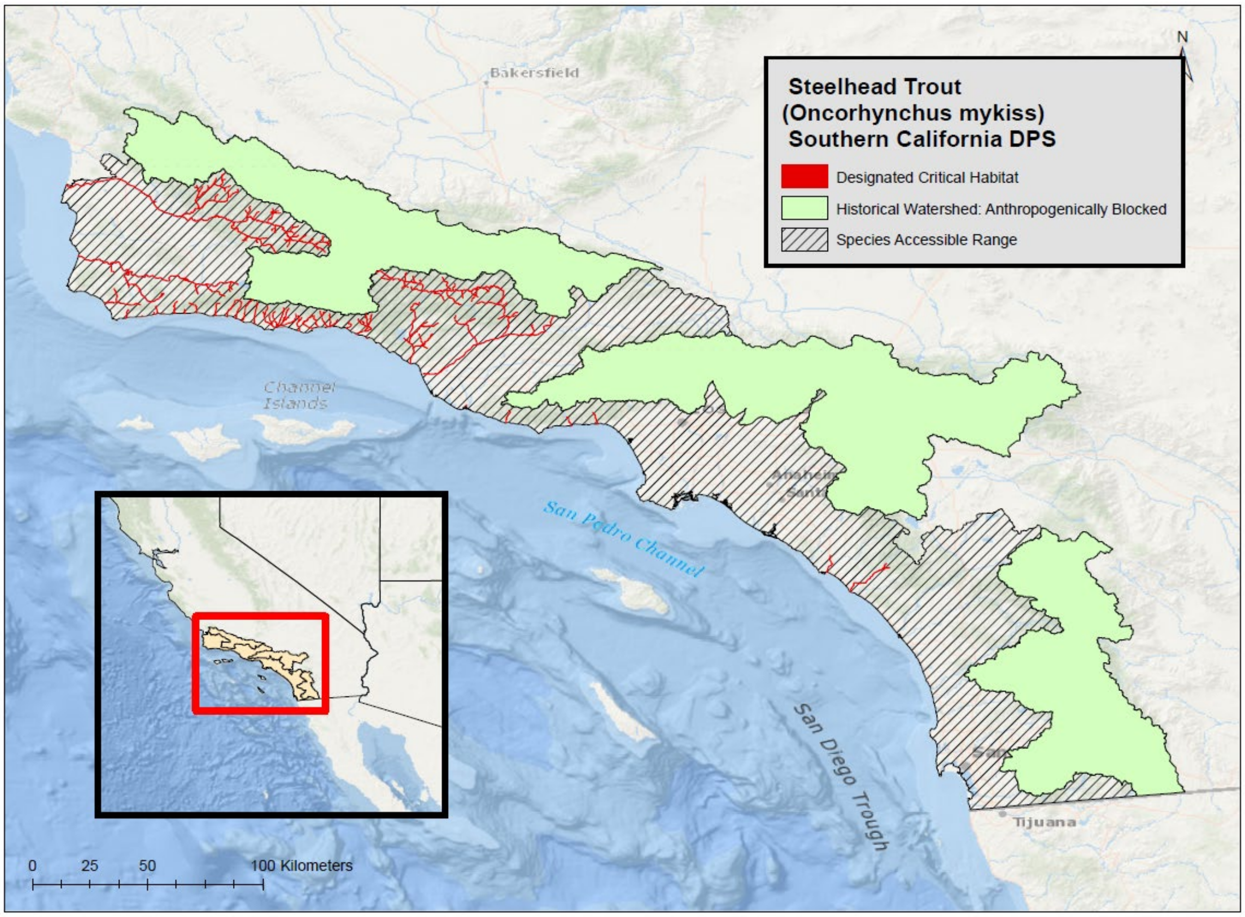

Figure 27. Steelhead, Southern California DPS range and designated critical habitat

5.3.20.2 Life History

There is limited life history information for Southern California steelhead. In general, migration and life history patterns of Southern California steelhead populations are dependent on rainfall and streamflow (Moore 1980). Steelhead within this DPS can withstand higher temperatures compared to populations to the north. The relatively warm and productive waters of the Ventura River have resulted in more rapid growth of juvenile steelhead compared to the more northerly populations (Table 43; Moore 1980).

Table 43. Temporal distribution of Steelhead, Southern California DPS.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td></td><td colspan="4">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Present</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.20.3 Population Dynamics

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. 1996). There is little new evidence to indicate that the status of the Southern California Coast Steelhead DPS has changed appreciably in either direction since the last status review (Williams et al. 2011).

5.3.20.4 Designated Critical Habitat

PBFs considered essential for the conservation of Southern California DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for Southern California DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. All PBFs have been affected by degraded water quality by pollutants from densely populated areas and agriculture within the DPS. Elevated water temperatures affect rearing and juvenile migration PBFs in all river basins and estuaries. Rearing and spawning PBFs have also been affected throughout the DPS by management or reduction in water quantity. The spawning PBF has also been affected by the combination of erosive geology and land management activities that have resulted in an excessive amount of fine-sized particles in the spawning gravel of most rivers.

5.3.20.5 Recovery Goals

See the 2012 recovery plan for the southern California steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2012). A viable population is defined as a population having a negligible risk (less than five percent) of extinction due to threats from demographic variation, natural environmental variation, and genetic diversity changes over a 100-year time frame. A viable DPS is comprised of a sufficient number of viable populations spatially dispersed, but proximate enough to maintain long-term (1,000-year) persistence and evolutionary potential (McElhany et al. 2000). The viability criteria are intended to describe characteristics of the species, within its natural environment, necessary for both individual populations and the DPS as a whole to be viable, i.e., persist over a specific period, regardless of other ongoing effects caused by human actions.

Recovery of the endangered Southern California Steelhead DPS will require recovery of a minimum number of viable populations within each of five population groups within their range. Recovery of these individual populations is necessary to conserve the natural diversity (genetic, phenotypic, and behavioral), spatial distribution, and abundance of the species, and thus the long-term viability of the DPS. Each population must exhibit a set of biological characteristics (e.g., minimum mean annual run size, persistence over variable oceanic conditions, spawner density, anadromous fraction, etc.) in order to be considered viable.

5.3.21 Steelhead Trout, Upper Columbia River DPS

On August 18, 1997 NMFS listed the UCR DPS of steelhead (Figure 28) as endangered and reaffirmed the DPS's status as endangered on January 5, 2006. Critical habitat was designated for this species on September 2, 2005. This DPS includes naturally spawned anadromous *O. mykiss* (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 and steelhead from six artificial propagation programs.

5.3.21.1 Threats

Upper Columbia River DPS steelhead face threats from habitat impediments (dams), habitat degradation, habitat loss, commercial and recreational fishing, and climate change. 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 populations (NWFSC 2015). 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 2015).

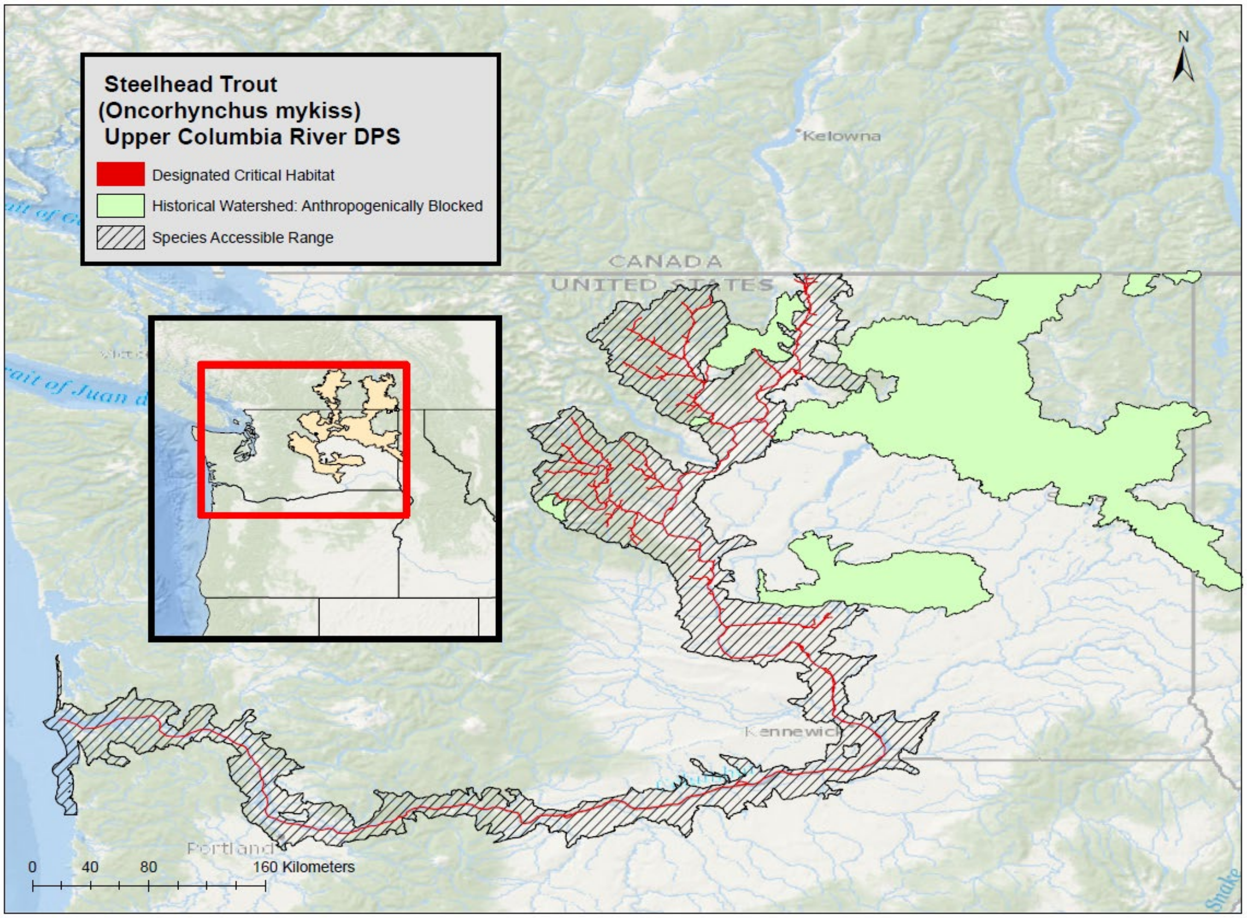

Figure 28. Steelhead, Upper Columbia River DPS range and designated critical habitat

5.3.21.2 Life History

All UCR steelhead are summer-run steelhead. Adults return in the late summer and early fall, with most migrating relatively quickly to their natal tributaries (Table 44). A portion of the returning adult steelhead overwinters 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 fresh water before migrating to sea. Smolt outmigrations 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 fresh water after one or two years at sea.

Table 44. Temporal distribution of Steelhead, Upper Columbia River DPS.

Life History phase	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Entering Fresh Water (adults/jacks)	Present											
Spawning			Present									
Incubation (eggs)			Present									
Emergence (alevin to fry phases					Present							
Rearing and migration (juveniles)	Present											

5.3.21.3 Population Dynamics

Returns of both hatchery and naturally produced steelhead to the UCR have decreased dramatically in the last five years, causing the 15-year trend to be negative. The abundance information for 2015 to 2019 suggests a roughly 50% decrease in three of the four spawning populations. The geometric mean abundance through time is presented in Table 45. Abundance estimates of all individuals broken out by life stage are presented in Table 46.

Table 45. Five-year geometric mean of raw total spawner counts (natural and hatchery). The geometric mean was computed as the product of counts raised to the power 1 over the number of counts available (2 to 5). A minimum of two values was used to compute the geometric mean. Percent change between the most recent two 5-year periods is shown on the far right.

Population	MPG	1990-1994	1995-1999	2000-2004	2005-2009	2010-2014	2015-2019	% Change
Wenatchee R.	North Cascades	1847	741	2319	1857	2774	1104	-60
Entiat R.	North Cascades	134	201	491	462	688	280	-59
Methow R.	North Cascades	1206	937	4255	3599	3833	1954	-49
Okanogan R.	North Cascades	678	526	2178	1328	2122	1020	-52

Table 46. Abundance estimates by life stage for the UCR DPS steelhead population (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

5.3.21.4 Designated Critical Habitat

PBFs considered essential for the conservation of UCR DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for UCR DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of critical habitat designated for the UCR steelhead is moderately degraded. Habitat quality in tributary streams varies from excellent in wilderness and roadless areas to poor in areas subject to heavy agricultural and urban development. Critical habitat is affected by reduced quality of juvenile rearing and migration PBFs within many watersheds; contaminants from agriculture affect both water quality and food production in several watersheds and in the mainstem Columbia River. Several dams affect the adult migration PBF by obstructing the migration corridor.

5.3.21.5 Recovery Goals

See the 2007 recovery plan for the UCR steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2007a).

5.3.22 Steelhead Trout, Upper Willamette River DPS

On March 25, 1999, NMFS listed the UWR DPS of steelhead (Figure 29) as threatened and reaffirmed the DPS's status as threatened on January 5, 2006. NMFS designated critical habitat for this species on September 2, 2005. 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.

5.3.22.1 Threats

UWR DPS steelhead face threats from habitat impediments (dams), habitat degradation, habitat loss, commercial and recreational fishing, and climate change. About 30 percent of all habitat for this species has been lost due to human activities (McElhany et al. 2007a). 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.

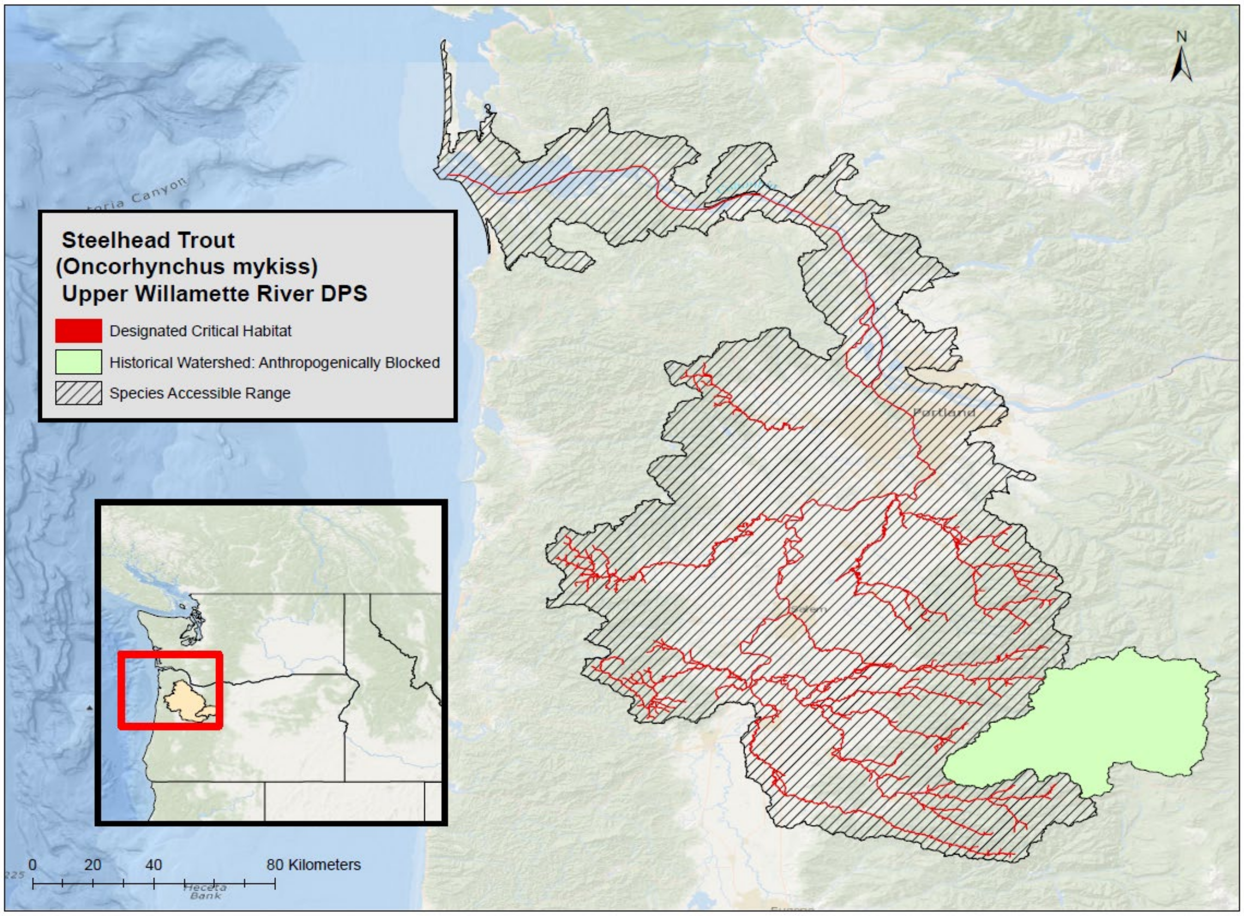

Figure 29. Steelhead, Upper Willamette River DPS range and designated critical habitat

5.3.22.2 Life History

Native steelhead in the UWR are a late-migrating winter group that enters fresh water in January and February (Howell et al. 1985). UWR 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 (Table 47). 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 the Multnomah Channel rather than the mouth of the Willamette River. As with other coastal steelhead, the majority of juveniles smolt and 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. 1996).

Table 47. Temporal distribution of Steelhead, Upper Willamette River DPS.

<table>
<tr><th>Life History phase</th><th>Jan</th><th>Feb</th><th>Mar</th><th>Apr</th><th>May</th><th>Jun</th><th>Jul</th><th>Aug</th><th>Sep</th><th>Oct</th><th>Nov</th><th>Dec</th></tr>
<tr><td>Entering Fresh Water (adults/jacks)</td><td colspan="6">Present</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Spawning</td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Incubation (eggs)</td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Emergence (alevin to fry phases)</td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Present</td><td></td><td></td><td></td></tr>
<tr><td>Rearing and migration (juveniles)</td><td colspan="12">Present</td></tr>
</table>

5.3.22.3 Population Dynamics

UWR steelhead are moderately depressed from historical levels (McElhany et al. 2007a). Average number of late-fall steelhead passing Willamette Falls decreased during the 1990s to less than 5,000 fish. The number increased to over 10,000 fish in 2001 and 2002. The geometric and arithmetic mean number of late-run steelhead passing Willamette Falls for the period 1998 to 2001 were 5,819 and 6,795, respectively.

Four basins on the east side of the Willamette River historically supported independent populations for the UWR steelhead, all of which remain extant. Data reported in McElhaney et al. (2007) 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.

Population information for individual basins exist as redds per (river) mile. These redd counts show a declining long-term trend for all populations (Good et al. 2005). One population, the Calapooia, had a positive short-term trend during the years from 1990 to 2001. McElhany et al. (2007a) found that the populations had a low risk of extinction. Two of the populations were considered at moderate risk from failed abundances and recruitment levels and two (North and South Santiam Rivers) were considered at low risk given current abundances and recruitment (McElhany et al. 2007a). Abundance estimates by life stage are provided in Table 48.

Table 48. Abundance estimate by life stage for the Upper Willamette River DPS steelhead population (NMF 2020).

Production	Life Stage	Abundance
Natural	Adult	2,912
Natural	Juvenile	143,898

5.3.22.4 Designated Critical Habitat

PBFs considered essential for the conservation of UWR DPS steelhead are shown in Table 5. The PBFs within critical habitat designated for UWR DPS steelhead that could be affected during fire retardant application include: (1) freshwater spawning; (2) freshwater rearing; and (3) freshwater migration. The current condition of critical habitat designated for the UWR steelhead is degraded, and provides a reduced conservation value necessary for species recovery. Critical habitat is affected by reduced quality of juvenile rearing and migration PBFs within many

watersheds; contaminants from agriculture affect both water quality and food production in several watersheds and in the mainstem Columbia River. Several dams affect the adult migration PBF by obstructing the migration corridor.

5.3.22.5 Recovery Goals

See the 2011 recovery plan for the UWR steelhead DPS for complete down-listing/delisting criteria for recovery goals for the species (NMFS 2011c).

5.3.23 Southern DPS Green Sturgeon

The southern DPS of green sturgeon was listed as threatened on April 7, 2006. Critical habitat was designated on October 9, 2009. This DPS includes all naturally-spawned populations of green sturgeon that occur south of the Eel River in Humboldt County, California.

5.3.23.1 Threats

The biggest threat to this DPS is the reduction in spawning habitat to a single population limited to a small portion of the Sacramento River. In addition to loss of freshwater spawning habitat, degradation of freshwater and estuarine habitat quality, water diversions, and fishing also pose threats to this DPS (NMFS 2018). While the extent of the threat is not clear, water diversions (Poletto et al. 2014) and poaching (NMFS 2018) for caviar are thought to be significant risks.

5.3.23.2 Life History

Southern DPS green sturgeon spawn in the Sacramento and Feather Rivers and possibly in the Russian River. As an iteroparous anadromous fish, they spawn in freshwater areas in the upper accessible areas of the Sacramento River system from April through early July. They enter the lower Sacramento River during the winter and spring. Adults spawn every three to four years, typically (Table 49). It is possible there is dual spawning in the river because larvae have been collected in October as well. Some adults will hold in the river after spawning and outmigrate in the fall and winter while others will leave the river quickly after spawning. Juveniles will rear in the mainstem of the Sacramento for roughly 1.5 years, leaving at the end of their first year at the earliest.

Table 49. Temporal distribution of green sturgeon in the Sacramento River.

Life stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult												
Eggs												
Juveniles												

5.3.23.3 Population Dynamics

The most updated estimate for spawning adult abundance in the Sacramento River ranges from 1,246 to 2,966 individuals with a total population abundance of approximately 17,550 individuals (Mora et al. 2018). At this point, there are no data to support an analysis of trends in

the abundance.

5.3.23.4 Designated Critical Habitat

A Critical Habitat Review Team (CHRT) identified and analyzed the conservation value of particular areas occupied by southern green sturgeon, and unoccupied areas they felt are necessary to ensure the conservation of the species. The CHRT did not identify those areas using HUC nomenclature, but did provide geographic place names for the areas, including the names of freshwater rivers, the bypasses, the Sacramento-San Joaquin Delta, coastal bays and estuaries, and coastal marine areas (within 110 m depth) extending from the California/Mexico border north to Monterey Bay, California, and from the Alaska/Canada border northwest to the Bering Strait; and certain coastal bays and estuaries in California, Oregon, and Washington.

For freshwater rivers north of and including the Eel River, the areas upstream of the head of the tide were not considered part of the geographical area occupied by the southern DPS. However, the critical habitat designation recognizes not only the importance of natal habitats, but of habitats throughout their range. Critical habitat has been designated in coastal U.S. marine waters 60 fathoms in depth from Monterey Bay, California (including Monterey Bay), north to Cape Flattery, Washington, including the Strait of Juan de Fuca, Washington, to its US boundary; the Sacramento River, lower Feather River, and lower Yuba River in California; the Sacramento-San Joaquin Delta and Suisun, San Pablo, and San Francisco Bays in California; the lower Columbia River estuary; and certain coastal bays and estuaries in California (Humboldt Bay), Oregon (Coos Bay, Winchester Bay, Yaquina Bay, and Nehalem Bay), and Washington (Willapa Bay and Grays Harbor), and freshwater. Table 50 delineates the PBFs for southern green sturgeon.

Table 50. Physical or biological features of critical habitat designated for southern green sturgeon and corresponding species life history events.

Physical or Biological Features Site Type	Physical or Biological Features Site Attribute	Species Life History Event
Freshwater riverine system	Food resources Migratory corridor Sediment quality Substrate type or size Water depth Water flow Water quality	Adult spawning Embryo incubation, growth and development Larval emergence, growth and development Juvenile metamorphosis, growth and development
Estuarine areas	Food resources Migratory corridor Sediment quality Water flow Water depth Water quality	Juvenile growth, development, seaward migration Subadult growth, development, seasonal holding, and movement between estuarine and marine areas Adult growth, development, seasonal holding, movements between estuarine and marine areas, upstream spawning movement, and seaward post-spawning movement
Coastal marine areas	Food resources Migratory corridor Water quality	Subadult growth and development, movement between estuarine and marine areas, and migration between marine areas Adult sexual maturation, growth and development, movements between estuarine and marine areas, migration between marine areas, and spawning migration

The CHRT identified several activities that threaten the PBFs in coastal bays and estuaries and necessitate the need for special management considerations or protection. The application of pesticides is likely to adversely affect prey resources and water quality within the bays and estuaries, as well as the growth and reproductive health of Southern DPS green sturgeon through bioaccumulation. Other activities of concern include those that disturb bottom substrates, adversely affect prey resources, or degrade water quality through re-suspension of contaminated sediments. Of particular concern are activities that affect prey resources. Prey resources are affected by: commercial shipping and activities generating point source pollution and non-point source pollution that discharge contaminants and result in bioaccumulation of contaminants in green sturgeon; disposal of dredged materials that bury prey resources; and bottom trawl fisheries that disturb the bottom (but result in beneficial or adverse effects on prey resources for green sturgeon). In addition, petroleum spills from commercial shipping and proposed hydrokinetic energy projects are likely to affect water quality or hinder the migration of green sturgeon along the coast (NMFS 2018).

5.3.23.5 Recovery Goals

The recovery plan (NMFS 2018) identifies a two-pronged approach to recovering the southern DPS of green sturgeon. The first approach identifies demographic recovery criteria. This involves abundance goals for adults and sub-adults, as well as increasing the spawning rivers. The second approach is threat-based, which addresses the main threats to green sturgeon recovery and proposes solutions.

5.3.24 Southern DPS Pacific Eulachon

The southern DPS of Pacific eulachon was listed as threatened on March 18, 2010. Critical habitat was designated on October 20, 2011. This DPS includes all naturally-spawned populations of eulachon spawning between the Mad River in northern California and the Skeena River, British Columbia.

5.3.24.1 Threats

The major threats to eulachon are impacts of climate change on oceanic and freshwater habitats (species-wide), fishery by-catch (species-wide), dams and water diversions (Klamath and Columbia subpopulations) and predation (species-wide; NMFS 2017c). They are a small, highly fecund, short-lived fish that can be relatively responsive to most threats, if temporary. However, at the same time, long-lasting threats, particularly to spawning success, pose a great risk to this species as frequent and successful reproduction is needed to sustain the population.

5.3.24.2 Life History

Eulachon leave salt water to spawn in their natal streams late winter through early summer, and typically spawn at night in the lower reaches of larger rivers fed by snowmelt (Table 51). After hatching, larvae are carried downstream and widely dispersed by estuarine and ocean currents. Eulachon movements in the ocean are poorly known, although the amount of eulachon bycatch in the pink shrimp fishery seems to indicate that the distribution of these organisms overlap in the ocean.

Table 51. Temporal distribution of southern DPS Pacific eulachon in freshwater habitats.

Life stage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult		■	■	■	■	■						
Eggs			■	■	■	■						
Juveniles												

5.3.24.3 Population Dynamics

In the early 1990s, there was an abrupt decline in the abundance of eulachon returning to the Columbia River with no evidence of returning to their former population levels since then (Drake et al. 2008). Eulachon abundance in monitored rivers has generally improved, especially in the 2013-2015 return years. However, recent poor ocean conditions and the likelihood that these conditions will persist into the near future suggest that population declines may be widespread in the upcoming return years. Therefore, it is too early to tell whether recent improvements in the status of southern DPS of eulachon will persist or whether a return to the severely depressed abundance years of the mid-late 1990s and late 2000s will recur (NMFS 2017c).

5.3.24.4 Designated Critical Habitat

Critical habitat for eulachon includes portions of 16 rivers and streams in California, Oregon, and Washington. All of these areas are designated as migration and spawning habitat for this species.

In Oregon, 24.2 miles of the lower Umpqua River, 12.4 miles of the lower Sandy River, and 0.2 miles of Tenmile Creek have been designated. The mainstem Columbia River from the mouth to the base of Bonneville Dam, a distance of 143.2 miles is also designated as critical habitat. Table 52 delineates the designated physical or biological features for eulachon.

Table 52. Physical or biological features of critical habitats designated for eulachon and corresponding species life history events.

Physical or biological features Site Type	Physical or biological features Site Attribute	Species Life History Event
Freshwater spawning and incubation	Flow Water quality Water temperature Substrate	Adult spawning Incubation
Freshwater migration	Flow Water quality Water temperature Food	Adult and larval mobility Larval feeding

The range of eulachon in the Pacific Northwest completely overlaps with the range of several ESA-listed stocks of salmon and steelhead, as well as green sturgeon. Although the habitat requirements of these fishes differ somewhat from eulachon, efforts to protect habitat generally focus on the maintenance of watershed processes that would be expected to benefit eulachon. The biological review team (BRT) identified dams and water diversions as moderate threats to eulachon in the Columbia and Klamath rivers where hydropower generation and flood control are major activities. Degraded water quality is common in some areas occupied by southern DPS eulachon. In the Columbia and Klamath systems, large-scale impoundment of water has increased winter water temperatures, potentially altering the water temperature during eulachon spawning periods (Gustafson et al. 2010). Numerous chemical contaminants are also present in spawning rivers, but the exact effect these compounds have on spawning and egg development is unknown (Gustafson et al. 2010). The BRT identified dredging as a low to moderate threat to eulachon in the Columbia River. Dredging during eulachon spawning would be particularly detrimental.

The lower Columbia River mainstem provides spawning and incubation sites, and a large migratory corridor to spawning areas in the tributaries. Prior to the construction of Bonneville Dam, eulachon ascended the Columbia River as far as Hood River, Oregon. Major tributaries that support spawning runs include the Grays, Skamokawa, Elochoman, Kalama, Lewis and Sandy Rivers.

The number of eulachon returning to the Umpqua River seems to have declined in the 1980s, and does not appear to have rebounded to previous levels. Additionally, eulachon are regularly caught in salmonid smolt traps operated in the lower reaches of Tenmile Creek by the Oregon Department of Fish and Wildlife (ODFW).

5.3.24.5 Recovery Goals

More remains to be discovered about Pacific eulachon than is currently known. Recovery criteria were developed with the understanding that, as more is learned, the criteria will need to be updated, though the recovery goals are developed within a framework that, if achieved, will lead to recovery. Identified priority actions will focus on identifying abundance and productivity, spawning habitat, and subpopulation structure. With this knowledge, recovery will:

1. Increase abundance,
2. Protect and enhance the genetic, life history, and spatial diversity of eulachon, and
3. Reduce existing threats.

5.3.25 Shortnose Sturgeon

Shortnose sturgeon were first listed under the Endangered Species Preservation Act on October 15, 1966. When the ESA was signed into law, replacing the Endangered Species Preservation Act, shortnose sturgeon remained listed as endangered. No critical habitat has been designated. Shortnose sturgeon are listed range-wide from the St. John River in Canada to the St. Johns River in Florida.

5.3.25.1 Threats

The most significant threats to the species are dams that block access to spawning areas or lower parts of rivers, poor water quality, dredging, water withdrawals from rivers, and unintended catch in some commercial fisheries. Shortnose sturgeon are present in four rivers that run through the Francis Marion (Santee-Cooper System), Sumter, Croatan, and Ocala (St. Johns River) National Forests: Santee-Cooper system, Savannah, Neuse, and St. Johns Rivers. The primary threat to the Santee-Cooper system and the Savannah River are the dams, which redirect water and obstruct spawning migrations, but also reduce dissolved oxygen (DO) concentrations downstream. The St. Johns River is the southern extent of shortnose sturgeon habitat and therefore has water quality that is stressful, including high temperatures and low DO.

5.3.25.2 Life History

Shortnose sturgeon are considered amphidromous, meaning that rather than full saltwater migrations like anadromous species make, they tend to migrate between freshwater habitats of their natal rivers and the mesohaline estuaries of their natal rivers. When they move into marine environments, their migrations tend to be brief and they often enter neighboring river’s estuaries. Because of this, adults and juveniles can be found all year in rivers in their range.

5.3.25.3 Population Dynamics

Shortnose sturgeon form three metapopulations along the Atlantic Coast, separated into a northeastern group from Canada to the Delaware River, a mid-Atlantic group in the Chesapeake Bay and North Carolina, and a southeastern group below North Carolina (King et al. 2014). Abundance has remained relatively stable throughout their range over the past decade (NMFS 2010). Unfortunately, the only known spawning population in the mid-Atlantic region is in the Cape Fear River and may have an abundance of only about one hundred fish. Shortnose sturgeon are thought to be extirpated from the Neuse River (Oakley and Hightower 2007).

In the southeastern metapopulation, the shortnose sturgeon population in the Santee-Cooper system is declining due to the operation of the Pinopolis and Santee Dams, which has shifted the primary flow of the system from the Santee River to the Cooper River. As a result, the hydropower companies are currently attempting to relocate shortnose sturgeon adults from the Santee River to the Cooper River in hopes of increasing spawning success. The Savannah River supports annual shortnose sturgeon reproduction with total individual abundance of under 2,000 (Bahr and Peterson 2017). Little is known of the status of the St. Johns River population, if it is extant.

5.3.25.4 Critical Habitat

Critical habitat has not been designated for this species.

5.3.25.5 Recovery Goals

The recovery plan identifies 19 population segments within their range with a goal of each segment maintaining a minimum population size to maintain genetic diversity and avoid extinction (NMFS 1998). The actions needed are:

1. Establish listing criteria for shortnose sturgeon population segments
2. Protect shortnose sturgeon and their habitats
3. Rehabilitate shortnose sturgeon populations and habitats
4. Implement recovery tasks

5.3.26 Chesapeake Bay DPS Atlantic Sturgeon

The Chesapeake Bay DPS of Atlantic sturgeon was listed as endangered on February 6, 2012. Critical habitat was designated on August 17, 2017. This DPS includes all Atlantic sturgeons that are spawned in the watersheds that drain into the Chesapeake Bay and into coastal waters from the Delaware-Maryland border on Fenwick Island to Cape Henry, Virginia.

5.3.26.1 Threats

Range-wide, the most significant threats to Atlantic sturgeon are unintended catch in some commercial fisheries, poor water quality (which harms development of sturgeon offspring), dredging of spawning areas, water withdrawals from rivers, and vessel strikes (NMFS 2007b). In the Chesapeake Bay, the greatest threats to populations may be availability of spawning habitat,

water quality, water withdrawals, ship strikes, and non-native species. However, Atlantic sturgeon are highly migratory species and are subjected to threats present in various localities along the Atlantic Coast.

5.3.26.2 Life History

In the Chesapeake Bay, there are two confirmed spawning populations and two suspected spawning populations. The two confirmed spawns are both from August to November in the James and York Rivers. Another late summer and early fall spawning event is suspected in the Nanticoke River. A spring spawn has been hypothesized in the James River as well, though no gravid females or larvae have ever been collected (White et al. 2021). Telemetry data suggests adult and sub-adult Atlantic sturgeon can be found in estuaries along the coast, migrating up non-natal rivers to the saltwater interface. Whether in natal or non-natal rivers, Atlantic sturgeon tend to be found in estuaries and rivers in the spring (February through June) and again in the fall (August through November).

5.3.26.3 Population Dynamics

The two confirmed spawning populations in the Chesapeake Bay are quite different. The James River appears to be relatively abundant, though no efforts at estimating abundance have ever been undertaken. The York River population is extremely small with annual spawning run abundances of between 52 and 330 (Kahn et al. 2019, Kahn et al. 2021) between 2013 and 2020. The James River appears to support periodic reproductive success with the most recent documented year class from the 2018 fall spawning adults. The York River also supports unknown levels of reproductive success with only a single young-of-year individual captured since 2012. Estimates of survival suggest individuals from the Chesapeake Bay DPS have similar mortality rates to individuals from other populations (ASMFC 2017).

5.3.26.4 Designated Critical Habitat

Spawning habitat amounting to approximately 729 km (453 miles) of aquatic habitat in rivers in Maryland, Virginia, and the District of Columbia for the Chesapeake Bay DPS of Atlantic sturgeon was designated as critical habitat. The protected areas in this DPS are the Susquehanna, Potomac, Rappahannock, York, and James Rivers from their mouths upstream to the fall line or the lowest dam with the exception of the York River, which was only protected upstream to where Rt. 360 crosses its two main tributaries.

PBFs of Atlantic sturgeon critical habitat are:

- Hard bottom substrate (*e.g.,* rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.,* 0.0 to 0.5 parts per thousand range) for settlement of fertilized eggs, refuge, growth, and development of early life stages;
- Aquatic habitat with a gradual downstream salinity gradient of 0.5 to 30 parts per thousand and soft substrate (*e.g.,* sand, mud) downstream of spawning sites for juvenile foraging and physiological development;

- Water of appropriate depth and absent physical barriers to passage (*e.g.,* locks, dams, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) Unimpeded movement of adults to and from spawning sites; (2) seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (3) staging, resting, or holding of subadults or spawning condition adults. Water depths in main river channels must also be deep enough (*e.g.,* ≥1.2 m) to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river; and
- Water, especially in the bottom meter of the water column, with the temperature, salinity, and oxygen values that, combined, support: (1) Spawning; (2) annual and interannual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment (*e.g.,* 13 °C to 26 °C for spawning habitat and no more than 30° C for juvenile rearing habitat, and 6 mg/L DO for juvenile rearing habitat).

5.3.26.5 Recovery Goals
There are no identified recovery goals for this species.

5.3.27 Carolina DPS Atlantic Sturgeon
The Carolina DPS of Atlantic sturgeon was listed as endangered on February 6, 2012. Critical habitat was designated on June 3, 2016. This DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) from Albemarle Sound southward along the southern Virginia, North Carolina, and South Carolina coastal areas to Charleston Harbor.

5.3.27.1 Threats
Range-wide, the most significant threats to Atlantic sturgeon are unintended catch in some commercial fisheries, dams that block access to spawning areas, poor water quality (which harms development of sturgeon offspring), dredging of spawning areas, water withdrawals from rivers, and vessel strikes (NMFS 2007b). In North and South Carolina, the greatest threats to populations may be access to historic spawning habitat, water quality, number of spawning individuals, and bycatch. However, Atlantic sturgeon are highly migratory species and are subjected to threats present in various localities along the Atlantic Coast.

5.3.27.2 Life History
In the Carolina DPS, Atlantic sturgeon are found all year in the Neuse River adjacent to the Croatan National Forest. Spawning has not been documented in the Neuse River. The Croatan National Forest is near the lower river reaches, where juvenile and sub-adult Atlantic sturgeon would be expected to congregate in the estuary in the spring (February through June) and again

in the fall (August through November) with juveniles possibly being present during the summer.

5.3.27.3 Population Dynamics

Only fall spawning is known to occur in this DPS, though there have been recent reports of gravid females observed in the spring in the Tar River. Known spawning populations are in the Roanoke (Smith et al. 2015) and Cape Fear Rivers (ASMFC 2017). There are no estimates of spawning abundances, though Flowers and Hightower (2015) estimated abundance of large sub-adult individuals in the DPS to be 2,031 with almost all of those identified in the Pee Dee River (1,944). The James River appears to support periodic reproductive success with the most recent estimates of survival suggesting individuals from the Carolina DPS have similar mortality rates to individuals from other populations (Hightower et al. 2015, ASMFC 2017).

5.3.27.4 Designated Critical Habitat

Critical habitat was designated in the watersheds from the Roanoke River southward along North Carolina and South Carolina coastal areas to the Cooper River, South Carolina. PBFs for Carolina DPS Atlantic sturgeon are identified as:

- Suitable hard bottom substrate (*e.g.,* rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.,* 0.0-0.5 parts per thousand [ppt] range) for settlement of fertilized eggs and refuge, growth, and development of early life stages;

- Transitional salinity zones inclusive of waters with a gradual downstream gradient of 0.5-30 ppt and soft substrate (*e.g.,* sand, mud) downstream of spawning sites for juvenile foraging and physiological development;

- Water of appropriate depth and absent physical barriers to passage (*e.g.,* locks, dams, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) Unimpeded movement of adults to and from spawning sites; (2) seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (3) staging, resting, or holding of subadults and spawning condition adults. Water depths in main river channels must be deep enough to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. Water depths of at least 1.2 m are generally deep enough to facilitate effective adult migration and spawning behavior.

- Water quality conditions, especially in the bottom meter of the water column, with temperature and oxygen values that support: (1) Spawning; (2) annual and inter-annual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment. Appropriate temperature and oxygen values will vary interdependently, and depending on salinity in a particular habitat. For example, 6.0 mg/L D.O. for juvenile rearing habitat is considered optimal, whereas D.O. less than 5.0 mg/L for longer than 30 days is considered suboptimal when water temperature is greater than 25 °C. In temperatures greater than 26 °C, D.O. greater than 4.3 mg/L is needed to

protect survival and growth. Temperatures of 13 °C to 26 °C for spawning habitat are considered optimal.

5.3.27.5 Recovery Goals

There are no identified recovery goals for this species.

5.3.28 South Atlantic DPS Atlantic Sturgeon

The South Atlantic DPS of Atlantic sturgeon was listed as endangered on February 6, 2012. Critical habitat was designated on June 3, 2016. This DPS includes all Atlantic sturgeon that spawn or are spawned in the watersheds (including all rivers and tributaries) of the Ashepoo, Combahee, and Edisto (ACE) River Basins southward along the South Carolina, Georgia, and Florida coastal areas to the St. Johns River, Florida.

5.3.28.1 Threats

Range-wide, the most significant threats to Atlantic sturgeon are unintended catch in some commercial fisheries, dams that block access to spawning areas, poor water quality (which harms development of sturgeon offspring), dredging of spawning areas, water withdrawals from rivers, and vessel strikes (NMFS 2007b). In the South Atlantic, the greatest threats to populations may be availability of access to historic spawning habitat, water quality, water withdrawals, and ship strikes. However, Atlantic sturgeon are highly migratory species and are subjected to threats present in various localities along the Atlantic Coast.

5.3.28.2 Life History

In the South Atlantic, most populations spawn in the fall, though it is possible adults in the Edisto River spawn in the spring and fall (Collins et al. 2000). The Santee-Cooper system runs past the Francis-Marion National Forest and may support a spawning population (ASMFC 2017). Juvenile and sub-adult Atlantic sturgeon would be expected to congregate in the estuary in the spring (February through June) and again in the fall (August through November) with juveniles possibly being present during the summer.

5.3.28.3 Population Dynamics

Fall spawning is confirmed for populations in the ACE Basin rivers, along with the Savannah, Ogeechee, Altamaha, Satilla, and St. Mary's Rivers (ASMFC 2017, Fox et al. 2018). Spring spawning is confirmed in the Edisto River (Collins et al. 2000). The only estimated spawning abundance in this region was made for the Altamaha River in a mark recapture study in the springs of 2004 and 2005 (Peterson et al. 2008). Subsequent telemetry information revealed approximately 37% of adults on the fall spawning run are present in the lower Altamaha River in the spring (Ingram and Peterson 2016). Therefore, the abundance estimates of approximately 325 to 385 spawning adults likely represents approximately one-third to three-eighths of the actual spawning abundance. Estimates of survival suggest individuals from the South Atlantic DPS have similar mortality rates to individuals from other populations (Hightower et al. 2015,

ASMFC 2017).

5.3.28.4 Designated Critical Habitat

Critical habitat was designated in the watersheds from the ACE Basin in South Carolina to the St. Johns River, Florida. PBFs for South Atlantic DPS Atlantic sturgeon are identified as:

- Suitable hard bottom substrate (*e.g.,* rock, cobble, gravel, limestone, boulder, etc.) in low salinity waters (*i.e.,* 0.0-0.5 ppt range) for settlement of fertilized eggs and refuge, growth, and development of early life stages;
- Transitional salinity zones inclusive of waters with a gradual downstream gradient of 0.5-30 ppt and soft substrate (*e.g.,* sand, mud) downstream of spawning sites for juvenile foraging and physiological development;
- Water of appropriate depth and absent physical barriers to passage (*e.g.,* locks, dams, reservoirs, gear, etc.) between the river mouth and spawning sites necessary to support: (1) Unimpeded movement of adults to and from spawning sites; (2) seasonal and physiologically dependent movement of juvenile Atlantic sturgeon to appropriate salinity zones within the river estuary; and (3) staging, resting, or holding of subadults and spawning condition adults. Water depths in main river channels must be deep enough to ensure continuous flow in the main channel at all times when any sturgeon life stage would be in the river. Water depths of at least 1.2 m are generally deep enough to facilitate effective adult migration and spawning behavior.
- Water quality conditions, especially in the bottom meter of the water column, with temperature and oxygen values that support: (1) Spawning; (2) annual and inter-annual adult, subadult, larval, and juvenile survival; and (3) larval, juvenile, and subadult growth, development, and recruitment. Appropriate temperature and oxygen values will vary interdependently, and depending on salinity in a particular habitat. For example, 6.0 mg/L D.O. for juvenile rearing habitat is considered optimal, whereas D.O. less than 5.0 mg/L for longer than 30 days is considered suboptimal when water temperature is greater than 25 °C. In temperatures greater than 26 °C, D.O. greater than 4.3 mg/L is needed to protect survival and growth. Temperatures of 13 °C to 26 °C for spawning habitat are considered optimal.

5.3.28.5 Recovery Goals

There are no identified recovery goals for this species.

5.3.29 Southern Resident Killer Whales

The SRKW DPS, composed of J, K and L pods, was listed as endangered under the ESA on November 18, 2005. Critical habitat was designated on November 29, 2006. A 5-year review under the ESA completed in 2016 concluded that Southern Residents should remain listed as endangered, and includes recent information on the population, threats, and new research results

and publications (NMFS 2016e). The limiting factors described in the final recovery plan included reduced prey availability and quality, high levels of contaminants from pollution, and disturbances from vessels and sound (NMFS 2008).

5.3.29.1 Threats

Historically it is thought that there may have been more than 140 SRKW, based on the number that were killed or removed for aquarium display during the 1960s and 1970s (Olesiuk et al. 1990). Since this population contraction 50 to 60 years ago, additional kills and removals, salmon declines (Krahn et al. 2002), nutritional limitation and body condition (Trites and Rosen 2018), toxic chemicals (Reijnders 1986, Subramanian et al. 1987, de Swart et al. 1996, de Boer et al. 2000, Reddy et al. 2001, Schwacke et al. 2002, Darnerud 2003, Legler and Brouwer 2003, Viberg et al. 2003, Ylitalo et al. 2005, Fonnum et al. 2006, Viberg et al. 2006, Darnerud 2008, Legler 2008, Bonefeld-Jørgensen et al. 2011), vessel noise (Richardson et al. 1995, Gordon and Moscrop 1996, National Research Council 2003, Gaydos et al. 2004), and genetic bottlenecks (Krahn et al. 2002, Ford et al. 2011) are the primary threats. Recent evidence has indicated pregnancy hormones (progesterone and testosterone) can be detected in SRKW feces and have indicated several miscarriages, particularly in late pregnancy (Wasser et al. 2017). The authors suggest this reduced fecundity is largely due to nutritional limitation. The SRKW population also spends approximately 6.1 years between births compared with every 4.88 years in healthier, increasing killer whale populations (Olesiuk et al. 2005).

5.3.29.2 Life History

SRKW spend winters offshore, moving into the Puget Sound area in late spring. They give birth in the summer, caring for their neonates through the summer in inland waters. At the end of the summer season, killer whales move back offshore. The primary period for strandings occurs in winter and spring. Likewise, mortality rates generally appear to be higher during winter based on the numbers of animals missing when killer whales return in the spring.

5.3.29.3 Population Dynamics

At present, the SRKW population has declined to historically low levels. At this time, there are 26 reproductive aged females (between 11 and 42 years old) and approximately 76 animals in total. Abundance rates have fluctuated from a high of 97 whales in 1996, down to 81 in 2002, back up to 86 in 2010, followed by declines in the past decade. The growth rate of the population is only 0.29 percent since 1974.

5.3.29.4 Designated Critical Habitat

In 2006, NOAA Fisheries designated inland waters of Washington State (approximately 2,560 mi^2; 6,630 km^2) as critical habitat for the SRKW. We designated this habitat because it contains

three features essential to the conservation of SRKWs:

- Water quality to support growth and development.
- Enough prey to support individual growth, reproduction, and development, as well as overall population growth.
- Passage conditions to allow for migration, resting, and foraging.

The critical habitat designation identified three specific areas, within the area occupied, which contained the essential features listed above. The three specific areas designated as critical habitat were: (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.

5.3.29.5 Recovery Goals

Because there is uncertainty as to which threat is causing the decline in abundance, the recovery plan identifies actions to address prey availability, pollution/contamination, vessel effects, oil spills, acoustic effects, education and outreach, response to strandings, international coordination, and research/monitoring. A primary recovery goal is to increase the population growth to 2.3% per year, nearly an order of magnitude above its present level. To accomplish this, researchers believe Chinook salmon abundance would need to be increased by 15% and ambient noise reduced by half.

6 Environmental Baseline

The "environmental baseline" is 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 CFR §402.02). The environmental baseline for this biological opinion also includes a general description of the natural factors influencing the current status of the listed species, their habitats, and the environment within the action area.

Our summary of the environmental baseline complements the information provided in the status of the species section of this biological opinion, provides information on the past and present ecological conditions of the action area that is necessary to understand the species' current risk of extinction, and provides the background necessary to understand information presented in the subsequent sections of this biological opinion.

Because this is a programmatic consultation on what is essentially a continuing action with a broad geographic scope that encompasses many waters of the US, the environmental baseline for this consultation focuses on the status and trends of the aquatic ecosystems in the US and the consequences of that status for listed resources that occur in a general region. Because our action area and the environmental baseline encompass a very broad spatial scale with many distinct ecosystems, wherever possible we have focused on common indicators of the biological, chemical, and physical health of the nation's aquatic environments. The environmental baseline for this consultation provides the backdrop for evaluating the effects of the action on listed resources under NMFS' jurisdiction.

We divided the environmental baseline for this consultation into two broad geographic regions: the Southeast Atlantic Region and the West Coast Region. In some instances, regions were further subdivided according to ecoregions, importance to NMFS' trust resources or other natural features. In each section, we described the biological and ecological characteristics of the region such as the climate, geology, and predominant vegetation to provide landscape context and highlight some of the dominant processes that influence the biological and ecological diversity of the region where threatened and endangered species reside. We then described the predominant land and water uses within a region to illustrate how the physical and chemical health of regional waters and the impact of human activities have contributed to current status of listed resources.

6.1 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. Climate change effects include changes in air and water temperatures, changes in precipitation and drought patterns, increased frequency and magnitude of severe weather events, and sea level rise; all of which are likely to affect ESA resources. 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). Globally, there have been more frequent heatwaves in most land regions and an increase in the frequency and duration of marine heatwaves (IPCC 2018). Additional 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). NOAA's climate information portal provides basic background information on these and other measured or anticipated climate change effects (see https://climate.gov).

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. 2006, McMahon and Hays 2006, Evans and Bjørge 2013, IPCC 2014). 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). 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. McMahon and Hays (2006) predicted increased ocean temperatures would expand the distribution of leatherback turtles into more northern latitudes. The authors noted this is already occurring in the Atlantic Ocean. Willis-Norton et al. (2015) acknowledged there would 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. MacLeod (2009) estimated, based upon expected shifts in water temperature, 88% of cetaceans will be affected by climate change with 47% predicted to experience unfavorable conditions (e.g., range contraction).

Changes in the marine ecosystem caused by global climate change (e.g., ocean acidification, salinity, oceanic currents, DO 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 marine mammals, sea turtles, and fish. For example, blue whales, as predators that specialize in eating krill, are likely to change their distribution in response to changes in the distribution of krill (Payne et al. 1986, Payne et al. 1990, Clapham et al. 1999). 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 whose diet is primarily squid and cephalopods. For leatherback sea turtles and ESA-listed whales which undergo long migrations, if either prey availability or habitat suitability is disrupted by changing ocean temperatures or regimes, the timing of migration can change or negatively impact population sustainability (Simmonds and Eliott 2009).

As carbon dioxide concentrations increase in the atmosphere, more carbon dioxide is absorbed by the oceans, causing lower pH and reduced availability of calcium carbonate. Because of the increase in carbon dioxide in the atmosphere since the Industrial Revolution, ocean acidity has increased by 26 percent since the beginning of the industrial era and is predicted to increase considerably between now and 2100 throughout the world’s oceans (IPCC 2014). Ocean acidification negatively affects organisms such as crustaceans, crabs, mollusks, and other calcium carbonate-dependent organisms such as pteropods (free-swimming pelagic sea snails and sea slugs), the latter being an important part of the food web in Alaska waters. Reduction in prey items can create a collapse of the zooplankton populations and thereby result in potential cascading reduction of prey at various levels of the food web, thereby reducing the availability of the larger prey items of marine mammals.

While it is difficult to accurately predict the precise consequences of climate change to a particular species or habitat, especially highly mobile marine species (Simmonds and Isaac 2007), a range of consequences are expected that are likely to change the status of the species and the condition of their habitats. For example, 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). It is also likely that consequences of climate change will overlap and result in synergistic impacts. For example, in sea turtles, sex is determined by the ambient sand temperature (during the middle third of incubation) with female offspring produced at higher temperatures and males at lower temperatures within a thermal tolerance range of 25 to 35 degree Celsius (Ackerman 1997). Increases in global temperature could skew future sex ratios toward higher numbers of females (NMFS and USFWS 2007a, NMFS and USFWS 2007b, NMFS and USFWS 2013a, NMFS and USFWS 2013b, NMFS and USFWS 2015). This impact on population dynamics will be exacerbated by the loss of nesting beach habitat due to sea level rise and erosion from changing winds, currents and storms (Antonelis et al. 2006, Baker et al. 2006).

6.2 Oceanic Temperature Regimes

Oceanographic conditions in the Pacific Ocean can be altered due to periodic shifts in atmospheric patterns (of high and low pressure systems) 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 (not the same as climate change but alterations of these natural events may drive climate change and its effects on ESA-listed species and critical habitat) can alter habitat conditions and prey distribution for ESA-listed species in the action area (Beamish and Bouillon 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 the Southern Oscillation events of El Niño, or La Niña, 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 tend to decrease productivity along the U.S. west coast as upwelling typically diminishes, similar to El Niño events (Hare et al. 1999, Childers et al. 2005).

El Niño periods can influence reproductive success by altering prey availability, probably linked to a decline in primary productivity in coastal areas, as evidenced by changes in salmonid survival (Daly and Brodeur 2015). These periodic shifts in oceanic conditions are complex and the resultant changes in habitat and productivity can be difficult to predict especially when trying to incorporate the longer-term anthropogenic-driven changes in climate (Kintisch 2006, Simmonds and Isaac 2007).

Vulnerable populations of listed species are going to be sensitive to climatic variability that affects the resources they need. Climate change may be driving the natural oscillation in oceanographic conditions to greater extremes, which poses more risk to the stability of a vulnerable population.

6.3 Baseline Conditions during a Fire

As part of our assessment of the environmental baseline in this opinion, we evaluated the natural conditions of the environment during a wildfire. Additionally, we discuss the effects of wildfire on food resources in the area.

Fires are important ecological disturbances and provide a regular ecological service. Fires are most influenced by topography, climate, and vegetation at a local and regional scale (Rollins *et al.* 2002). Most fires are small in area (under 10 acres) and have limited adverse effects locally with negligible effects to whole populations of animals. In some cases, topography, climate, and vegetation can come together to produce a large fire, but even then, the burn pattern at the regional scale provides a mosaic of variable-aged vegetative stands and new growth.

Millions of acres of land are burned by wildland fires each year in the US (Figure 30). Between 1960 and 2014, total acreage burned ranged from 1.14 million acres in 1984 to over 9 million in 2006, 2007, and 2012. Since 2015 until now, over 10 million acres have burned in three of the six years. Since 2004, new records for acreage burned are set somewhat routinely (NIFC 2021). According to the USFS, between 1950 and 1970, fire suppression activities resulted in relatively stable burned areas, whereas the 1980s marked an increase in wildfires, due in part to unprecedented success of fire suppression and its effects on forest conditions.

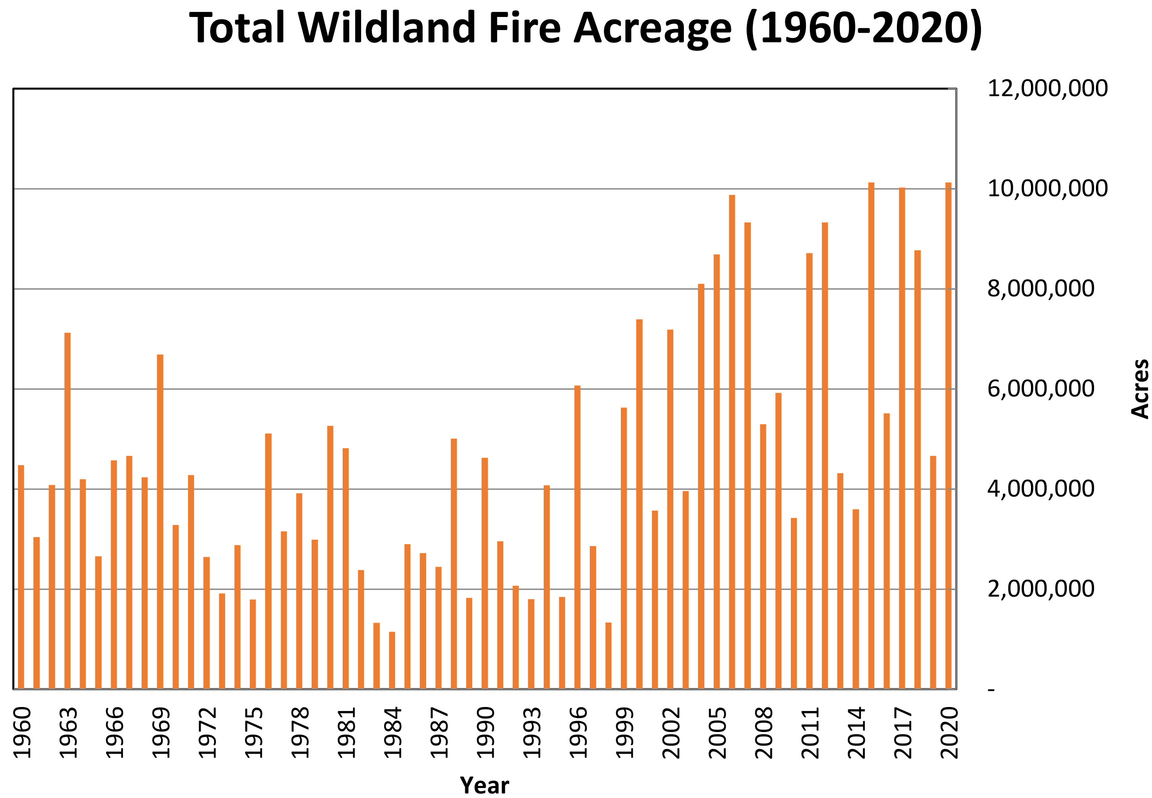

Figure 30. Total Wildland Fires in the US between 1960 and 2010 (NFIC 2021. Note: Statistics were compiled by state and agency prior to 1983; 2004 data does not include fires in North Carolina).

Wildfires do not only occur on USFS lands; however, the action area for this consultation is only USFS lands and waterways immediately downstream of the forest boundaries. The wildfire acres burned since 1960 (NFIC 2021) are considerably more than the amount of USFS land that has burned during the same period. Fires on USFS lands rarely account for more than a third of the wildfires affecting the US since 2000, although one year they accounted for over half (Figure 31).

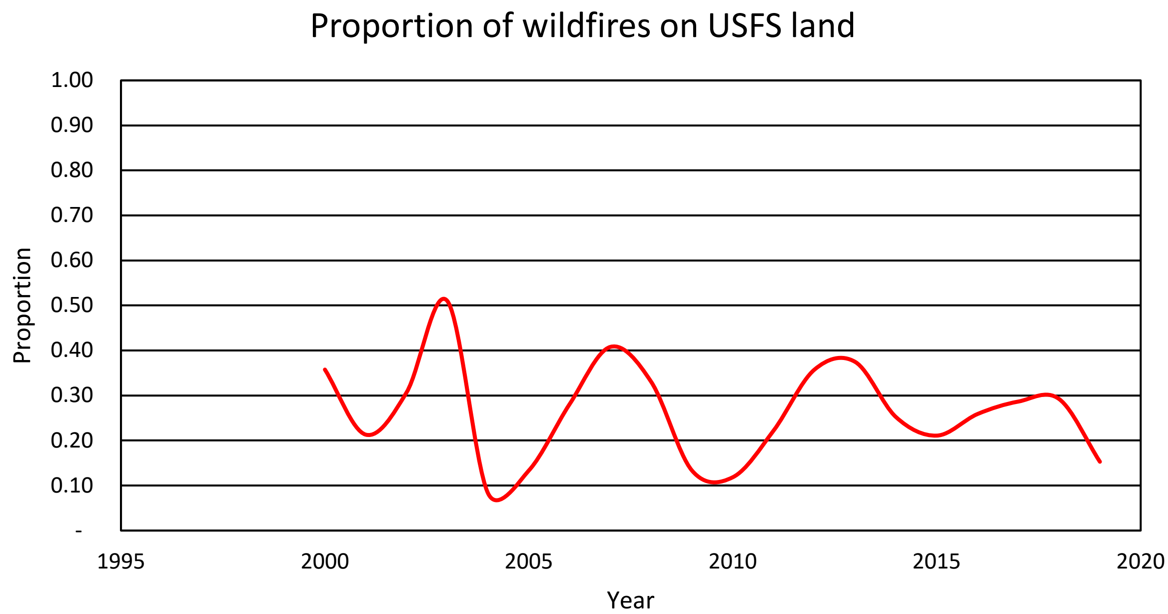

Figure 31. Proportion of wildfire acres burned on USFS lands since 2000.

Wildland fires that are allowed to burn naturally in riparian or upland areas have the potential to either benefit or harm aquatic species, depending on the severity and area coverage of the fire. As fire size increases, so do the chances of adverse effects, although, as mentioned above, most fires are small (under 10 acres). Large fires that burn near the shores of streams and rivers can have biologically significant short-term effects such as increased water temperatures, ash, nutrients, pH, sediment, toxic chemicals, and large woody debris (Earl and Blinn 2003, Rinne 2004), and long-term effects such as removal of shade trees and increased sedimentation (Amaranthus et al. 1989, Mahlum et al. 2011). Many large fires burning near streams can result in fish kills with the survivors actively moving downstream to avoid the temporary poor water quality (Gresswell 1999, Rinne 2004). Small fires or fires that burn entirely in upland areas also cause ash to enter rivers and increase smoke in the atmosphere, contributing to ammonia concentrations in rivers as the smoke adsorbs into the water (Gresswell 1999).

Alternatively, fire is also one of the dominant habitat-forming processes in mountain streams, creating short- and long-term benefits for the aquatic ecosystem and salmonids (Bisson et al. 2003, Flitcroft et al. 2016, David et al. 2018). The patchy, mosaic pattern burned by fires provides a refuge for fish and invertebrates that leave a burning area or simply spares some fish that were in a different location at the time of the fire.

The presence of ash has effects on aquatic species depending on the amount of ash that enters the water. All ESA-listed fish rely on macroinvertebrates as a food source for at least a portion of their life histories. When small amounts of ash get into the water, there are usually no noticeable changes to the macroinvertebrate community or the water quality (Bowman and Minshall 2000).

When significant amounts of ash are deposited into rivers, the macroinvertebrate community density and composition may be moderately to drastically reduced for a full year with long-term effects lasting 10 years or more (Minshall et al. 2001, Earl and Blinn 2003). Larger fires can also affect fish by altering water quality because ash and smoke contribute to elevated ammonium, nitrate, phosphorous, potassium, and pH, which can remain elevated for up to four months after forest fires (Earl and Blinn 2003).

Many species have evolved in the presence of regular fires and have developed population-level mechanisms to withstand even the most intense fires (Gresswell 1999) and have even come to rely on fire's disturbance to provide habitat heterogeneity. In the past century, humans have begun to move away from centralized towns and have increasingly developed land in remote locations, increasing the urban/wildland interface. As a result, the threat of fires to personal property and people has increased and so has the demand for protection of their safety and belongings. The most common form of protection is the use of aerial fire retardants. As a result, we expect listed fish species will be exposed to an increasing number of fires and fire-fighting techniques over time.

The impacts of fire retardant must be considered in conjunction with the baseline conditions that exist during a fire. Low DO, high temperature, high ammonia, and ash in the water are all natural baseline conditions that may result in fish mortality without the use of fire retardant. Their presence in the system at the time of application makes fish more susceptible to lethal and sub-lethal effects. The risk assessment (Section 7) conducted below evaluates how fire retardant intrusions impact listed species and their critical habitat as a separate stressor from natural wildfires.

6.4 Southeast Atlantic Region

The portion of this region in the action area are the Santee-Cooper system, Savannah, Neuse, and St. Johns Rivers. These rivers are located in two ecoregions: the hot continental division and the subtropical division. The ecoregions run parallel along the coast with the subtropical division being the coastal plain and the hot continental division being inland covering the Appalachian Mountains and Piedmont. Atlantic and shortnose sturgeon use these rivers for foraging, migrating, and spawning.

The hot continental division is characterized by its winter deciduous forest dominated by tall broadleaf trees, moderately leached soils rich in humus (Inceptisols, Ultisols, and Alfisols), and rainfall totals that decrease with distance from the ocean (Bailey 1995). Each of these rivers is within the subtropical ecoregion and is characterized by a humid subtropical climate with particularly high humidity during summer months, and warm mild winters. Soils are strongly leached and rich in oxides of iron and aluminum (Bailey 1995). The subtropical ecoregion is forested, largely by second growth forests of longleaf, loblolly, and slash pines, with inland areas dominated by deciduous trees. Rainfall is moderate to heavy with annual averages of about 40

inches in the north, decreasing slightly in the central portion of the region, and increasing to 64 inches in southern Florida.

In the sections that follow, we describe the basins in the action area. These rivers are characterized by large portions of low gradient reaches and streambeds that are composed of greater amounts of sand and fine sediments, are often high in suspended solids, and have neutral to slightly acidic waters with high concentrations of dissolved organic carbon. Rivers, like the St. Johns, emanating entirely within the Coastal Plain are acidic, low alkalinity, blackwater systems with dissolved organic carbon concentrations often up to 50 mg/L (Smock et al. 2005).

6.4.1 Albemarle-Pamlico Sound Complex

The Neuse River flows into Pamlico Sound.

6.4.1.1 Natural History

The Albemarle-Pamlico Sound Estuarine Complex, the largest lagoonal estuarine system in the US, includes seven sounds including Currituck Sound, Albemarle Sound, Pamlico Sound, and others (EPA 2006). The Estuarine Complex is separated from the Atlantic Ocean by the Outer Banks, a long barrier peninsula, and is characterized by shallow waters, wind-driven tides that result in variable patterns of water circulation and salinity. Estuarine habitats include salt marshes, hardwood swamp forests, and bald cypress swamps.

The Neuse River watershed encompasses four physiographic regions—the Valley and Ridge, Blue Ridge, Piedmont, and Coastal Plain Provinces. The geology of the basin strongly influences the water quality and quantity within the basin. The headwaters of the basin tributaries are generally steep and surface water flowing downstream has less opportunity to pick up dissolved minerals. However, as the surface water flows reach the Piedmont and Coastal Plain, water velocity slows due to the low gradient and streams generally pick up two to three times the mineral content of surface waters in the mountains (Spruill et al. 1998). At the same time, much of the upper watershed is composed of fractured rock overlain by unconsolidated and partially consolidated sands. Because of the basin's geology, generally more than half of the water flowing in streams discharging to the Albemarle-Pamlico Estuarine Complex comes from ground water.

The Neuse River is 248 miles long and has a watershed of 6,235 mi^2 (Smock et al. 2005). The Neuse River watershed is also located entirely within the state of North Carolina, flowing through the same habitat as the Cape Fear River, but ultimately entering Pamlico Sound. The river originates in weathered crystalline rocks of the piedmont and crosses sandstone, shale, and limestone before entering Pamlico Sound. The average precipitation in the Neuse River watershed is approximately 48 inches per year. At the mouth, the average discharge is 3.4 billion gallons each day, or 5,297 cfs (USGS 2005).

6.4.1.2 Land Use

The Neuse River entered the national spotlight during the early 1990s due to massive and frequent fish kills within the basin. Over one billion American shad have died in the Neuse River since 1991. In 2004, more than 700,000 estuarine fish died and more than 5,000 freshwater fish died within the basin. Freshwater species most commonly identified during investigations of fish mortality included sunfishes, shad, and carp, while estuarine species most commonly reported included menhaden, perch, and croaker. Atlantic menhaden have historically been involved in a majority of estuarine kill events and have exhibited stress and disease in conjunction with fish kills. Fish kill events are a persistent problem but often have different causative agents, and in many cases, the precise cause is not clear. High levels of nutrients, HABs, toxic spills, outbreaks of a marine organism, *Pfiesteria pescicida*, low DO concentrations, and sudden wind changes that mix hypoxic waters, are some of contributing factors or causes to the basins persistent fish kills (NCDWQ 2004).

The Neuse Rivers is fragmented by dams. The reservoirs are used for flood control and recreation, but the amount of agricultural and urban runoff that collects behind the dams has caused sanitation problems in the recent past. Three dams were removed between 1997 and 2017 in an effort to improve environmental conditions and fish passage. The removal of Quaker Neck Dam in 1997 was the first dam in the US removed for environmental reasons alone. In addition to habitat alternation by dams, widespread stream modification and bank erosion were rated high within the greater watershed relative to other sites in the Nation (Spruill et al. 1998).

6.4.1.3 Commercial and Recreational Fishing

The Albemarle and Pamlico Sounds and associated rivers support a dockside commercial fishery valued at over $54 million annually. The commercial harvest includes blue crabs, southern flounder, striped bass, striped mullet, white perch, croaker, and spot, among others. Roughly 100 species are fished commercially or recreationally in the region. The Neuse River supports many of these species.

Commercial and recreational fisheries exist for oyster, crab, clam, American shad, American eel, shrimp, and many other species. Shellfish are sometimes collected by dredging, which has adverse effects to benthic organisms, including Atlantic and shortnose sturgeon that use estuarine areas for feeding. Commercial fisheries along the South Carolina coast use channel nets, fyke nets, gillnets, seines, and trawls. All of those methods must use some sort of turtle excluder device, but likely still have lethal and sub-lethal effects to Atlantic and shortnose sturgeon.

6.4.2 Major Southeast Coastal Plains Basins

The Santee-Cooper, Savannah, and the St. Johns Rivers (Table 53) are basins in the Southeast Coastal Plains.

6.4.2.1 Natural History

Rainfall is abundant in the region and temperatures are generally warm throughout the year. The Savannah River originates in the Blue Ridge Mountains, the Santee-Cooper system in the Piedmont Plateau, and the St. Johns River in the Coastal Plain, but all the rivers described in this section have sizeable reaches of slack water as they flow through the flat Coastal Plain. The highest elevation of the St. Johns River is 26 feet above sea level, so the change in elevation is essentially one inch every mile, making it one of the most gradually flowing rivers in the country.

Anadromous fish do not migrate upstream of the fall line, which is a steep change in elevation resulting in rapids or falls before the rivers level off in their Coastal Plain reaches. In the Coastal Plain reaches of the area's rivers, soils are acidic with a low cation exchange capacity, a sandy or loamy surface horizon, and a loamy or clay subsurface. The acidic characteristics, slow flowing water with poor flushing, and high organic and mineral inputs gives these waters their characteristic "blackwater" (or "brownwater" for those that originate in the Piedmont Plateau) appearance.

Table 53. Rivers in the action area of the Southeast US (Smock et al. 2005).

Watershed	Length (mi.)	Basin Size (mi^2)	Physiographic Provinces*	Mean Annual Precipitation (in.)	Mean Discharge (cfs).	No. Fish Species	No. Endangered Species
Santee-Cooper River	440	15,251	BR, PP, CP	50	15,327	>100	6 fish, 2 reptiles
Savannah River	300	10,585	BR, PP, CP	45	11,265	>100	8 fish, 4 amphibians, 2 reptiles, 8 mussels, 3 crayfish
St. Johns River	311	8,702	CP	52	7,840	>150	1 mammal, 5 fish, 2 reptiles, 2 birds

* Physiographic Provinces: BR = Blue Ridge, PP = Piedmont Plateau, CP = Coastal Plain

6.4.2.2 Land Use

Land use in these watersheds is dominated by agriculture and industry, and to a lesser extent timber and paper production, although more than half of most basins remain forested. Basin population density is highly variable throughout the region with the greatest density in the St. Johns River watershed with about 200 people per mi^2 of catchment, most of whom are located

near Jacksonville, Florida. See Table 54 for a summary of land uses and population densities in several area basins across the region (data from Smock et al. 2005).

The largest population centers in the region include Jacksonville, Florida, and Savannah, Georgia. Several of the rivers in the region have elevated levels of contaminants including mercury, fecal coliform, bacteria, ammonia, turbidity, and low DO. These impairments are caused by municipal sewage overflows, mining, and non-point source pollution, waterfowl, urban runoff, marinas, agriculture, and industries, including textile manufacturing, power plant operations, paper mills and chemical plants (Harned and Meyer 1983, Berndt et al. 1998, NCDENR 1998, Smock et al. 2005).

The Savannah River exhibits high nitrogen loads (Bricker et al. 2007). Nitrate concentrations (as nitrogen) tend to be higher in streams draining basins with agricultural and mixed land uses (Berndt et al. 1998). Based on studies in Georgia, nitrate loads did not vary with growing season of crops (periods of heaviest fertilizer application), but were influenced by high streamflow, which could be related to downstream transport by subsurface flows (Berndt et al. 1998).

Table 54. Land Use Percentages and Population Density in the action area of Southeast Atlantic Basins (data from Smock et al. 2005).

River Basin	Agriculture	Forested	Urban	Other	Population Density (mi^2)
Santee-Cooper River	26	64	6	4	168
Savannah River	22	65	4	9	91
St. Johns River	25	45	6	24 (wetlands & water)	202

6.4.2.3 Mining

Mining occurs throughout the region. South Carolina produces 1%, Georgia 4%, and Florida 5% of the total nonfuel mineral production value in the US (NMA 2007). Georgia produces 24% of the clay in the nation; other leading nonfuel minerals include crushed stone and Portland cement. Florida is the top phosphate rock mining state in the US and produces about six times more than any other state in the nation. Peat and zirconium concentrates are also produced in Florida.

6.4.2.4 Hydromodification Projects

The Santee-Cooper and Savannah Rivers have been modified by dams and impoundments. There are many dams on Santee-Cooper River system. The Santee River Dam forms Lake Marion and diverts the Santee River to the Cooper River, where another dam, St. Stephen Dam regulates the outflow of the Santee River. Lake Moultrie is formed by both St. Stephen Dam and Pinopolis Dam, which regulates the flow of the Cooper River to the ocean. In response to a draft biological opinion, the Federal Energy Regulatory Commission proposed addressing outflows and fish attraction within the Santee and Cooper Rivers to better protect shortnose sturgeon. Below the fall line, the Savannah River is free-flowing with a meandering course, but above the fall line, there are three large dams that turn the piedmont section of the river into a 100-mile long stretch

of reservoir. There are no major dams on the mainstem St. Johns River, but one of the largest tributaries has a dam on it. The St. Johns River's flow is altered, however, by water diversions for drinking water and agriculture.

6.4.2.5 Commercial and Recreational Fishing

The region is home to many commercial fisheries targeting species like shrimp, blue crab, clams, American and hickory shad, oysters, whelks, scallops, channel catfish, flathead catfish, snapper, and grouper. Atlantic and shortnose sturgeon can be caught in gillnets, but gillnets and purse seines account for less than 2% of the annual bycatch. Shrimpers are responsible for 50% of all bycatch in Georgia waters and bycatch often includes sea turtles. There are approximately 1.15 million recreational anglers in the state.

6.4.3 The Risk of Fire in the Southeast Region

Peak fire season in the Southeast Atlantic Region occurs between October and June, depending on vegetation types. Based on a review of more than 80,000 wildfires, Malamud et al. (2005) calculated the wildfire recurrence interval for large fires ($\geq$ 2,471 acres [10 km^2]) in the subtropical ecoregion that encompasses most of this region, as between every 19 years to every 47. Of the total land area within this ecoregion (more than 4,000,000 mi^2), the USFS manages 16,571 mi^2 (less than 1%).

6.5 West Coast Region

This region covers the Pacific Coastline from southern California to the Puget Sound, and associated watersheds.

6.5.1 California Coast

The basins described in this section are encompassed by California and parts of Oregon. Select watersheds described herein characterize the general ecology and natural history of the area, and the past, present and future human activities and their impacts on this portion of the action area. Essentially, this region encompasses all Pacific Coast Rivers south of Cape Blanco, Oregon through southern California. The Cape Blanco area marks a major biogeographic boundary and has been identified by NMFS as a DPS/ESU boundary for Chinook and coho salmon, and steelhead based on strong genetic, life history, ecological and habitat differences north and south of this landmark. Major rivers contained in this grouping of watersheds are the Sacramento, San Joaquin, Salinas, Klamath, Russian, Santa Ana and Santa Margarita Rivers (Table 55).

6.5.1.1 Natural History

The physiographic regions covered by the basins discussed herein, include: (a) the Cascade-Sierra Nevada Mountains province, (b) the Pacific Border province, and (c) the Lower California province (Carter and Resh 2005). The broader ecoregions division, as defined by Bailey (1995), is the Mediterranean Division. Three major vegetation types are encompassed by this region: the temperate coniferous forest, the Mediterranean shrub and savannah, and the temperate

grasslands/savannah/shrub. The area, once dominated by native grasses, is naturally prone to fires set by lightening during the dry season (Bailey 1995).

This region is the most geologically young and tectonically active region in North America. The Coast Range Mountains are folded and faulted formations, with a variety of soil types and nutrients that influence the hydrology and biology of the individual basins (Carter and Resh 2005). The region also covers the Klamath Mountains and the Sierra Nevada.

The climate is defined by hot dry summers and wet, mild winters, with precipitation generally decreasing in southern latitudes, although precipitation is strongly influenced by topography and generally increases with elevation. Annual precipitation varies from less than 10 inches to more than 50 inches in the region. In the Sierra Nevada about 50% of the precipitation occurs as snow (Carter and Resh 2005), as a result, snowmelt strongly influences hydrological patterns in the area. Severe seasonal patterns of flooding and drought, and high interannual variation in total precipitation makes the general hydrological pattern highly predictable within a basin, but the constancy is low across years (Carter and Resh 2005). According to Carter and Resh (2005), this likely increases the variability in the annual composition of the fish assemblies in the region.

Table 55. Select Rivers in the Southwest Coast Region (Carter and Resh 2005).

Watershed	Length (mi. [approx.)	Basin Size (mi^2)	Physiographic Provinces*	Mean Annual Precipitation (inches)	Mean Discharge (cfs).	No. Fish Species (native)	No. Endangered Species
Rogue River	211	5,154	CS, PB	38	10,065	23 (14)	11
Klamath River	287	15,679	PB, B/R, CS	33	17,693	48 (30)	41
Eel River	200	3651	PB	52	7416	25 (15)	12
Russian River	110	1439	PB	41	2331	41 (20)	43
Sacramento River	400	27,850	PB, CS, B/R	35	23,202	69 (29)	>50 T & E spp.
San Joaquin River	348	83,409	PB, CS	49	4,662	63	>50 T & E spp.
Salinas River	179	4241	PB	14	448	36 (16)	42 T & E spp.
Santa Ana River	110	2438	PB	13	60	45 (9)	54
Santa Margarita River	27	1896	LC, PB	49.5	42	17 (6)	52

* Physiographic Provinces: PB = Pacific Border, CS = Cascades-Sierra Nevada mountains, B/R=Basin & Range

The San Joaquin River, drains the largest basin in the region, originates within the Sierra Nevada near the middle of California, and flows in a northwesterly direction through the southern portion of the Central Valley. The alluvial fan of the Kings River separates the San Joaquin from the Tulare River basin.

6.5.1.2 Land Use

Land use is dominated by forest (and vacant land) in northern basins, and grass, shrubland, and urban uses dominate in southern basins (see Table 56). Overall, the most developed watersheds are those of the Santa Ana, Russian, and Santa Margarita Rivers. The Santa Ana watershed encompasses portions of San Bernardino, Los Angeles, Riverside, and Orange Counties. About 50% of coastal sub-basin of the Santa Ana watershed is dominated by urban land uses and the population density is about 1,500 people per mi^2. When steep and unbuildable lands are excluded from this area, then the population density in the watershed is 3,000 people per mi^2. However, the most densely populated portion of the basin is near the city of Santa Ana where density reaches 20,000 people per mi^2 (Burton 1998, Belitz et al. 2004). The basin is home to nearly 5 million people and the population is projected to increase two-fold in the next 50 years (Burton 1998, Belitz et al. 2004).

Not only is the Santa Ana watershed the most heavily developed watershed in the region, the Santa Ana is the most heavily populated study site out of more than 50 assessment sites studied across the nation by the USGS under the National Water-Quality Assessment (NAWQA) Program. Water quality and quantity in the basin reflects the influence of the high level of urbanization. For instance, the primary source of baseflow to the river is the treated wastewater effluent; secondary sources (sources that influence peak flows) include stormwater runoff from urban, agricultural, and undeveloped lands (Belitz et al. 2004). Concentrations of nitrates and pesticides are elevated within the basin, and were more frequently detected than in other national NAWQA sites (Belitz et al. 2004). Belitz et al. (2004) found that total nitrogen concentrations commonly exceeded 3 mg/L in the Santa Ana basin. In other NAWQA basins with elevated total nitrogen concentrations across the country, the primary influencing factor was the level of agriculture and the application of manure and pesticides within the basin. In the Santa Ana basin the elevated nitrogen is attributed largely to the wastewater treatment plants, where downstream reaches consistently exceeding 3 mg/L total nitrogen. Samples of total nitrogen taken upstream of the wastewater treatment plants were commonly below 2 mg/L (Belitz et al. 2004). Other contaminants detected at high levels included volatile organic compounds (VOCs; including chlorform, which sometimes exceeded water quality standards), pesticides (including diuron, diazinon, carbaryl, chlophyrifos, lindane, malathion, and chlorothalonil), and trace elements (including lead, zinc, arsenic). Because of the changes in water quality, the biological community in the basin is heavily altered (Belitz et al. 2004).

Table 56. Land Uses and Population Density in Several Southwest Coast Region (Carter and Resh (2005).

Watershed	Land Use Categories (Percent)				Density (people/mi.^{2})
	Agriculture	Forest	Urban	Other	
Rogue River	6	83	<1	9 grass & shrub	32
Klamath River	6	66	<1	24 grass, shrub, wetland	5
Eel River	2	65	<1	31 grass & shrub	9
Russian River	14	50	3	31 (23 grassland)	162
Sacramento River	15	49	2	30 grass & shrub	61
San Joaquin River	30	27	2	36 grass & shrub	76
Salinas River	13	17	1	65 (49 grassland)	26
Santa Ana River	11	57	32	---	865
Santa Margarita River	12	11	3	71 grass & shrub	135

In many basins, agriculture is the major water user and the major source of water pollution to surface waters. In 1990, nearly 95% of the water diverted from the San Joaquin River was diverted for agriculture, and 1.5% diverted for livestock (Carter and Resh 2005). During the same period, Fresno, Kern, Tulare, and Kings Counties ranked top in the nation for nitrogen fertilizer use. Nitrogen fertilizer use increased 500% and phosphorus use increased 285% in the San Joaquin River basin in a 40-year period (Carter and Resh 2005). A study conducted by USGS in the mid-1990s on water quality within San Joaquin River basin detected 49 pesticides in the mainstem and three sub-basins with 22 pesticides detected in 20% of the samples and in concentrations exceeding water quality standards for seven (Dubrovsky et al. 1998). Water chemistry in the Salinas River is strongly influenced by intensive agriculture—water hardness, alkalinity, nutrients and conductivity are high in areas where agricultural uses predominate.

6.5.1.3 Mining

Famous for the gold rush of the mid 1800s, California has a long history of mining. In 2004, California ranked top in the nation for nonfuel mineral production with 8.23% of the total production (NMA 2007). Today, gold with silver and iron ore comprises only 1% of the production value. Primary minerals include construction sand and gravel, cement, boron, and crushed stone. California is the only state to produce boron, rare-earth metals, and asbestos (NMA 2007).

The state contains some 1,500 abandoned mines and roughly 1% are suspected of discharging metal-rich waters in the basins. The Iron Metal Mine in the Sacramento Basin releases more than 500 kilogram (kg) of copper and more than 350 kg of zinc to the Keswick Reservoir below Shasta Dam, as well as elevated levels of lead (Carter and Resh 2005). Metal contamination seriously reduces the biological productivity within a basin, can result in fish kills at high levels, and at low levels contributes to sub-lethal effects including reduced feeding, overall activity levels, and growth. The San Francisco Bay watershed, primarily made up of the Sacramento-San Joaquin River Basins, is one of the most heavily impacted basins within the state from mining activities, largely because the basin drains some of the most productive mineral deposits in the region. Methylmercury contamination within San Francisco Bay, the result of 19th century mining practices using mercury to amalgamate gold in the Sierra Nevada Mountains, remains a persistent problem. Based on sediment cores, we know that pre-mining mercury concentrations were about five times lower than concentrations detected within the Bay today (EPA 2006).

6.5.1.4 Hydromodification Projects

Dams, water diversions and drainage systems for agriculture and drinking water, and some of the most drastic channelization projects within the nation have modified several of the rivers within the area. In all, there are about 1,400 dams within California, more than 5,000 miles of levees, and more than 140 aqueducts (Mount 1995 *in* Carter and Resh 2005). While about 75% of the runoff occurs in basins in the northern half of the state, 80% of the water demand is in the southern half of the state. Two water diversion projects meet these demands: the Bureau of Reclamation's (BOR) Central Valley Project and the California State Water Project. The Central Valley Project, one of the world's largest water storage and transport systems, has more than 20 reservoirs and delivers about 7 million acre-feet (ac-ft) each year to southern California. The State Water Project has 20 major reservoirs and holds nearly 6 million ac-ft of water, delivering about 3 million ac-ft. Together these diversions irrigate about 4 million acres of farmland and deliver drinking water to about 22 million residents. NMFS recently determined the BOR was unable to insure this project would avoid jeopardizing listed species or adversely modifying their critical habitat within the Central Valley of California and both parties have agreed to a set of RPAs that will allow for the survival and recovery of listed species in this area (NMFS 2019a).

Both the Sacramento River and the San Joaquin River are heavily modified, each with hundreds of dams. The Rogue, Russian, and Santa Ana Rivers each have more than 50 dams, and the Eel, Salinas, and the Klamath Rivers have between 14 and 24 dams. The Santa Margarita, considered one of the last free flowing rivers in coastal southern California has nine dams in its watershed. All major tributaries of the San Joaquin River have at least one impoundment and most have multiple dams or diversions. The Stanislaus River, a tributary of the San Joaquin River, has over 40 dams. As a result, the natural hydrograph of the San Joaquin River is seriously altered and the temperature and sediment transport regimes are altered. These changes have had profound influences on the biological community within the basin—while the modifications generally result in a reduction of suitable habitat for native species, these changes frequently result in a

concomitant increase of suitable habitat for nonnative species. The Friant Dam on the San Joaquin River is attributed with the extirpation of spring-run Chinook salmon from the basin, a run once estimated as producing 300,000 to 500,000 fish (Carter and Resh 2005).

6.5.1.5 Commercial and Recreational Fishing

The region is home to many commercial fisheries. The largest in terms of total landings in 2019 were northern anchovy, Pacific sardine, Pacific mackerel, Chinook salmon, sablefish, Dover sole, squid, red sea urchin, ocean shrimp, and Dungeness crab (CDFG 2020). Red abalone are harvested off the shores of California. Illegal poaching of abalone, including endangered white abalone, continues to be of concern in the state, with the demand for abalone in local restaurants, seafood markets and international businesses. The first salmon cannery established along the west coast was located in the Sacramento River watershed in 1864 but it only operated for about two years because the sediment from hydraulic mining decimated the runs in the basin (Hittell 1882, and Goode et al. 1888, cited in NRC 1996).

6.5.2 Columbia River Basin

This region encompasses Washington, Oregon, and Idaho. The region is ecologically diverse, encompassing northern marine lowland forests, mountain forests, alpine meadows and northern desert habitat. The broader ecoregion divisions, as defined by Bailey (1995) and encompassed within this region, are the Marine and Marine Mountains Divisions, portions of the Temperate Desert, and Temperate Steppe and Temperate Steppe Mountains.

6.5.2.1 Natural History

The largest river in the Pacific Northwest and the fourth largest river in terms of average discharge in the US, the Columbia River drains an area over 258,000 mi^2 (making it the sixth largest in terms of drainage area). The Columbia River Basin includes parts of Washington, Oregon, Nevada, Utah, Idaho, Wyoming, Montana, and British Columbia and encompasses 13 terrestrial and three freshwater ecoregions, including arid shrub-steppes, high desert plateaus, temperate mountain forests, and deep gorges (Hinck et al. 2004, Kammerer 1990, Stanford et al. 2005).

Major tributaries include the Snake, Willamette, Salmon, Flathead, and Yakima Rivers; smaller rivers include the Owyhee, Grande Ronde, Clearwater, Spokane, Methow, Cowlitz and the John Day Rivers (see Table 57 for a description of select Columbia River Tributaries). The Snake River is the largest tributary at more than 1,000 miles long and its headwaters originate in Yellowstone National Park, Wyoming. The second largest tributary is the Willamette River in Oregon (Kammerer 1990; Hinck et al. 2004). The Willamette River is the 19th largest river in the nation in terms of average annual discharge (Kammerer 1990). The basins drain portions of the Rocky Mountains, the Bitterroot Range, and the Cascade Mountain Range.

The average annual runoff at the mouth of the Columbia River is 265,000 cfs (Kammerer 1990).

A saltwater wedge extends 23 miles upstream of the mouth with tidal influences extending up to 146 miles upriver (Hinck et al. 2004). The climate within the basin is a mix of arid, dry summers, cold winters, and maritime air masses entering from the west. It is common for air temperatures in the Rocky Mountains to dip below zero in mid-winter, but summer air temperatures can reach more than 100 °F in the middle basin.

Table 57. Select Tributaries of the Columbia River (Carter and Resh 2005).

Watershed	Length (mi. [approx.)	Basin Size (mi^2)	Physiographic Provinces*	Mean Annual Precipitation (inches)	Mean Discharge (cfs).	No. Fish Species (native)	No. Endangered Species
Snake/Salmon River	870	108,495	CU, NR, MR, B/R	14	55,267	39 (19)	5 fish, 6 snails, 1 plant
Yakima River	214	6,139	CS, CU	7	3,602	50	2 fish
Willamette River	143	11,478	CS, PB	60	32,384	61 (~31)	5 fish

* Physiographic Provinces: CU = Columbia-Snake River Plateaus, NR = Northern Rocky Mountains, MR = Middle Rocky Mountains, B/R=Basin & Range, CS = Cascade-Sierra Mountains, PB = Pacific Border

The river and estuary were once home to more than 200 distinct runs of Pacific salmon and steelhead, and represented adaptation to the local environment within a tributary or segment of a river (Stanford et al. 2005). Salmonids within the basin include Chinook, chum, coho, sockeye salmon, steelhead and redband trout, bull trout, and cutthroat trout. Other fish species within the basin include white and green sturgeon, eulachon, lamprey, and sculpin (Wydoski and Whitney 1979). According to a review by Stanford et al. (2005), the basin contained 65 native fish species and at least 53 nonnative fishes. The most abundant non-native fish is the American shad, which was introduced to the basin in the late 1800s (Wydoski and Whitney 1979).

6.5.2.2 Land Use

More than 50% of the US' portion of the Columbia River Basin is in federal ownership (most of which occurs in high desert and mountain areas), 39% is in private land ownership (most of which occurs in river valleys and plateaus), and the remainder is divided among Tribes, state, and local governments (Hinck et al. 2004). See Table 58 for a summary of land uses and population densities in several sub-basins within the Columbia River watershed (data from Stanford et al. 2005).

Table 58. Land Uses and Population Density in Select Tributaries of the Columbia River (data from Stanford et al. 2005).

Watershed	Agriculture	Forest	Urban	Other	Population Density (#/mi^2)
Snake/Salmon River	30	10-15	1	54 scrub/rangeland/barren	39
Yakima River	16	36	1	47 shrub	80
Willamette River	19	68	5	--	171

The interior Columbia Basin has been altered substantially by humans leading to dramatic

changes and declines in many native fish populations. In general, the basin supports a variety of mixed uses. Predominant human uses include logging, agriculture, ranching, hydroelectric power generation, mining, fishing and a variety of recreational activities, and urban uses.

The decline of salmon runs in the Columbia is attributed to loss of habitat, blocked migratory corridors, altered river flows and pollution, overharvest, and competition from hatchery fish. Critical ecological connectivity (mainstem to tributaries and riparian floodplains) has been lost due to dams and associated activities such as floodplain deforestation and urbanization. The most productive floodplains of the watershed are either flooded by hydropower dams or dewatered by irrigation diversions. Portions of this basin are also subject to impacts from cattle grazing and irrigation withdrawals. In the Yakima River, 72 stream and river segments are listed as impaired by the Washington Department of Ecology and 83% exceed temperature standards. In the Willamette River, riparian vegetation was greatly reduced by land conversion. By 1990, only 37% of the riparian area within 120 m of either side of the river was forested, 30% was agricultural fields, and 16% was urban or suburban lands. In the Flathead River, aquatic invasive plants such as pondweed, hornwort, water milfoil, waterweed, cattail and duckweed grow in the floodplain wetlands and shallow lakes and, in the Yakima River, non-native grasses and other plant are commonly found along the lower reaches of the river (Stanford et al. 2005).

6.5.2.3 Agriculture and Ranching

Roughly 6% of the annual flow from the Columbia River is diverted for the irrigation of 7.3 million acres of croplands within the basin. The vast majority of these agricultural lands are located along the lower Columbia River, the Willamette, Yakima, Hood, and Snake Rivers, and the Columbia Plateau (Hinck et al. 2004). The Yakima River Basin is one of the most agriculturally productive areas in the US (Fuhrer et al. 2004). Croplands within the Yakima Basin account for about 16% of the total basin area of which 77% is irrigated.

Agriculture and ranching increased steadily but slowly within the Columbia River basin from the mid to late 1800s. By the early 1900s, agricultural opportunities began increasing at a much more rapid pace with creation of more irrigation canals and the passage of the Reclamation Act of 1902 (NRC 2004). Today, agriculture represents the largest water use within the basin. More than 105,000 ac-ft per day (more than 90 percent) is used for agricultural purposes. Agriculture, ranching, and the related services employ more than nine times the national average (19% of the households within the basin; NRC 2004).

Ranching practices have led to increased soil erosion and sediment loads within adjacent tributaries, the worst of these effects may have occurred in the late 1800s and early 1900s with deliberate burning to increase grass production (NRC 2004). Several measures are in use to reduce the impacts of grazing including restricted grazing in degraded areas, reduced grazing allotments, and lower stocking rates. Today agricultural impacts to water quality within the basin are second to large-scale influences of hydromodification projects for both power generation and

irrigation. Water quality effects from agricultural activities include alteration of the natural temperature regime, insecticide and herbicide contamination, and increased suspended sediments, concentrating in the lowest order systems.

The USGS has a number of fixed water quality sampling sites throughout various tributaries of the Columbia River, many of which have been in place for decades, and pesticides are regularly detected in the water. Water volumes, crop rotation patterns, crop-type, and location within the basin are some of the variables that influence the distribution and frequency of pesticides within a tributary. Detection frequencies for a particular pesticide can vary widely. The Columbia River is an Environmental Protection Agency (EPA) 303(d) impaired waterbody for a variety of reasons, one of which is pesticides (Gruen 2020). Pesticide concerns range from the number of chemicals (Ebbert and Embrey 2001) to the concentration of certain chemicals (Johnson and Newman 1983, Joy 2002, Joy and Madrone 2002, Fuhrer et al. 2004, Bexfield et al. 2020). The current and legacy chemicals continue to pose a serious problem to water quality and fish communities (Hinck et al. 2004).

Fish and macroinvertebrate communities exhibit an almost linear decline in condition as the level of agriculture intensity increases within a basin (Cuffney et al. 1997, Fuhrer et al. 2004). A study conducted in the late 1990s examined 11 species of fish, including anadromous and resident fish collected throughout the basin, for a suite of 132 contaminants, which included 26 pesticides, revealed organochlorines, specifically hexachlorobenzene, chlordane and related compounds, and DDT and its metabolites, were the most frequently detected pesticides within fish tissues (Hinck et al. 2004).

6.5.2.4 Urban and Industrial Development

The largest urban area in the basin is the greater Portland metropolitan area, located at the mouth of the river. Portland's population exceeds 600,000 people, whereas the next largest cities, Spokane, Salem, Eugene, and Boise, have more than 100,000 people (2018 US Census estimate). The population in the Columbia River watershed is approximately 8.5 million people, expected to rise to 10 million by 2030.

Discharges from sewage treatment plants, paper manufacturing, and chemical and metal production represent the top three permitted sources of contaminants within the lower basin according to discharge volumes and concentrations (Rosetta and Borys 1996). According to Rosetta and Borys (1996) based on their review of 1993 data, 52% of the point source wastewater discharge volume is from sewage treatment plants, 39% from paper and allied products, 5% from chemical and allied products, and 3% from primary metals. However, suspended sediment loading is predominantly from point sources from the paper and allied products industry (71%), while 26% comes from sewage treatment plants and 1% is from the chemical and allied products industry. Non-point source discharges (urban stormwater runoff) account for more of the total pollutant loading to the lower basin for most organics and over half of the metals. Although rural non-point sources contributions were not calculated, Rosetta and

Borys (1996) surmised that in some areas and for some contaminants, rural areas may contribute a large portion of the load; this is particularly the case for pesticide contamination in the upper river basin where agriculture is the predominant land use.

A study conducted in the late 1990s examined 11 species of fish, including anadromous and resident fish collected throughout the basin, for a suite of 132 contaminants, which included 51 semi-volatile chemicals, 26 pesticides, 18 metals, seven PCBs, 20 dioxins, and 10 furans. The results revealed PCBs, metals, chlorinated dioxins and furans (products of wood pulp bleaching operations) and other contaminants within fish tissues—white sturgeon tissues contained the greatest concentrations of chlorinated dioxins and furans (Hinck et al. 2004).

6.5.2.5 Hydromodification Projects

More than 400 dams exist in the basin ranging from mega dams that store large amounts of water to small diversion dams for irrigation. Every major tributary of the Columbia except the Salmon River is totally or partially regulated by dams and diversions. More than 150 dams are major hydroelectric projects of which 18 dams are located on mainstem Columbia River and its major tributary, the Snake River. The Federal Columbia River Power System operates 14 major dams and reservoirs on the Columbia and Snake Rivers as a coordinated system. The Army Corps of Engineers operates nine of 10 major federal projects on the Columbia and Snake Rivers, and Dworshak, Libby and Albeni Falls Dams. The BOR operates Grand Coulee and Hungry Horse Dams. These federal projects are a major source of power in the region, and provide flood control, navigation, recreation, fish and wildlife, municipal and industrial water supply, and irrigation benefits.

The BOR has operated irrigation projects within the basin since 1904. The irrigation system delivers water to about 2.9 million acres of agricultural lands; 1.1 million acres of land are irrigated using water delivered by two structures, the Columbia River Project (Grand Coulee Dam) and the Yakima Project. Grand Coulee Dam delivers water for the irrigation of over 670,000 acres of croplands and the Yakima Project delivers water to nearly 500,000 acres of crop lands (BOR 2007).

The Bonneville Power Administration, an agency of the U.S. Department of Energy, wholesales electric power produced at 31 federal dams (67% of its production) and non-hydropower facilities in the Columbia-Snake Basin, selling about half the electric power consumed in the Pacific Northwest. The federal dams were developed over a 37-year period starting in 1938 with Bonneville Dam and Grand Coulee in 1941, and ending with construction of Libby Dam in 1973 and Lower Granite Dam in 1975.

Development of the Pacific Northwest regional hydroelectric power system, dating to the early twentieth century, has had profound effects on the ecosystems of the Columbia River Basin (ISG 1996). These effects have been especially adverse to the survival of anadromous salmonids. The construction of the federal power system modified migratory habitat of adult and juvenile

salmonids, and in many cases presented a complete barrier to habitat access. The dams impede both upstream and downstream migrating fish, and a substantial number of juvenile salmonids are killed and injured during downstream migrations. Physical injury and direct mortality occurs as juveniles pass through turbines, bypasses, and spillways. Indirect effects of passage through all routes may include disorientation, stress, delays in passage, and exposure to high concentrations of dissolved gases, warm water, and increased predation. Dams have also flooded historical spawning and rearing habitat with the creation of massive water storage reservoirs. Large dams have blocked more than 55% of the Columbia River Basin that was accessible to salmon and steelhead before 1939 (NWPPC 1986). Construction of Grand Coulee Dam blocked 1,000 miles of habitat from migrating salmon and steelhead (Wydoski and Whitney 1979). The mainstem habitats of the lower Columbia and Willamette Rivers have been reduced primarily to a single channel. As a result, floodplain area is reduced, off-channel habitat features have been eliminated or disconnected from the main channel, and the amount of large woody debris in the mainstem has been reduced. Remaining areas are affected by flow fluctuations associated with reservoir management for power generation, flood control and irrigation. Overbank flow events, important to habitat diversity, have become rare because of controlling peak flows and associated revetments. Consequently, the dynamics of the estuary have changed substantially.

6.5.2.6 Artificial Propagation

There are several artificial propagation programs for salmon production within the Columbia River Basin, many of which were instituted under federal law to ameliorate the effects on fishing of lost natural production of salmon within the basin from the dams. The hatcheries are operated by federal, state, and tribal managers. For more than 100 years, hatcheries in the Pacific Northwest have produced fish for harvest and to replace natural production lost to dam construction, and have only minimally been used to protect and rebuild naturally produced salmonid populations (e.g., Redfish Lake sockeye salmon). In 1987, 95% of the coho salmon, 70% of the spring Chinook salmon, 80% of the summer Chinook salmon, 50% of the fall Chinook salmon, and 70% of the steelhead returning to the Columbia River Basin originated in hatcheries (CBFWA 1990). More recent estimates suggest that almost half of the total number of smolts produced in the basin come from hatcheries (Mann et al. 2005).

The impact of artificial propagation on the total production of Pacific salmon and steelhead has been extensive (Hard et al. 1992). Hatchery practices, among other factors, were a contributing factor to the 90% reduction in natural coho salmon runs in the lower Columbia River over a 30 year period leading to modified hatchery practices that consider genetics (Flagg et al. 1995, Good et al. 2005, Welch et al. 2021). Past hatchery and stocking practices have resulted in the transplantation of salmon and steelhead from nonnative basins, and the impacts of these practices are largely unknown. Adverse effects of these practices likely include: the loss of genetic variability within and among populations (Hard *et al.* 1992, Reisenbichler 1997); disease transfer; increased competition for food, habitat, or mates; increased predation; altered migration; displacement of natural fish (Hard et al. 1992, Fresh 1997); and likelihood of a higher

risk of domestication, predation, or altered migration for species with extended freshwater residence versus species that spend only a brief time in freshwater (Hard et al. 1992). Nonetheless, artificial propagation also may contribute to the conservation of listed salmon and steelhead, although it is unclear whether or how much artificial propagation during the recovery process will compromise the distinctiveness of natural populations (Hard et al. 1992).

NMFS was mandated by Congress in 2005 to institute hatchery reform within the Columbia River Basin. This reform is a collaborative effort to review of how harvest and hatcheries, both federal and non-federal, are affecting the recovery of listed salmon and steelhead. This effort has resulted in some improvements in hatchery practices. Eventually, the goal is to have tribal, state, and federal managers effectively manage Columbia River Basin hatcheries in a way that will meet conservation and harvest goals consistent with their respective legal responsibilities.

6.5.2.7 Mining

Most of the mining in the basin is focused on minerals such as phosphate, limestone, dolomite, perlite, or metals such as gold, silver, copper, iron, and zinc. Mining in the region is conducted using a variety of methods and in various places within the basin. Alluvial or glacial deposits are often mined for gold or aggregate, and ores are often excavated from the hard bedrocks of the Idaho batholiths. Eleven percent of the nation’s output of gold has come from mining operations in Washington, Montana, and Idaho, and more than half of the nation’s silver output has come from a few select silver deposits, with 30% coming from two deposits located in the Columbia River Basin (the Clark Fork River and Coeur d’Alene deposits; Hinck et al. 2004, Butterman and Hilliard 2005). According to Wydoski and Whitney (1979), one of the largest mines in the region, located near Lake Chelan, once produced up to 2,000 tons of copper-zinc ore with gold and silver on a daily basis. Most of the phosphate mining within the basin occurs within the headwaters of the Snake River, but the overall output from these deposits accounts for 12% of the US production of phosphate (Hinck et al. 2004).

Many of the streams and river reaches in the basin are impaired from mining and several abandoned and former mining sites are designated as EPA Superfund cleanup areas (Stanford et al. 2005, EPA 2007). According to the U.S. Bureau of Mines, there are about 14,000 inactive or abandoned mines within the Columbia River Basin of which nearly 200 pose a potential hazard to the environment (Hinck et al. 2004). Contaminants that have been detected in the water include lead and other trace metals. Mining of copper, cadmium, lead, manganese, and zinc in the upper Clark Fork River have contributed wastes to this basin since 1880 (Woodward et al. 1994). Benthic macroinvertebrates and fish within the basin have bioaccumulated metals—the exposure and bioaccumulation of these metals in native fishes in the basin are suspected of reducing their survival and growth (Farag et al. 1994, Woodward et al. 1994). In the Clark River, several fish kills have occurred since 1984 and are attributed to contamination from trace metals from mining waste such as cadmium, copper, lead, and zinc (Hinck et al. 2004).

6.5.2.8 Commercial, Recreational, and Subsistence Fishing

Archeological records indicate that indigenous people caught salmon in the Columbia River more than 7,000 years ago. One of the most well-known tribal fishing sites within the basin was located near Celilo Falls, an area in the lower river that has been occupied by Dalles Dam since 1957. Salmon fishing increased with better fishing methods and preservation techniques, such as drying and smoking, such that harvest substantially increased in the mid-1800s along with canning techniques. Harvest techniques also changed over time, from early use of hand-held spears and dip nets, to riverboats that used seines and gill-nets, eventually transitioning to large ocean-going vessels with trolling gear and nets and the harvest of Columbia River salmon and steelhead off the waters of the entire west coast, from California to Alaska (Mann et al. 2005).

During the mid-1800s, an estimated 10 to 16 million adult salmon of all species entered the Columbia River each year. Large harvests of returning adult salmon during the late 1800s ranging from 20 million to 40 million pounds of salmon and steelhead annually significantly reduced population productivity (Mann et al. 2005). The largest harvest of Chinook salmon ever recorded occurred in 1883 when Columbia River canneries processed 43 million pounds of salmon (Lichatowich 1999). Commercial landings declined steadily from the 1920s to a low in 1993, when just over one million pounds were harvested (Mann et al. 2005).

Harvested and spawning adults reached 2.8 million in the early 2000s, of which almost half are hatchery produced (Mann et al. 2005). Most of the fish caught in the river are steelhead and spring/summer Chinook salmon, while ocean harvest consists largely of coho and fall Chinook salmon. Most ocean catches occur north of Cape Falcon, Oregon. Between 1999 and 2004, the number of spring and fall salmon commercially harvested in tribal fisheries has averaged between 25,000 and 110,000 fish (Mann et al. 2005). Recreational catch in both ocean and in-river fisheries varies around 140,000 to 150,000 fish (Mann et al. 2005).

6.5.3 Puget Sound Region

Puget Sound and the coastal drainages are contained within the Marine Division, while the Columbia River watershed encompasses portions of all five ecoregions.

6.5.3.1 Natural History

The Puget Sound watershed is defined by the crest lines of the Olympia Mountain Range (and the Olympic Peninsula) to the west and the Cascade Mountain Range to the east. The Olympic Mountains reach heights of about 8,000 ft above sea level, and are extremely rugged and steeply peaked with abrupt descents into the Puget Lowland. The Cascade Mountains on the east range in heights of 4-8,000 ft above sea level with the highest peak, Mount Rainer towering over the region at 14,410 ft above sea level. As the second largest estuary in the US, Puget Sound has about 1,330 mi of shoreline, extends from the mouth of the Strait of Juan de Fuca east, including the San Juan Islands and south to Olympia, and is fed by more than 10,000 rivers and streams.

Puget Sound is generally divided into four major geographic marine basins: Hood Canal, South

Sound, Whidbey Basin, and the Main Basin. The Main Basin has been further subdivided into two sub-basins: Admiralty Inlet and Central Basin. Each of the above basins forms a depression on the sea floor in which a shallower ledge or sill separates the relatively deep water from the adjacent basin. The waters of Puget Sound function as a partially mixed, two-layer system, with relatively fresh water flowing seaward at the surface and salty oceanic water entering at depth.

The main ledge of Puget Sound is located at the north end of Admiralty Inlet where the water shoals to a depth of about 200 ft at its shallowest point (King County 2001). The deepest point in Puget Sound is in the Central Basin and is over 920 ft. Approximately 43% of the Puget Sound's tideland is located in the Whidbey Island Basin. This reflects the large influence of the Skagit River, which is the largest river in the Puget Sound system and whose sediments are responsible for the extensive mudflats and tidelands of Skagit Bay.

Habitat types that occur within the nearshore environment include eelgrass meadows, kelp forest, mud flats, tidal marshes, sub-estuaries (tidally influenced portions of river and stream mouths), sand spits, beaches and backshore, banks and bluffs, and marine riparian vegetation. These habitats provide critical functions such as primary food production, support habitat for invertebrates and juvenile and adult fishes, and provide foraging and refuge opportunities for birds and other wildlife.

The Puget Sound ecoregion is a glaciated area consisting of glacial till, glacial outwash and lacustrine deposits with high quality limestone is found in the San Juan Islands (Wydoski and Whitney 1979). Relief in the valley is moderate with elevation ranging from sea level to about 1,300 ft. Geology in the region consists of mostly Tertiary sedimentary bedrock formations.

The land and vegetation surrounding Puget Sound waters are classified as Puget Lowland Forest and occupy the depression or valley between the Olympic Peninsula on the west and the Cascade Mountains on the east (Franklin and Dyrness 1973). The alpine zone is expressly devoid of trees. Vegetation changes abruptly along the mountain slopes and across minimal horizontal distances because of steep topography, soil, and microclimate (sun exposure, temperature, and precipitation). Dominant vegetation types include, from the Puget lowland region, the lowland forest, the mid-montane forest of Pacific silver fir (*Abies amabilis*) with Alaska yellow cedar (*Chamaecyparis nootkatensis*), the subalpine forest of mountain hemlock (*Tsuga mertensiana*) with subalpine fir (*Abies lasiocarpa*) and Alaska yellow cedar, and the alpine tundra or meadow above the tree line (Kruckeberg 1991).

The Puget Sound region has a Mediterranean-like climate, with warm, dry summers, and mild wet winters (Franklin and Dyrness 1973). Annual precipitation varies from 28-35 in, and falls predominantly as rain in lowland areas. Annual snowpack in the mountain ranges is often high—although the elevation of the Olympia Mountains is not as high as that of the Cascade Mountain Range, abundant accumulation occurs, such that it will sometimes persist throughout much of the summer months. Average annual rainfall in the north Cascades at Mount Baker Lodge is about

110 inches, and at Paradise Station at Mount Rainer is about 105 inches, while average annual snowfall is 550 inches and 582 inches, respectively, sometimes reaching more than 1,000 inches on Mount Rainer (Wydoski and Whitney 1979; Kruckeberg 1991).

Major rivers draining to Puget Sound from the Cascade Mountains include the Skagit River, the Snohomish River, the Nooksack River, the Puyallup/Green River, and the Lake Washington/Cedar River watershed. Major rivers from the Olympic Mountains include the Hamma Hamma, the Duckabush, the Quilcene, and the Skokomish Rivers. Numerous other smaller rivers drain to the Sound, many of which are significant producers of salmonids despite their small size.

The Puget Sound Basin is home to more than 200 fish species, representing more than 50 families; and more than 140 mammals, of which less than a third are marine mammals. SRKWs are one of the most notable, relying on the native salmonids for a large part of their diet (Bonefeld-Jørgensen et al. 2011). Salmonids within the region include coho salmon, Chinook salmon, sockeye salmon and kokanee, chum salmon, pink salmon, steelhead and rainbow trout, coastal cutthroat trout, bull trout, and Dolly Varden (Wydoski and Whitney 1979, Kruckeberg 1991). Important commercial fishes include the five Pacific salmon species and several rockfish species. A number of introduced species occur within the region, including brown trout, brook trout, Atlantic salmon, bass, tunicates (sea squirts), and a saltmarsh grass (*Spartina*). Estimates suggest that more than 90 species have been intentionally or accidentally introduced in the region (Ruckelshaus and McClure 2007). At present over 40 species in the region are listed as threatened and endangered under the ESA.

6.5.3.2 Land Use

Land use in the Puget Sound lowland is composed of agricultural areas (including forests for timber production), urban areas (industrial and residential use), and rural areas (low density residential with some agricultural activity). In the 1930s, all of Western Washington contained about 15.5 million acres of "harvestable" forestland and, by 2004, the total acreage was nearly half that, with an additional 243 square miles of timber cover lost to development between 2011 and 2016 (PSAT 2021). Forest cover in Puget Sound alone was about 5.4 million acres in the early 1990s and about a decade later, the region had lost another 200,000 acres of forest cover with some watersheds losing more than half the total forested acreage. The most intensive loss of forest cover has occurred in the state's Urban Growth Boundary, which encompasses specific parts of the Puget Lowland; in this area, forest cover shows steady rates of decline: by 11.1% between 1991 and 1999 (Ruckelshaus and McClure 2007), increasing to 37.9% from 2011 to 2016 (PSAT 2021). Projected land cover changes (reviewed in Ruckelshaus and McClure 2007) indicate that trends are likely to continue over the next several decades with population changes and coniferous forests are projected to decline at an alarming rate as urban uses increase.

The Puget Sound Lowland contains the most densely populated area of Washington. The regional population currently is an estimated 4.5 million people, expected to increase by another

1.8 million by 2050. Of those, 86% reside in King, Pierce and Snohomish Counties (Snohomish, Cedar-Sammamish Basin, Green-Duwamish, and Puyallup River watersheds; WA DOE 2021).

Currently, impervious surfaces cover 4.6% of the region (WA DOE 2021). In one decade (1991 – 2001), impervious surfaces increased 10.4% region-wide. The is largely driven by population growth that currently stands around 100,000 new residents each year (WA DOE 2021). The Snohomish River watershed population, one of the fastest growing in the region, increased 15.7% in the same period.

Much of the region's estuarine wetlands have been heavily modified, primarily from agricultural land conversion and urban development (NRC 1996). Although most estuarine wetland losses result from conversions to agricultural land by ditching, draining, or diking, these wetlands are also experiencing increasing effects from industrial and urban causes.

The most extreme case of river delta conversion is observed in the Duwamish Waterway in Seattle. As early as the mid-1800s, settlers in the region began discussing the need for a ship canal that linked Lake Washington directly with Puget Sound. After several private and smaller attempts, by the early 1900s, locks were built to achieve this engineering feat. The resultant outcome was that the Black River, which formerly drained Lake Washington to the Green and White Rivers (at their confluence, these rivers formed the Duwamish River), dried up. The lower White River, which historically migrated sporadically between the Puyallup and the Green/Duwamish Basins, was permanently diverted into the Puyallup River Basin in 1914 with the construction of a concrete diversion at river mile 8.5, resulting in a permanent increase of the Puyallup River flows by about 50% and a doubling of the drainage area (Kerwin 1999). The Cedar River, on the other hand, was permanently diverted to Lake Washington. The oxbow in the lower Duwamish River was lost with the lower river dredging in the early 1900s reducing the lower nine miles of the river to 5 mi in length. Overtime the waterway has been heavily armored and diked, result in the loss of all tidal swamps, 98% of the tidal forests, marshes, shallows and flats, and 80% of the riparian shoreline (Blomberg et al. 1988 in Ruckelshaus and McClure 2007).

By 1980, an estimated 27,180 ac of intertidal or shore wetlands had been lost at eleven deltas in Puget Sound (Bortleson et al. 1980). Tidal wetlands in Puget Sound represent about 17-19% of their historical extent (Collins and Sheikh 2005). Coastal marshes close to seaports and population centers have been especially vulnerable to conversion with losses of 50-90% common for individual estuaries.

More than 100 years of industrial pollution and urban development have affected water quality and sediments in Puget Sound. Many different kinds of activities and substances release contamination into Puget Sound and the contributing waters. Positive changes in water quality in the region, however, are also evident. One of the most notable improvements was the elimination of sewage effluent to Lake Washington in the mid-1960s, which significantly reduced problems

within the lake from phosphorus pollution and triggered a concomitant reduction in the cyanobacteria (see Ruckelshaus and McClure 2007 for a review).

Even so, as the population and industry have increased in the region, a number of new and legacy pollutants are of concern. According to the 'State of the Sound' report (PSAT 2021) in 2014, 87% of assessed fresh and marine waters in the region were listed as impaired. Almost two-thirds of these waterbodies were listed as impaired due to contaminants such as toxics and pathogens, and low DO or high temperatures, and less than one-third had established cleanup plans. More than 5,000 ac of submerged lands (primarily in urban areas; 1% of the study area) are contaminated with high levels of toxic substances, including polybrominated diphenyl ethers (PBDEs—flame retardants), however, contaminant levels have decreased in the past 20 years (PSAT 2021). Body burdens of PCBs, PBDEs, and DDT have declined or remained the same in several populations of fish and mammals over the past decade (Ross et al. 2013, West et al. 2017). Primary pollutants of concern in Puget Sound include heavy metals, organic compounds, PAHs, PCBs, dioxins, furans, DDT, phthalates, and PBDEs.

Areas of highest concern in Puget Sound are Southern Hood Canal, Budd Inlet, Penn Cove, Commencement Bay, Elliott Bay, Possession Sound, Saratoga Passage, and Sinclair Inlet. Hypoxic DO concentration (<3 mg/L) were found at several (11 out of 54) stations. DO concentrations less than 3 mg/L were measured in Hood Canal, Penn Cove, Saratoga Passage, Bellingham Bay, Discovery Bay, Elliott Bay, Strait of Georgia and West Point. Conditions in South Hood Canal were especially severe, with low DO concentration (<5 mg/L) evident year-round. Penn Cove also exhibited re-occurring hypoxia. Low DO was found at 18 other stations, including Saratoga Passage, Discovery Bay, Bellingham Bay, Elliott Bay, Budd Inlet, and Commencement Bay.

In 1989, the Washington State Department of Ecology (DOE) began a program to monitor marine sediment conditions called the Puget Sound Assessment and Monitoring Program (PSAMP). The PSAMP is a multi-agency partnership administered by the Puget Sound Action Team. From 1989-1995, the Marine Sediment Monitoring Program was implemented to characterize baseline sediment quality conditions and trends throughout the Greater Puget Sound area. This was the first large scale evaluation of Puget Sound sediment quality at ambient (i.e. away from point sources of contamination) stations throughout the Sound. Eighty-six stations were established throughout Puget Sound, Hood Canal, the Strait of Georgia, and the Strait of Juan de Fuca. Stations were grouped in two categories: core stations sampled annually, and rotating stations sampled once every three years alternating between North, Central, and South Puget Sound regions. At each station, replicate sediment samples were collected for the analysis of chemical contaminants, sediment variables, and benthic community structure.

Overall, contaminant concentrations at monitoring stations were generally low and below state sediment quality standards. Metals and semi-volatile organic compounds were most frequently detected. The highest metal and organic contamination was found in locations associated with

urban and industrial centers. Low metal concentrations were also detected in some rural areas and in deep depositional environments. Contaminant concentrations occasionally exceeded state regulatory sediment quality standards. However, there was not a consistent pattern across years. An exception was mercury in Sinclair Inlet and Dyes Inlet, with concentrations above standards for each of the seven years monitored.

By 2000, annual monitoring of sediments at ten historical PSAMP stations showed mixed trends for some chemicals found in sediments. Chemicals were detected in less than one-third (32 percent) of almost 13,000 samples analyzed. Those detected most often exceeded sediment quality guidelines in urban embayments, specifically Sinclair Inlet (mercury) and Thea Foss Waterway (PAHs).

In general, metals concentrations in 2000 were lower than the period from 1989 to 1996 more often than they were higher, while the opposite was true of PAHs. At the Port Gardner and Inner Budd Inlet station, concentrations of a number of priority pollutant and metals also decreased significantly. Individual PAH levels decreased at the Point Pully station, but increased significantly at the Bellingham Bay, Port Gardner, and East Anderson Island stations. Total PAH levels increased significantly at the Strait of Georgia, Bellingham Bay, East Anderson Island, and Budd Inlet stations. These changes may reflect changes in anthropogenic input of contaminants to the estuarine system over this 12-year study period. In addition, changes in grain size and benthic infaunal community composition seen at the Strait of Georgia station were probably linked to increased precipitation and subsequent increased flow and sediment loading from the Fraser River in 1996 and 1997.

From 1997 to 1999, sediments were collected throughout Puget Sound as part of a joint monitoring program conducted by the DOE and NMFS. Analyses were performed to quantify concentrations of potentially toxic chemicals, responses in laboratory toxicity tests, and the structure of benthic infauna communities in sediments.

Degraded conditions, as indicated by a combination of relative high chemical concentrations, statistically significant responses in one or more tests of toxicity, and adversely altered benthos, occurred in samples that represented about 1% of the total area (5,700 acres). These conditions occurred in samples collected within urbanized bays and industrial waterways, especially near the urban centers of Everett, Seattle, Tacoma, and Bremerton, where degraded conditions were reported in previous studies. Sediments with high quality (as indicated by no elevated chemical concentrations, no significant responses in the toxicity tests, and the presence of abundant and diverse infauna and/or pollution sensitive taxa) occurred in samples that represented a majority, 68% of the total study area (400,000 acres). When sediment analyses provided conflicting results, those sediments were classified as intermediate in quality and represented about 31% of the total area (179,000 acres).

Although the highly degraded sediments comprise a small percentage of Puget Sound’s area,

these hot spots upload pollution into the food web, and the resulting damage to the ecological health and function of the Puget Sound ecosystem may be much greater than the small area suggests.

Researchers detected arsenic, copper, lead, and mercury throughout the Sound. They found cadmium at 59% of the stations and tributyltin, an antifouling chemical found in ship hull paint before it was banned, at 50% of the stations. PAHs were common while phthlalate esters, PCBs, DDTs and dibenzofurans appeared at fewer stations (PSAT 2021). Degraded sediments were most prevalent in the Whidbey Basin and Central Sound regions (Everett Harbor, Elliott Bay, Commencement Bay). A higher degree of degradation in critical nearshore habitat may disproportionately affect important fish, shellfish and aquatic plant species (PSAT 2021).

The USGS assessed water quality of streams, rivers and groundwater in the Puget Sound Basin as part of the NAWQA Program between 1996 and 1998. This assessment focused on the quality of surface and ground waters and biological indicators such as fish, algal, and invertebrate status in relation to land use. A widespread detection of pesticide compounds was observed in surface waters of the Puget Sound Basin (Bortleson and Ebbert 2000). Slightly more than half of the pesticide compounds (26 of 47 analyzed) were detected. The study found that large rivers in the Puget Sound Basin were more likely to meet federal and state water quality guidelines than were small streams (Ebbert et al. 2000). A total of 74 manmade organic chemicals were detected in streams and rivers, with different mixtures of chemicals linked to agricultural and urban settings including atrazine, prometon, simazine and tebuthiuron, carbaryl, diazinon, and malathion (Bortleson and Ebbert 2000). A commonly detected volatile organic compound in the agricultural land-use study area was associated with the application of fumigants to soils prior to planting (Ebbert et al. 2000). The average concentration of total nitrogen in small streams draining agricultural lands was twice the concentration in streams draining urban areas and over 40 times the concentration in streams draining undeveloped areas (Ebbert et al. 2000). The study concluded that contaminants in runoff from urban and agricultural land surfaces were major influences on the water quality of streams and rivers (Ebbert et al. 2000), and, according to the 'State of the Sound' report, water quality impacts from stormwater and wastewater runoff is a major limiting factor in the recovery of salmon and bull trout (PSAT 2021).

6.5.3.3 Hydromodification Projects

More than 20 dams occur within the region's rivers and overlap with the distribution of salmonids, and a number of basins contain water withdrawal projects or small impoundments that can impede migrating salmon. The resultant impact of these and land use changes (forest cover loss and impervious surface increases) have caused significant modification of the seasonal flow patterns of area rivers and streams, and the volume and quality of water delivered to Puget Sound waters. Several rivers have been hydromodified by other means including levees and revetments, bank hardening for erosion control, and agriculture uses. The first dike in the Skagit River delta was built in 1863 for agricultural development (Ruckelshaus and McClure 2007),

other basins like the Snohomish River are diked and have active drainage systems to drain water after high flows that top the dikes. Dams were also built on the Cedar, Nisqually, White, Elwha, Skokomish, Skagit and several other rivers in the early 1900s to supply urban areas with water, prevent downstream flooding, allow for floodplain activities (like agriculture or development), and power local timber mills (Ruckelshaus and McClure 2007).

The Elwha River dam was removed in 2011. The Elwha River was formerly a very productive salmon river and signs of recovery were quickly noted (Warrick et al. 2015). Many protected salmonids have returned to the river and are now using it for natural reproduction (Weinheimer et al. 2017).

About 800 miles of Puget Sound's shorelines are hardened or dredged (Ruckelshaus and McClure 2007). The area most intensely modified is the urban corridor (eastern shores of Puget Sound from Mukilteo to Tacoma); here nearly 80% of the shoreline has been altered, mostly from armoring associated with the Burlington Northern Railroad tracks (Ruckelshaus and McClure 2007). Levee development within the rivers and their deltas has isolated significant portions of former floodplain habitat that was historically used by salmon and trout during periods with rising floodwaters.

6.5.3.4 Mining

Mining has a long history in Washington, and, in 2004, the state was ranked 13th nationally in total nonfuel mineral production value and 17th in coal production (Palmisano et al. 1993, NMA 2007). Metal mining for all metals (e.g., zinc, copper, lead, silver, and gold) peaked in the state between 1940 and 1970 (Palmisano et al. 1993). Today, construction sand and gravel, Portland cement and crushed stone are the predominant materials mined. Where sand and gravel is mined from riverbeds (gravel bars and floodplains), it may result in changes in channel elevations and patterns, instream sediment loads, and seriously altered instream habitat. In some cases, instream or floodplain mining has resulted in large-scale river avulsions. The effect of sediment mining in a stream or reach depends upon the rate of harvest (removal of sediments) and the natural rate of replenishment, as well as flood and precipitation conditions during or after the mining operations.

6.5.3.5 Commercial and Recreational Fishing

Most of the commercial landings in the region are groundfish, Dungeness crab, shrimp, and salmon. Many of the same species are targeted by tribal fisheries, and by charter fishing and recreational anglers. Nets and trawling are used in commercial and tribal fisheries, whereas recreational anglers typically use hook-and-line, and may fish from boat, riverbank, and docks. Entanglement of marine mammals in fishing gear is common and can lead to mortality or serious injury of the animal.

6.5.4 Oregon-Washington-Northern California Coastal Drainages

This region encompasses drainages originating in the Klamath Mountains, the Oregon Coast Mountains and the Olympic Mountains--the Coast Range ecoregion where elevations range from sea level to about 4,000 ft. More than 15 watersheds drain the region's steep slopes including the Umpqua, Alsea, Yaquina, Nehalem, Chehalis, Quillayute, Queets, and Hoh Rivers. Numerous other small to moderately sized streams dot the coastline. Many of the basins in this region are relatively small—the Umpqua River drains a basin of 4,685 miles^2 and is a little over 110 mi long and the Nehalem River drains a basin of 855 mi^2 and is almost 120 mi long—yet represent some of the most biologically diverse basins in the Pacific Northwest (Johnson 1999, Kagan et al. 1999, Carter and Resh 2005).

The region is part of a coastal, temperate rainforest system characterized by moderate maritime climate marked by long wet seasons with short dry seasons and mild to cool year-round temperatures. Average annual precipitation ranges from about 60 inches to more than 180 inches, much of which falls as rain, and supports a rich temperate forest. Vegetation is characterized by giant coniferous forests of Sitka spruce, western hemlock, Douglas fir, western red cedar, red alder, and black cottonwood.

The Oregon Coast supports a unique coastal sand dune system. The sand dunes were largely created by the sand deposited from the coastal rivers, in particular the Umpqua and Columbia Rivers. North, steep headlands and cliffs are separated by stretches of flat coastal plain and large estuaries. Significant estuaries in the region (outside of the Columbia River estuary) include Coos Bay, Tillamook Bay and the Nehalem River Estuary in Oregon, and Grays Harbor, and Willapa Bay in Washington.

6.5.4.1 Land Use

The rugged topography of the western Olympic Peninsula and the Oregon Coastal Range has limited the development of dense population centers. For instance, the Nehalem River and the Umpqua River Basins consist of less than 1% urban land uses. Most basins in this region have long been exploited for timber production, and are still dominated by forestlands. In Washington State, roughly 90% of the coastal region is forested (Palmisano et al. 1993). Approximately 92% of the Nehalem River Basin is forested, with only 4% considered agricultural. Similarly, in the Umpqua River Basin about 86% is forested land, 5% agriculture and 0.5% are considered urban lands—with about half the basin under federal management (Carter and Resh 2005).

Tillamook County boasts about its dairy farming and cheese production—having a higher density of cows than people but even so, Tillamook County like many others in the region is dominated by forested lands (EPA 2006). Roughly 90% of Tillamook County is forestland, held by federal and state governments and private entities. In the Nehalem Basin, state and private landowners own more than 90% of the forestlands, and about 80% of the private land holdings are large timber companies.

6.5.4.2 Hydromodification Projects

Compared to other areas in the greater Northwest Region, the coastal region has fewer dams and several rivers remain free-flowing (e.g., Clearwater River). The Umpqua River is fragmented by 64 dams, the fewest number of dams on any large river basin in Oregon (Carter and Resh 2005). According to Palmisano et al. (1993), dams in the coastal streams of Washington permanently block only about 30 miles of salmon habitat.

In the past, temporary splash dams were constructed throughout the region to transport logs out of mountainous reaches. The general practice involved building a temporary dam in the creek adjacent to the area being logged, the pond that developed behind the dam was filled with logs and, when the dam broke, the floodwater would carry the logs to downstream reaches where they could be rafted and moved to market or downstream mills. Thousands of splash dams were constructed across the Northwest in the late 1800s and early 1900s. While the dams typically only temporarily blocked salmon habitat, in some cases they remained long enough to wipe out entire runs and the effects of the channel scouring and loss of channel complexity resulted in the long-term loss of salmon habitat (NRC 1996).

6.5.4.3 Mining

Oregon ranked 35th nationally in total nonfuel mineral production value in 2004, while Washington was ranked 13th nationally in total nonfuel mineral production value in 2004 and 17th in coal production (Palmisano et al. 1993, NMA 2007). Metal mining for all metals (e.g., zinc, copper, lead, silver, and gold) peaked in Washington between 1940 and 1970 (Palmisano et al. 1993). Today, construction sand and gravel, Portland cement, and crushed stone are the predominant materials mined in both Washington and Oregon. Where sand and gravel is mined from riverbeds (gravel bars and floodplains), it may result in changes in channel elevations and patterns, instream sediment loads, and seriously alter instream habitat. In some cases, instream or floodplain mining has resulted in large-scale river avulsions. The effect of mining in a stream or reach depends upon the rate of harvest and the natural rate of replenishment, as well as flood and precipitation conditions during or after the mining operations.

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6.5.5 The Risk of Fire in the West Coast Region

Peak fire season in the Southwest Coast Region occurs between April and October, but, in the past decade, fires have been reported every month. Based on a review of more than 80,000 wildfires, Malamud et al. (2005) calculated the wildfire recurrence interval for large fires ($\geq$

2,471 acres [10 km^2]) in the Mediterranean and Mediterranean Mountain ecoregions that encompass most of this region, as every year to three years in the lowland or Mediterranean ecoregion, approximately every 9 to 17 years in the Mediterranean Mountains. Monitoring of USFS lands since 2007 has shown fire intervals range from every other year in the San Bernadino National Forest to only one major fire year during that time for many other forests. The average return of large fires in the past 13 years has been every four years.

Peak fire season in the Pacific Northwest Region occurs between April and October. Based on a review of more than 80,000 wildfires, Malamud et al. (2005) calculated the wildfire recurrence interval for large fires ($\geq$ 2,471 acres (10 km^2)) in the marine mountain ecoregion that encompasses the Coastal Basins and Puget Sound, as ranging between every 63 to 137 years. Monitoring of USFS lands since 2007 shows no major fires in the Puget Sound area.

The wildfire recurrence interval for large fires ($\geq$ 2,471 acres [10 km^2]) in the Columbia River watershed, which also covers the more arid Temperate Desert, Temperate Steppe, and Temperate Steppe Mountain ecoregions, is more frequent. It ranges from every 8 to 18 years in the Temperate Desert to every 14 to 30 years in the Temperate Steppe ecoregion, and to every 26 to 46 years in the Temperate Steppe Mountain ecoregion (Malamud et al. 2005). Monitoring by the USFS since 2007 reveals returns of large fires approximately every five years in the Columbia River basin (maximum of once every four years).

In Oregon, the ten-year average area of fires burned annually prior to 2007 was slightly more than 20,000 acres (ODF 2007). Monitoring by the USFS since 2007 shows the area burned in that time has been in the millions of acres, far exceeding the rate reported in the early 2000s. The Rogue-Siskiyou National Forest lands have had the most frequent large fire returns of the Oregon national forests, which is approximately once every three years.

7 Effects Analysis

Under the ESA, "effects of the action" are defined 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. Effects of the action may occur later in time and may include consequences occurring outside the immediate area involved in the action." (50 C.F.R. §402.02).

We assess the anticipated effects of the action by considering the probability of ESA-listed species being exposed to aerially applied long-term fire retardants and the loss of prey resources (the lone stressors remaining of those identified in Section 5.1). We then consider the range of responses that would be expected because of being exposed to those stressors. In the subsequent sections, we will combine the information gathered in our exposure and response analyses with our analysis of cumulative effects and the previous sections of this opinion to evaluate the ultimate risk of the fire retardant program to individuals, populations, and species.

7.1 Exposure

In a formal ESA consultation, the exposure analysis is limited to the probability of exposure of listed resources to stressors caused by the proposed action. The stressors that have the potential to adversely affect some species are intrusions as a result of the aerial application of long-term fire retardants and effects of any salmonid mortality that results from the aerial application of long-term fire retardants that would limit food resources for threatened or endangered predators (discussed in Section 5.1). Intrusions, for the purpose of calculating probable exposure, are incidents when any amount of fire retardant is introduced into a waterway. The exposure of individuals is then calculated as a measure of the density of listed species in the area affected by the spike in toxicity resulting from the intrusion. The area affected is modelled using the USFS spill calculator (Rehmann et al. 2021).

The probability of exposure to stressors can be influenced by the activity producing the stressors, as well as the mitigation measures implemented to minimize the likelihood of exposure. The USFS has implemented several minimization measures meant to prevent intrusions of fire retardants into streams with listed species. There is a buffer around all streams that extends 300 feet to either side of the waterbody where fire retardants are not to be applied. The pilots receive training about the importance of avoiding streams with their fire retardant applications, including timing approximations to help the pilots estimate when to start and stop applications leading to streams and after passing over them to avoid the buffers, minimizing the chances of retardant reaching water.

7.1.1 Identifying the Chemical Concentration of an Exposure

EPA uses ranges of concentrations to represent levels of toxicity (EPA 2022a). An LC_{50} with a concentration below 0.1 mg/L is considered very highly toxic, a concentration of .1 to 1 mg/L is highly toxic, a concentration of 1 to 10 mg/L is moderately toxic, a concentration of 10 to 100 mg/L is slightly toxic, and a concentration over 100 mg/L is practically non-toxic. Un-ionized ammonia is highly toxic to fish, while ionized ammonia is less toxic because it does not pass easily through the gill membranes (Sampaio et al. 2002, Camargo and Alonso 2006)

Ammonia is considered highly toxic to fish. Toxicity of chemicals including ammonia can be measured in a standard way called an LC_{50}, which is the concentration at which half of the effected population will die in an established time. An LC_{50} can be established by graphing a range of mortality rates at various concentrations over time, where a curve forms with higher mortality at higher concentrations to lower mortality at lower concentrations for a given exposure duration. However, because we are considering endangered species, relying on an LC_{50}, which is a standard measure for toxicity tests, is not a reasonable endpoint. Further, the studies presented below do not report the LC_x values (x being a percentage of mortality that is usually small; 5 or 10), which would give an indication to the slope of the mortality curve to estimate when the curve would intercept with zero. The intercept with zero is still a measure of no mortality and overlooks sub-lethal effects. Ideally, we would rely on a no effect concentration

(NOEC) or no adverse effects concentration (NOAEC) to be protective of listed species. However, simple solutions rarely exist and a wide range of concentrations could produce a no effect result, so most researchers consider a firm NOEC or NOAEC line to be unreliable and discourage its use (Warne and Van Dam 2008, de Vries and Murk 2013). Therefore, because the LC_{50} values are what is widely available for each chemical compound, we chose to identify a level of exposure that may still result in a response, but not rise to the level of take. EPA (2022b) suggests a level of one twentieth (0.05) the LC_{50} concentration as the lowest level of concern for ESA-listed species. However, in research conducted by NMFS (Dietrich et al. 2014), the threshold of responses to fire retardant chemicals was between four and eight times higher than the 10% LC_{50} value. For this reason, we are using the value of 10% of the 96-hour LC_{50} to approximate the level below which we would not expect any take of ESA listed species, but again, there may be responses that do not rise to the level of take (Bechmann 1994, Dietrich et al. 2014, Auxillio 2021).

Rehmann et al. (2021) developed a model to help USFS collect the necessary information on fire retardant intrusions and estimate the effects of each intrusion as it occurs given its location on the landscape. This model was applied to 13 documented intrusions as well as another 1,152 hypothetical intrusions. Of the 13 that occurred since 2011, the exposure to fire retardants above the 10% LC_{50} value ranged from eight to 362 km downstream. Further, the sensitivity analysis conducted using the 1,152 hypothetical exposures suggests most intrusions affect a stream for between 1.5 hours and five hours. Because of this short exposure time, 96-hour LC_{50} tests over-estimate expected exposures and likely overestimate expected responses. There are currently no publications assessing the effects of ammonia on salmonids for under 5-hour periods.

7.1.2 Intrusion Frequency

To understand exposure frequency, we assessed the frequency of intrusions, which were defined earlier to be the intentional or unintentional application of fire retardant into aerial retardant avoidance area (a waterway or the buffer around it). However, there are several types of intrusions, each with different consequences and risks. Table 59 shows the number of intrusions since 2011 in all forests with NMFS trust resources. Over this period, the USFS has tracked intrusions into buffer zones, into waterways without listed species, into waterways with listed species, and into ephemeral streams that were dry during application. Each of these is important as there could be delayed risks due to intrusions into dry creeks or buffer zones, where the retardant could sit immobilized until the next rainfall. Intrusions directly into waterways pose more direct threats of exposure to fire retardants.

The USFS implemented a buffer around all waterways (wet and ephemeral) to minimize the likelihood of intrusions into water. The thought was that by establishing the buffer, intrusions into water would be fewer, but we may still see intrusions into the buffer when pilots failed to cease an application to avoid the buffer. Interestingly, intrusions into buffers that did not reach waterways appear to be relatively rare. The data for these assessments are provided in

Appendices C and D of the BA (USDA Forest Service 2019). On the forests with NMFS-managed species, approximately 0.16% (46 of 28,044 fire retardant drops) of all applications since 2011 fell within the buffer zone around waterways. This may be an artifact of not reporting intrusions occurring far from water and not measuring 300 feet with every near miss.

Like with buffers, we suspect that reports of intrusions into ephemeral creek beds may be less common because these tend to be extremely small, headwater systems that would be difficult to identify during dry conditions. Additionally, ephemeral streams are less common than year round streams, so there may be fewer possible ephemeral streams to encounter. Since 2011, 31 intrusions were reported into ephemeral streams, amounting to 0.11% of all retardant drops. For either intrusions into buffers or dry creeks, the mode of effects would be through run off. This is likely irrelevant as risk assessment modeling for fish and aquatic invertebrates reveals run-off risks are insignificant (Section 5.1; Auxilio 2021a, b). Because of this, we focus the exposure analysis on intrusions into water, as those are the exposures that affect listed fish and their food resources.

When fire retardant enters water, there is a lower likelihood that it could be missed or go unreported. NMFS manages marine and anadromous fish, species that don't always reach the headwaters of systems and most often, species that are confined to larger, deeper areas of mainstem systems. This may leave large sections of watersheds that are unoccupied by listed species until reaching areas far enough downstream to support these larger fish. Therefore, there are two types of aquatic intrusions tracked: those that land in waters occupied by listed species and those that land in water that is unoccupied. Since 2011, 117 intrusions went into waterways without listed species and 60 intrusions went into waterways with listed species present or critical habitat present. These rates equate to 0.42% of applications reaching water without listed species, 0.21% of applications reaching water with listed species, and 0.63% (117 + 60 of 28,044) of applications reaching waterways generally.

To estimate the likely rate of intrusions for future fire retardant applications, we will use the rate into waterways with listed fish present (0.21%) as these best reflect the conditions being considered here. We also chose to calculate this rate using national forests with NMFS-trust resources where ICs stress the avoidance zones and the presence of listed species and critical habitat rather than nationally.

For the purposes of estimating exposure, we rely on the best available data, which exists at the national forest level. There is not more detailed information of fires and fire retardant use at watershed scales or by ranger districts on national forests. Unfortunately, in very few cases do listed species actually reside on the entire national forest. Because of this, we are knowingly over-estimating exposure probability for each species, but there is no better information available to allow us to produce more detailed estimates of what is reasonably certain to occur. Further, because fire retardant has not been uniformly applied across national forests, nor is wildfire probability uniform across each national forest, it is no more appropriate to use the fraction of

the national forest occupied by a listed species to calculate exposure probability because that could unintentionally underestimate the likelihood of exposure. For the purposes of a Jeopardy analysis, when the best available information would knowingly either overestimate or underestimate exposure, it is better to knowingly overestimate exposure so the conclusions we ultimately reach insure the action is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat.

The probability of an intrusion (0.21%, explained above) over time forms a normal binomial distribution around the most likely number of intrusions resulting from a number of fire retardant applications. The equation for this calculation is:

$$b(x, n, p) = \binom{n}{x} p^x (1-p)^{n-x}$$

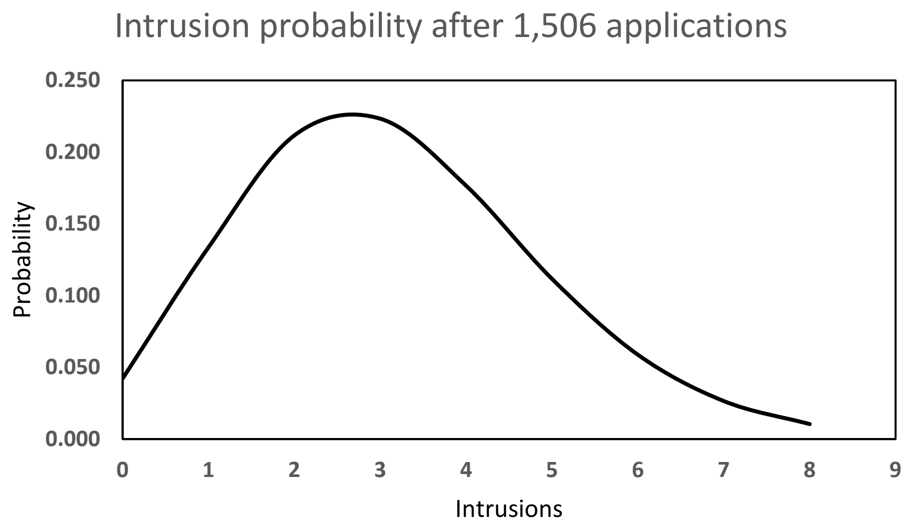
Here, b is the binomial distribution of x, n, and p, which are the number of intrusions (x), probability of an intrusion (p), and number of applications (n). In this case, there is a 0.21% chance that a single fire retardant application errantly falls into water. If a second application is made on that forest, there is a 0.42% chance one of those applications reaches water (x = 1, n = 2, p = 0.0021) and a 0.0004% chance that both of those applications errantly land in water (x = 2, n = 2, p = 0.0021; p^n; or 0.21% * 0.21%). The more applications made, the greater the likelihood of an intrusion or multiple intrusions. For instance, on the Boise National Forest (Table 59), given a 0.21% intrusion rate and 1,506 applications, there is a 22.33% chance of three intrusions ($[1506! / (3! * 1503!)] * [.0021]^3 * [1-.0021]^{1503}$) and a 21.2% likelihood of two intrusions (Figure 32). Therefore, while there was a greater than 60% chance of three or fewer intrusions occurring in listed species habitat on the Boise National Forest, there were five intrusions there that had only an 11% probability of occurring.

Table 59. Total fire retardant applications and intrusions on forests with NMFS trust resources since 2011.

National Forest	Buffer intrusions	Water intrusions outside of listed species habitat	Water intrusions into listed species habitat	Intrusion into dry intermittent stream	Total fire retardant applications	Probability of an intrusion to water
Bitterroot NF	0	0	1	0	324	0.31%
Boise NF	10	20	5	2	1,506	1.66%
Cleveland NF	1	0	2	0	1,297	0.15%
Columbia River Gorge	0	0	0	0	10	0%
Deschutes/ Ochoco NF	0	0	1	0	719	0.14%
Eldorado NF	0	2	0	0	787	0.25%
Gifford Pinchot NF	1	0	0	0	114	0%
Klamath NF	1	14	1	0	2,288	0.66%
Lassen NF	3	6	2	1	333	2.4%

Los Padres NF	1	2	8	8	5,160	0.19%
Malheur NF	1	1	3	0	526	0.76%
Mendocino NF	11	15	15	12	412	7.28%
Mount Baker-Snoqualmie	0	0	0	0	0	0%
Mount Hood NF	1	0	1	0	56	1.79%
Nez Perce-Clearwater NF	2	2	0	0	733	0.27%
Okanogan-Wenatchee NF	0	1	2	0	1,653	0.18%
Olympic NF	0	0	0	0	0	0%
Payette NF	0	6	3	2	875	1.03%
Plumas NF	0	4	0	1	1,021	0.39%
Rogue River/Siskiyou	0	0	1	0	1,118	0.09%
Salmon-Challis NF	0	3	1	0	440	0.91%
Sawtooth NF	1	2	4	0	416	1.44%
Shasta Trinity NF	3	8	4	2	1,927	0.62%
Sierra NF	3	16	1	0	3,712	0.46%
Six Rivers NF	6	7	1	3	785	1.02%
Siuslaw NF	0	0	0	0	0	0%
Tahoe NF	1	4	1	0	442	1.13%
Umatilla NF	0	0	2	0	393	0.51%
Umpqua NF	0	0	0	0	233	0%
Wallowa-Whitman NF	0	3	0	0	610	0.49%
Willamette NF	0	0	0	0	88	0%
North Carolina	0	1	0	0	11	9.09%
Florida	0	0	1	0	55	1.82%
Total	46	117	60	31	28,044	0.63%

Figure 32. An example of normally distributed probabilities to estimate the anticipated number of intrusions based on the Boise National Forest application history.



7.1.3 Application Frequency

The western US is home to most of the national forests in this country and most of the USFS land with listed species in their watersheds. Along the west coast, there are 32 national forests with listed species and critical habitat designations (Table 59). Additionally, the proportion of a species' range that is located on these national forests is not a meaningful metric for determining risks to the DPSs or ESUs because of variability of fire location. Furthermore, to understand exposure to individuals, we need information on the life stages present, the subpopulation and/or genetic structure of the species present on USFS lands, its importance to the survival and recovery of the DPS or ESU, and the importance of that habitat compared to the habitat elsewhere in their range.

To understand application frequency, we relied on the monitoring conducted by the USFS since 2011 to understand acres burned as well as amount of fire retardant applied each year during that time. While some listed species may be found within entire national forests, others are found only on small segments. We lacked the fine scale resolution in the compiled data to identify exact proportions of each species' habitat that burned in the past decade. Furthermore, a geographic perspective of fire return interval is more meaningful to an analysis of future wildfire expectations. There is a concern that using data from an entire forest when a species may be exposed to activities on only a small portion of that forest can lead to over-estimating risk. However, because of the scales at which the best available data is compiled, efforts at increasing accuracy would likely lead to less precise estimates. Therefore, we believe analyzing exposure probability at the species scale and national forest scale will provide reliable, if possibly over-estimated, exposure estimates. This strategy will also minimize the risk of committing the equivalent of a Type I error in statistics; in this case, determining there is no significant risk to listed species when there is risk.

Fire retardant applications since 2011 were tracked by volume administered on each national forest, not as individual applications. This is because a plane may on occasion make multiple applications from a single load. The average fire retardant application is 1,800 gallons; therefore, we estimate the number of aerial applications of fire retardant each year as the volume applied to each national forest divided by 1,800. For instance, since 2011 in North Carolina, 19,583 gallons of fire retardant have been applied, which amounts to 11 applications in that time. Wildfires tend to be cyclical, burning across a landscape and then not returning until sufficient fuel has rebuilt for another fire. As an example, again using North Carolina, the full 19,583 gallons of fire retardants were applied in 2016 with no retardant used in any other year. Fire return interval will vary by fuel type and can be estimated for each forest by observing rates of fire retardant application. The fire retardant applications each year as a proportion of total applications from 2012 through 2019 are reported in Table 60.

Table 60. Proportion of fire retardant applications by year since 2011 with an estimate of the total number of fire retardant applications made over the same time.

Forest	2012	2013	2014	2015	2016	2017	2018	2019	Total drops
Bitterroot	0.09	0.00	0.01	0.06	0.64	0.03	0.15	0.03	324
Boise	0.23	0.14	0.11	0.05	0.40	0.02	0.03	0.02	1,506
Cleveland	0.00	0.10	0.10	0.03	0.04	0.07	0.65	0.00	1,297
Columbia River Gorge	0.00	0.00	0.36	0.00	0.00	0.64	0.00	0.00	10
Deschutes/ Ochoco	0.05	0.10	0.08	0.09	0.02	0.50	0.11	0.06	719
Eldorado	0.00	0.04	0.78	002	0.14	0.02	0.00	0.01	787
Gifford Pinchot	0.98	0.00	0.00	0.02	0.00	0.00	0.00	0.00	114
Klamath	0.04	0.01	0.57	0.01	0.15	0.17	0.01	0.03	2,288
Lassen	0.00	0.15	0.37	0.04	0.05	0.05	0.30	0.04	333
Los Padres	0.02	0.03	0.00	0.02	0.71	0.156	0.03	0.03	5,160
Malheur	0.04	0.06	0.10	0.53	0.01	0.03	0.01	0.21	526
Mendocino	0.48	0.03	0.00	0.18	0.02	0.17	0.11	0.02	412
Mount Baker-Snoqualmie	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Mount Hood	0.00	0.00	0.34	0.52	0.00	0.08	0.05	0.00	56
Nez Perce-Clearwater	0.15	0.06	0.04	0.21	0.02	0.17	0.29	0.05	733
Okanogan-Wenatchee	0.12	0.03	0.21	0.09	0.03	0.01	0.44	0.06	1,653
Olympic	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Payette	0.19	0.17	0.03	0.19	0.00	0.02	0.24	0.15	875
Plumas	0.23	0.02	0.02	0.01	0.05	0.30	0.05	0.32	1,021
Rogue River/ Siskiyou	0.00	0.01	0.22	0.06	0.00	0.29	0.40	0.03	1,118
Salmon-Challis	0.07	0.39	0.00	0.15	0.13	0.00	0.10	0.16	440

Sawtooth	0.16	0.27	0.05	0.00	0.32	0.07	0.13	0.00	416
Shasta Trinity	0.25	0.03	0.04	0.27	0.01	0.09	0.27	0.04	1,927
Sierra	0.01	0.14	0.04	0.48	0.03	0.12	0.17	0.00	3,712
Six Rivers	0.01	0.14	0.03	0.43	0.01	0.38	0.00	0.01	785
Siuslaw	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0
Tahoe	0.00	0.74	0.04	0.00	0.00	0.02	0.20	0.00	442
Umatilla	0.00	0.08	0.13	0.42	0.02	0.04	0.12	0.19	393
Umpqua	0.00	0.17	0.01	0.22	0.00	0.23	0.37	0.00	233
Wallowa-Whitman	0.16	0.04	0.11	0.13	0.26	0.27	0.00	0.03	610
Willamette	0.00	0.00	0.47	0.04	0.00	0.41	0.06	0.02	88
Florida	0.00	0.00	0.00	0.00	0.00	0.64	0.00	0.36	55
North Carolina	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	11

Fire return intervals are variable through time and depend on burn intensity (Hudec and Peterson 2012, Parisien et al. 2012, Koontz et al. 2020), as lighter burns may leave fuel available for fires in subsequent years. While the exact return interval may not be predictable, it is unlikely that any forest or adjacent forests experience consistent burn rates from year to year (Chikamoto et al. 2015). Because we would expect some years to experience peaks and other years to have no wildfire activity, we are considering the risk of exposure as the cumulative number of intrusions based on annual averages over a 10-year period. A review of the national forests occupied by NMFS' trust species shows a fire return interval of once every four- to five-years to each West Coast forest, largely because of the size of the national forests and wildfires affecting a small portion of the total area. Return intervals to the four east coast national forests with NMFS' listed species present are so infrequent, the acres burned and fire retardant applied are compiled at the state level rather than forest level.

7.1.4 Species and critical habitat exposure

Identifying wildfire return intervals on each national forest is important for understanding exposure probabilities on those forests, but most listed species are present on multiple national forests, thus risking exposure at the population or species level from fires in multiple national forests at any given time. Therefore, to understand the exposure each species is likely to encounter in any given year, we need to identify the national forests each species occupies, and then identify the cumulative risk they face from all of those forests. For instance, Lower Columbia River Chinook salmon are found in Mt. Hood National Forest, Gifford Pinchot National Forest, and the Columbia River Gorge National Scenic Area. Table 60 shows from 2012 through 2019, those three NFS lands received 56, 114, and 10 fire retardant applications, respectively. This amounts to a total retardant application over 8 years of 180 applications. The highest annual application amount on all three NFS lands during any of those years occurred in 2012, which happened to occur entirely on the Gifford Pinchot National Forest. Applications on Mt. Hood National Forest primarily occurred in 2014 and 2015, but not to levels seen on Gifford

Pinchot in 2012. Table 61 shows each species, the national forest lands they reside on or immediately downstream of, and the reported applications from the past eight years with the number of intrusions anticipated over the next decade and each decade thereafter.

Table 61. The 2012 to 2019 cumulative fire retardant applications in watersheds of each DPS or ESU and the number of anticipated exposures every 10 years given the past intrusion rate.

ESU/DPS	National Forests	Cumulative applications	Peak annual application	Anticipated intrusions	Proportion of years with at least one intrusion	Species status
CA Coastal Chinook	Mendocino NF Shasta-Trinity NF Six Rivers NF	3,124	925	9	0.5	Threatened
Central Valley spring-run Chinook	Six Rivers NF Shasta-Trinity NF Mendocino NF Lassen NF Sierra NF	7,169	2,724	19	0.625	Threatened
LCR Chinook	Mt. Hood NF Gifford Pinchot NF Columbia River Gorge NSA	179	112	1	0	Threatened
Snake River fall-run Chinook	Nez Perce NF Umatilla NF Clearwater NF Wallowa-Whitman NF Columbia River Gorge NSA	2,621	569	7	.125	Threatened
Snake River spring/ summer-run Chinook	Boise NF Payette NF Salmon-Challis NF Nez Perce NF Clearwater NF Umatilla NF Wallowa-Whitman NF Columbia River Gorge NSA	3,554	680	10	0.625	Threatened
UCR spring-run Chinook	Okanogan-Wenatchee NF	1,654	735	5	0.125	Endangered
Upper Willamette River Chinook	Mt. Hood NF Willamette NF	144	60	1	0	Threatened
Sacramento winter run Chinook	Lassen NF Mendocino NF Shasta-Trinity NF	2,672	679	8	0.375	Endangered
Columbia River Chum	Mt. Hood NF Gifford Pinchot NF Columbia River Gorge NSA	179	112	1	0	Threatened
LCR coho	Mt. Hood NF Gifford Pinchot NF Columbia River Gorge NSA	179	112	1	0	Threatened

SONCC coho	Rogue NF Siskiyou NF Klamath NF Shasta-Trinity NF Six Rivers NF Mendocino NF	6,530	1,653	18	0.625	Threatened
Oregon Coast coho	Umpqua NF Siskiyou NF Suislaw NF	1,352	534	4	0.125	Threatened
Snake River Sockeye	Wallowa-Whitman NF Salmon-Challis NF Sawtooth NF Nez Perce NF	2,199	363	6	0	Endangered
CA Central Valley steelhead	Eldorado NF Lassen NF Mendocino NF Tahoe NF Shasta-Trinity NF Plumas NF	4,923	915	13	0.75	Threatened
LCR steelhead	Mt. Hood NF Gifford Pinchot NF Columbia River Gorge NSA	179	112	1	0	Threatened
MCR steelhead	Umatilla NF Ochoco NF Malheur NF Okanogan-Wenatchee NF Columbia River Gorge NSA	3,301	867	9	0.375	Threatened
Northern California steelhead	Six Rivers NF Shasta-Trinity NF Mendocino NF	3,124	925	9	0.5	Threatened
Snake River steelhead	Boise NF Payette NF Salmon-Challis NF Sawtooth NF Nez Perce NF Clearwater NF Umatilla NF Bitterroot NF Wallowa-Whitman NF Columbia River Gorge NSA	5,306	1,183	14	0.625	Threatened
South Central CA Coast steelhead	Los Padres NF	5,160	3,685	14	0.25	Threatened
Southern California steelhead	Los Padres NF Cleveland NF	6,457	3,741	17	0.375	Endangered
UCR steelhead	Okanogan-Wenatchee NF Columbia River Gorge NSA	1,663	735	4	0.125	Threatened
Upper	Willamette NF	88	42	1	0	Threatened

Willamette River steelhead						
Green sturgeon	Shasta-Trinity NF Mendocino NF Rogue NF Siskiyou NF Siuslaw NF	3,457	968	9	0.5	Threatened
Pacific eulachon smelt	Six Rivers NF Columbia River Gorge NSA Mt. Hood NF Gifford Pinchot NF Siuslaw NF Siskiyou NF	2,082	630	6	0.375	Threatened
South Atlantic DPS Atlantic sturgeon	NC Forests FL Forests	67	36	1	0	Endangered
Carolina DPS Atlantic sturgeon	NC Forests FL Forests	67	36	1	0	Endangered
Chesapeake Bay DPS Atlantic sturgeon	NC Forests FL Forests	67	36	1	0	Endangered
Shortnose sturgeon	NC Forests FL Forests	67	36	1	0	Endangered

7.1.4.1 California Coastal Chinook Salmon

California Coastal Chinook salmon freshwater habitat reaches upriver into the Six Rivers, Shasta-Trinity, and Mendocino National Forests (Figure 33). Between 2012 and 2019, those three forests experienced cumulative fire retardant applications of 3,124 drops with a peak of 925 fire retardant applications in 2015. At that application rate, we would anticipate nine intrusions over a 10-year period with at least one intrusion occurring in any given year about half the time. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, only juvenile fish would be present and possibly exposed to fire retardants.

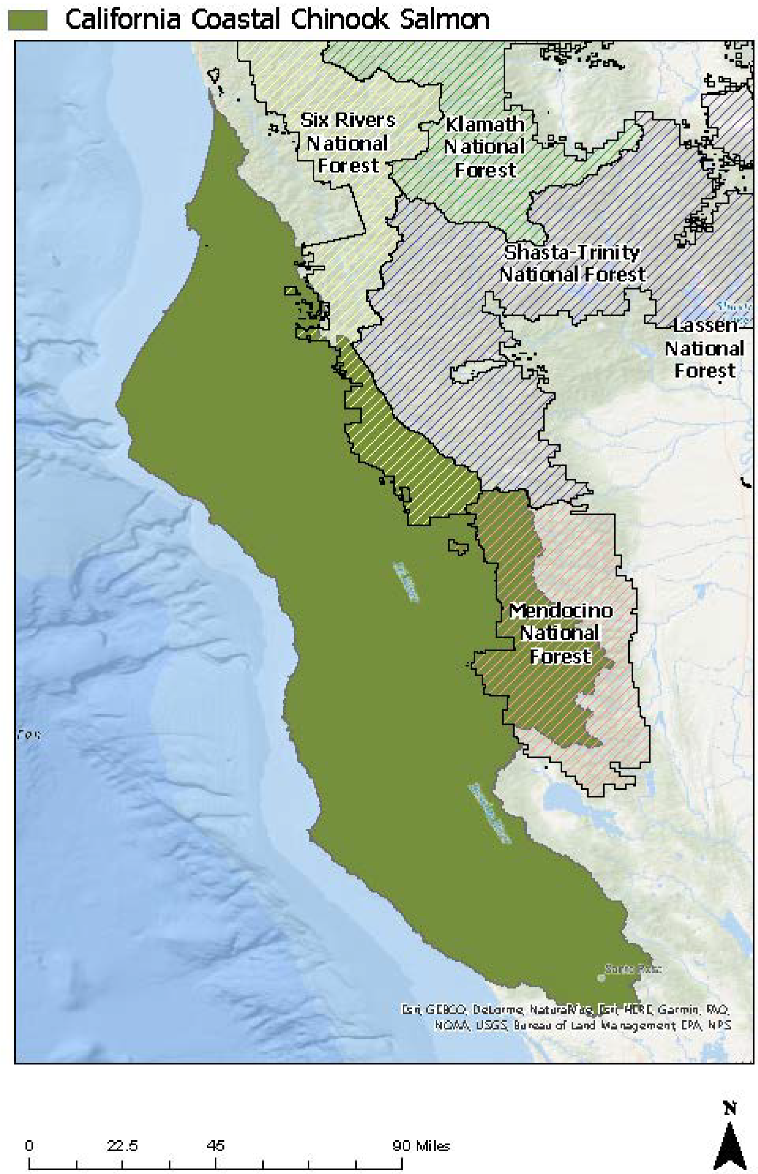


Figure 33. California Coastal Chinook salmon range overlapping Six Rivers, Shasta-Trinity, and Mendocino National Forests.

7.1.4.2 Central Valley Spring Run Chinook Salmon

Central Valley spring-run Chinook salmon freshwater habitat reaches upriver into the Six Rivers, Shasta-Trinity, Mendocino, Lassen, and Sierra National Forests. Their freshwater habitat is found in the lower extents of each national forest (Figure 34). Between 2012 and 2019, those three forests experienced cumulative fire retardant applications of 7,169 drops with a peak of 2, 724 fire retardant applications in 2015. At that application rate, we would anticipate 19 intrusions over a 10-year period with at least one intrusion occurring in approximately 62% of fire seasons. Based on data since 2000 on these national forests, approximately 99% of fires are expected

from June through September. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

Figure 34. Central Valley spring run Chinook salmon occupied habitat overlapping with Six Rivers, Mendocino, Shasta-Trinity, Lassen, and Sierra National Forests.

7.1.4.3 Lower Columbia River Chinook Salmon

Lower Columbia River Chinook salmon freshwater habitat reaches upriver into the Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area. Their freshwater habitat is found extensively throughout these national forests (Figure 35). Between 2012 and 2019, those three USFS managed areas experienced cumulative fire retardant applications of 179 drops with a peak of 112 fire retardant applications in 2012. At that

application rate, we would anticipate one intrusion over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

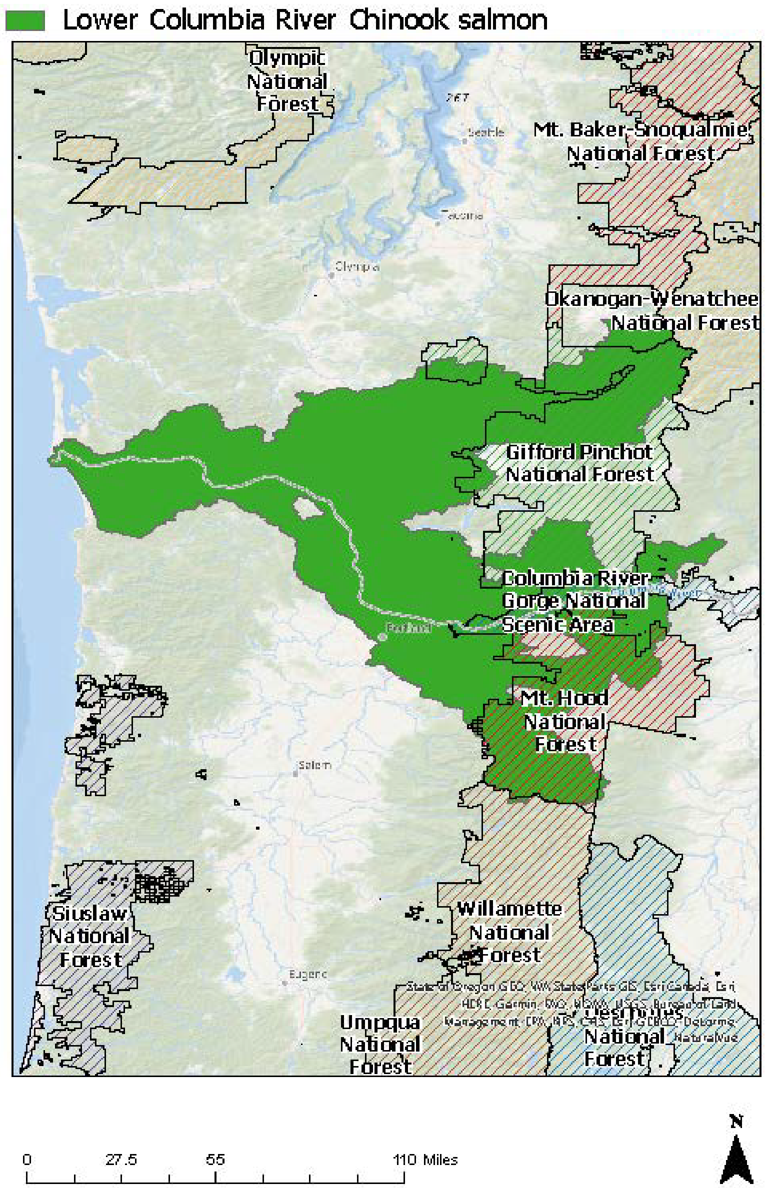


Figure 35. Lower Columbia River Chinook salmon range map overlaid with national forests, showing their distribution on the Gifford Pinchot and Mt. Hood National Forests as well as the Columbia River Gorge National Scenic Area.

7.1.4.4 Snake River Fall-run Chinook

Snake River fall-run Chinook salmon freshwater habitat reaches upriver into the Nez Perce-Clearwater, Umatilla, Payette, and Wallowa-Whitman National Forests as well as the Columbia

River Gorge National Scenic Area. Their freshwater habitat is found extensively throughout these national forests (Figure 36). Between 2012 and 2019, those three USFS managed areas experienced cumulative fire retardant applications of 2,621 drops with a peak of 569 fire retardant applications in 2015. At that application rate, we would anticipate seven intrusions over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September, with over 92% in July and August. During this time, adult and juvenile fish would be present and possibly exposed to fire retardants.

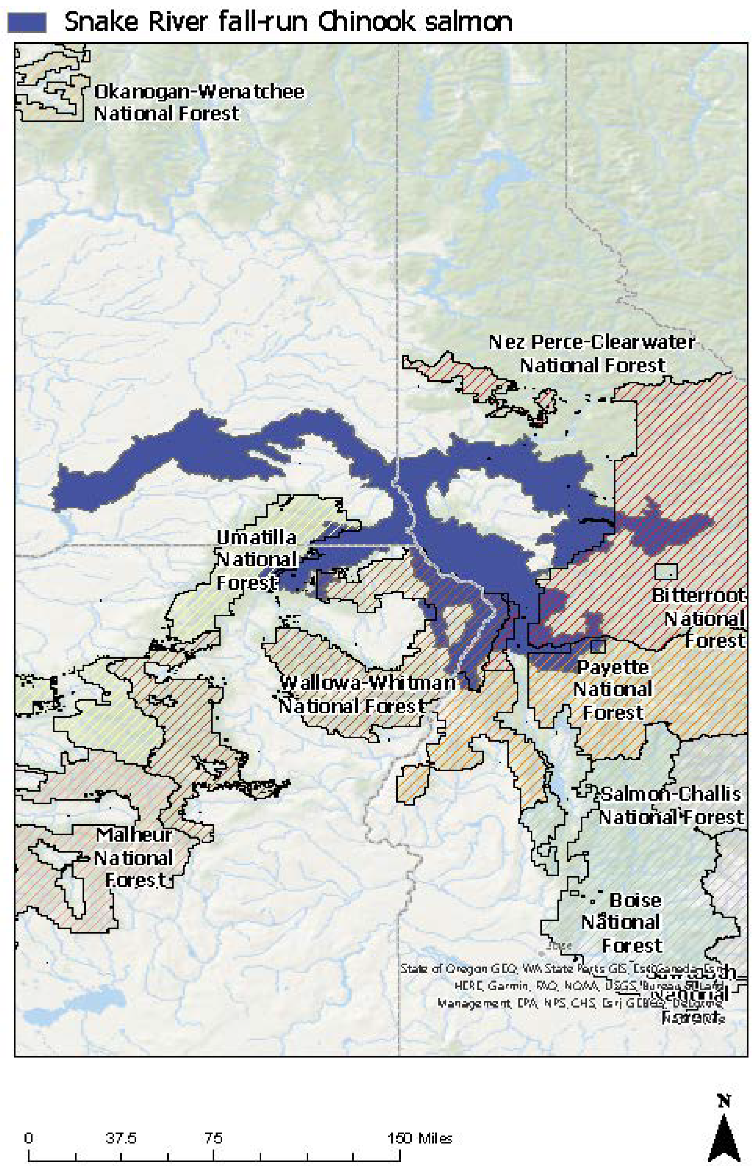


Figure 36. Snake River fall-run Chinook salmon occupy habitat overlapping with Nez Perce-Clearwater, Umatilla, Payette, and Wallowa-Whitman National Forests as well as the Columbia River Gorge National Scenic Area.

7.1.4.5 Snake River Spring/Summer-run Chinook

Snake River spring/summer Snake River fall Chinook salmon freshwater habitat reaches upriver into the Boise, Payette, Salmon-Challis, Nez Perce, Clearwater, Umatilla, Wallowa-Whitman National Forests and the Columbia River Gorge National Scenic Area (Figure 37). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 3,554 drops with a peak of 680 fire retardant applications in 2016. At that application rate, we would anticipate 10 intrusions over a 10-year period with at least one intrusion occurring in about 62% of years. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September with over 95% in July and August. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

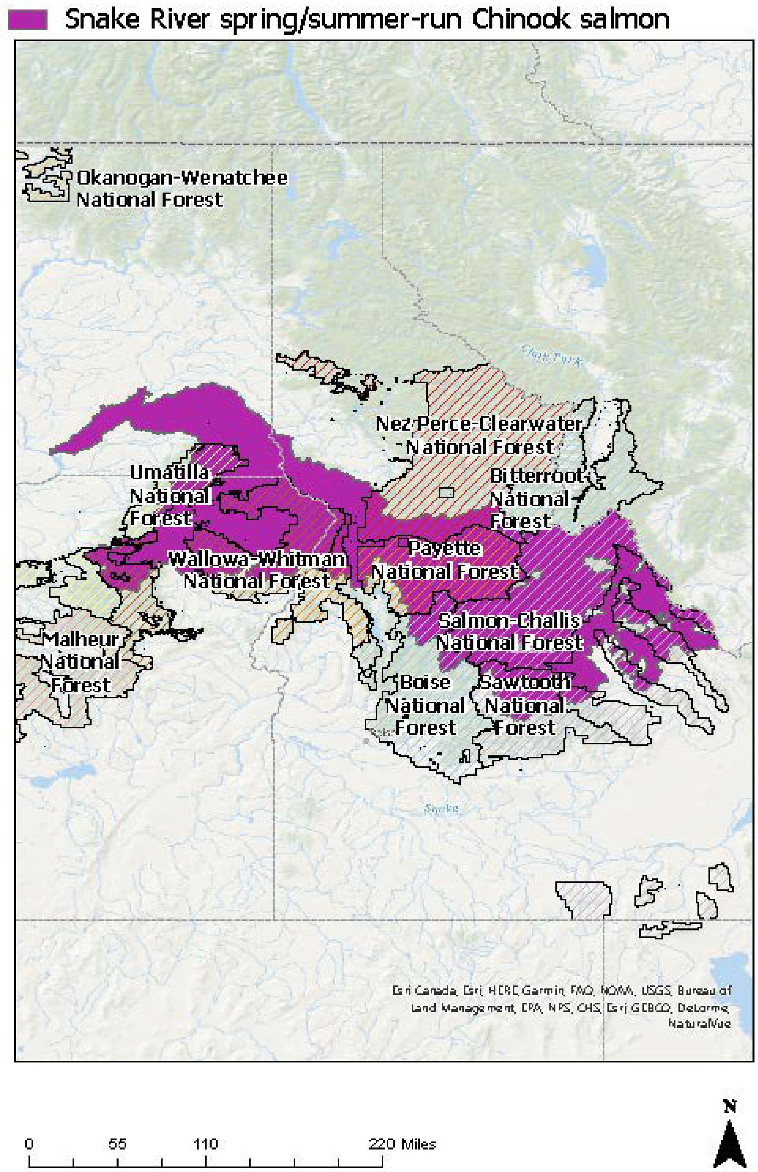


Figure 37. Snake River spring/summer-run Chinook salmon occupy habitat that overlaps with the Boise, Payette, Salmon-Challis, Nez Perce, Clearwater, Umatilla, Wallowa-Whitman National Forests and the Columbia River Gorge National Scenic Area.

7.1.4.6 Upper Columbia River Spring-run Chinook

UCR spring-run Chinook salmon freshwater habitat reaches upriver into the Okanogan-Wenatchee National Forest (Figure 38). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 1,654 drops with a peak of 735 fire retardant applications in 2018. At that application rate, we would anticipate five intrusions over a 10-year period with at least one intrusion occurring in about 12% of years. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

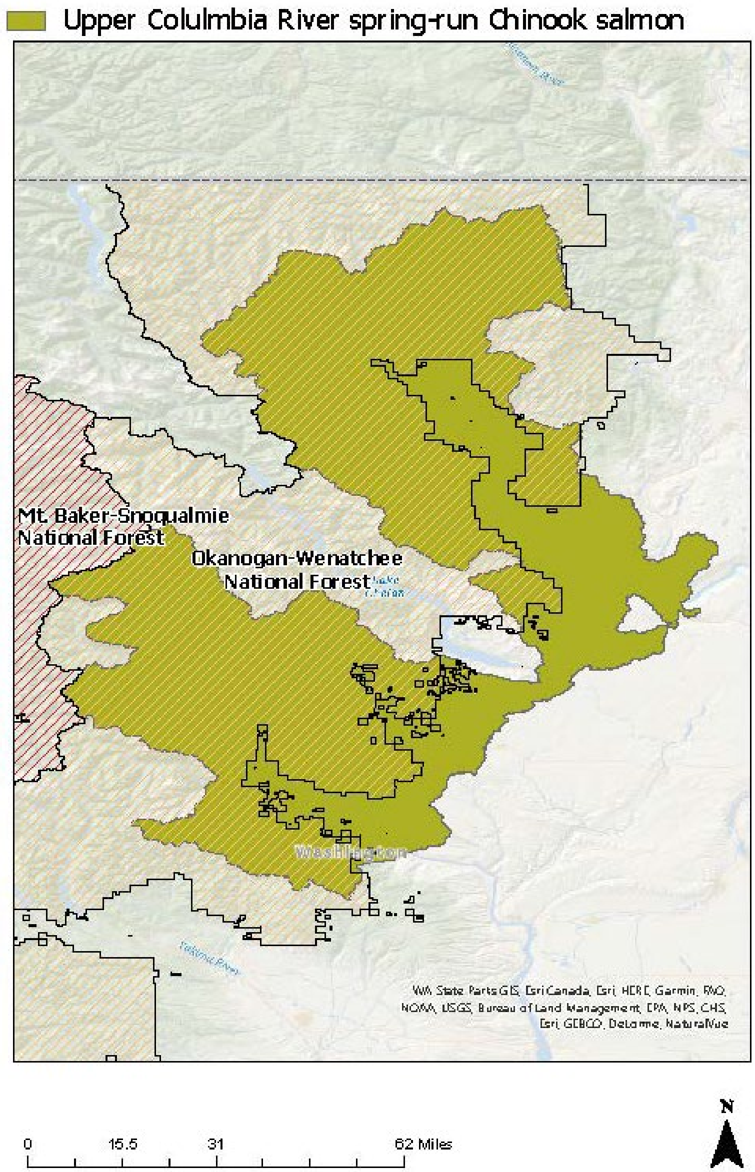


Figure 38. Upper Columbia River Chinook salmon occupy habitat that overlaps with the Okanogan-Wenatchee National Forest.

7.1.4.7 Upper Willamette River Chinook

UWR Chinook salmon freshwater habitat reaches upriver into the Mt. Hood and Willamette National Forests (Figure 39). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 144 drops with a peak of 60 fire retardant applications in 2014. At that application rate, we would anticipate one intrusion over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected from July through September. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

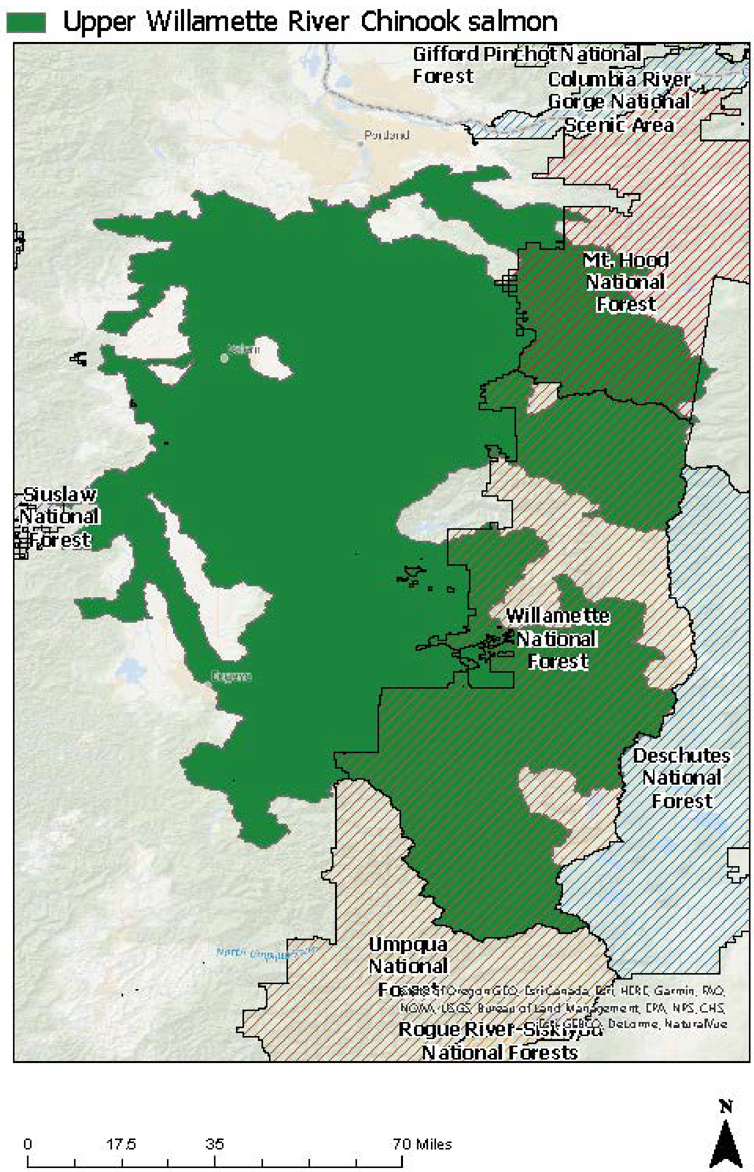


Figure 39. Upper Willamette River Chinook salmon occupy habitat that overlaps with the Mt. Hood and Willamette National Forests.

7.1.4.8 Sacramento River Winter-run Chinook

Sacramento River winter-run Chinook salmon freshwater habitat reaches upriver into the Lassen, Mendocino, and Shasta-Trinity National Forests (Figure 40). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 2,672 drops with a peak of 679 fire retardant applications in 2012. At that application rate, we would anticipate eight intrusions over a 10-year period with multiple intrusions in 38% of years. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages of fish would be present and possibly exposed to fire retardants.

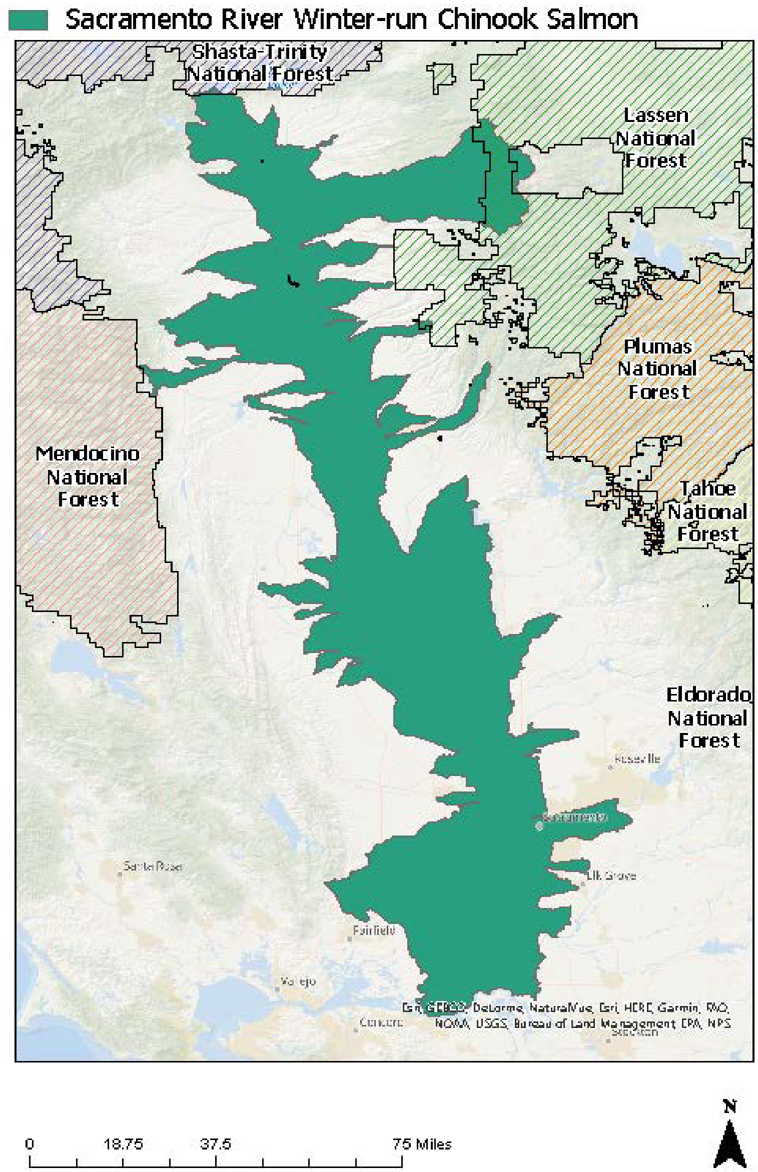


Figure 40. Sacramento River winter-run Chinook salmon occupy habitat that overlaps with the Lassen, Mendocino, and Shasta-Trinity National Forests.

7.1.4.9 Columbia River Chum

Columbia River chum salmon freshwater habitat reaches upriver into the Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area. Their freshwater habitat is found extensively throughout these national forests (Figure 41). Between 2012 and 2019, those three USFS managed areas experienced cumulative fire retardant applications of 179 drops with a peak of 112 fire retardant applications in 2012. At that application rate, we would anticipate one intrusion over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected to occur from June through September; however, Columbia River chum salmon are only present during September when

approximately 38% of fires occur. During this time, only adult fish would be present and possibly exposed to fire retardants.

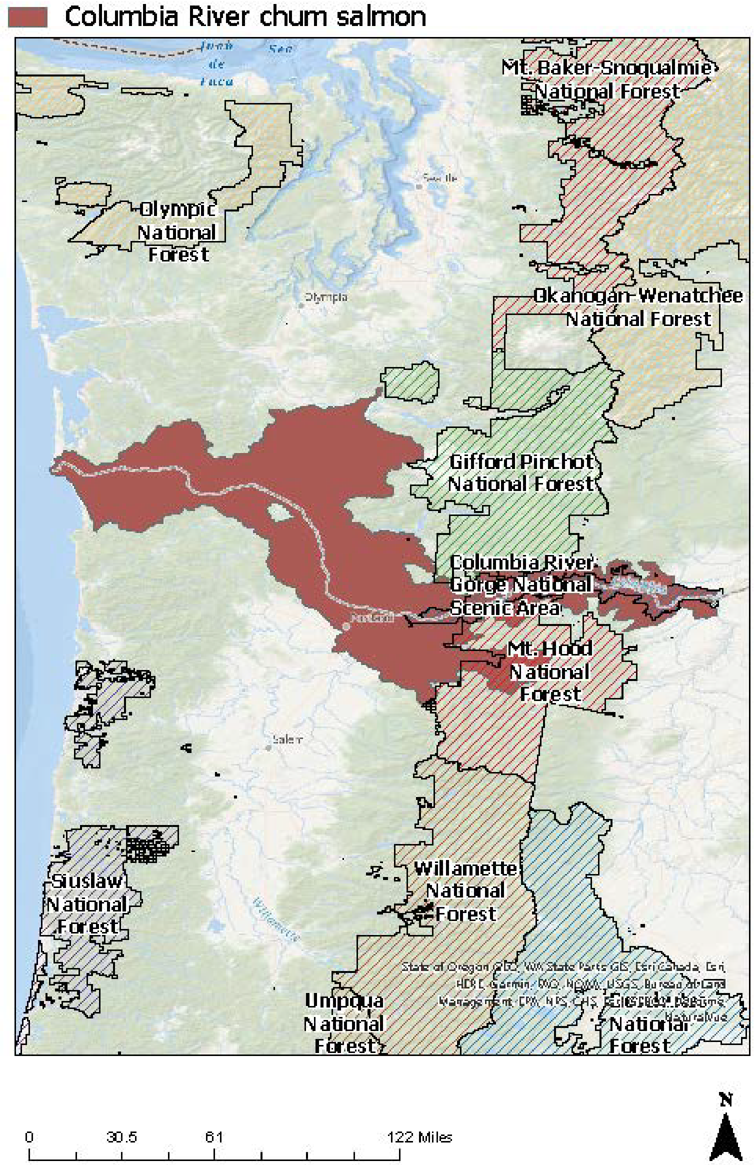


Figure 41. Columbia River chum salmon occupy habitat that overlaps with Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area.

7.1.4.10 Lower Columbia River Coho

LCR coho salmon freshwater habitat reaches upriver into the Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area. Their freshwater habitat is found extensively throughout these national forests (Figure 42). Between 2012 and 2019, those three USFS managed areas experienced cumulative fire retardant applications of 179 drops with a peak of 112 fire retardant applications in 2012. At that application rate, we would

anticipate one intrusion over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

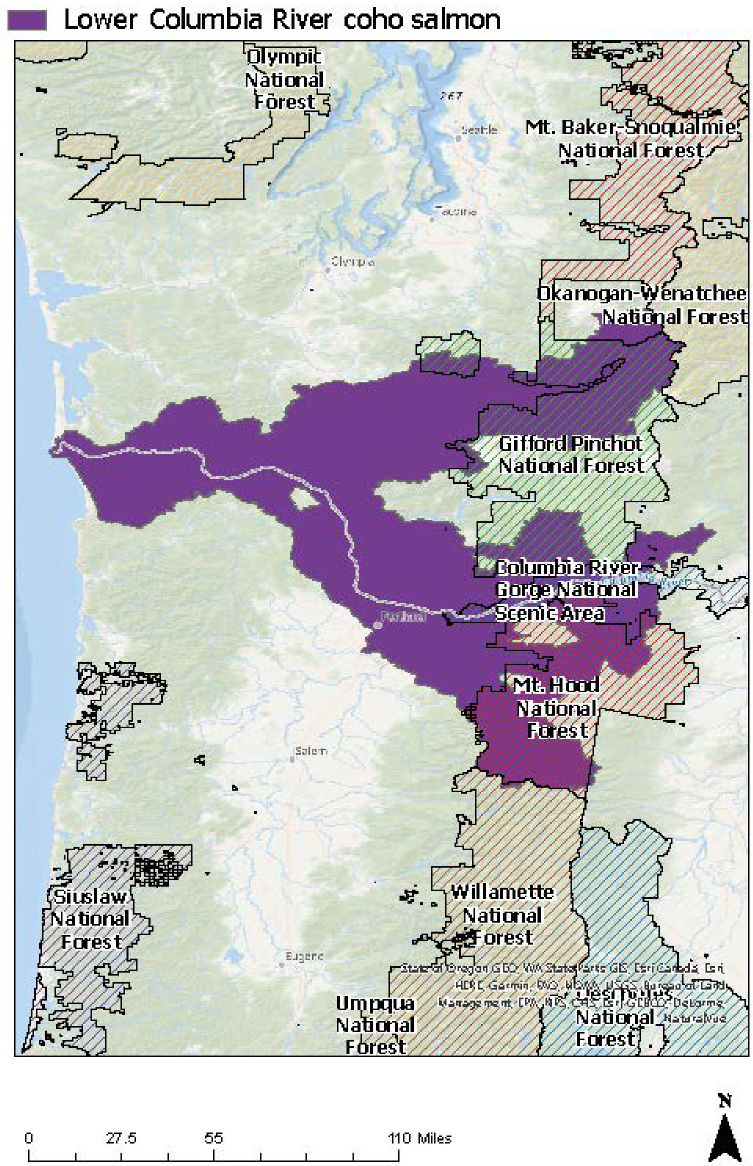


Figure 42. Lower Columbia River coho salmon occupy habitat that overlaps with Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area.

7.1.4.11 Southern Oregon/Northern California Coast coho

SONCC coho salmon freshwater habitat reaches upriver into the Rogue, Siskiyou, Klamath, Shasta-Trinity, Six Rivers, and Mendocino National Forests (Figure 43). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 6,530 drops with a peak of 1,653 fire retardant applications in 2014. At similar application rates, we would anticipate 18

intrusions over a 10-year period with multiple intrusions in 62% of years. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, adult and juvenile fish would be present and possibly exposed to fire retardants.

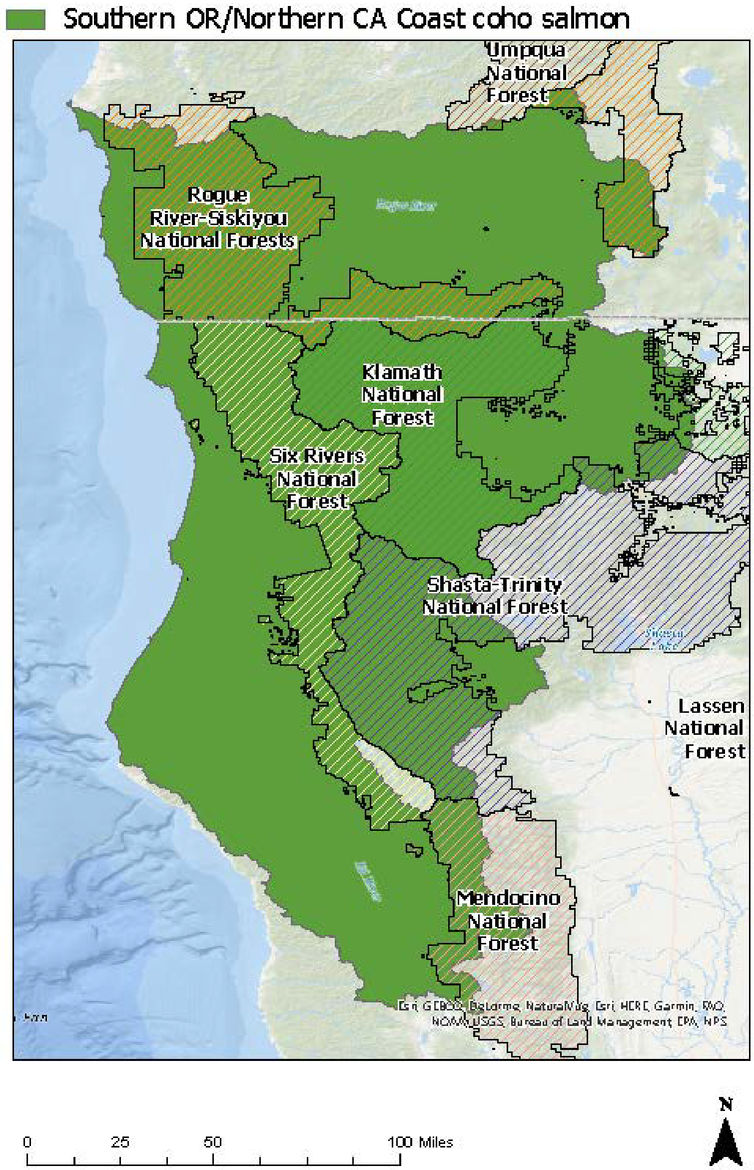


Figure 43. Southern Oregon/Northern California Coast coho salmon occupy habitat that overlaps with the Rogue, Siskiyou, Klamath, Shasta-Trinity, Six Rivers, and Mendocino National Forests.

7.1.4.12 Oregon Coast Coho

Oregon Coast coho salmon freshwater habitat reaches upriver into the Umpqua, Siskiyou, and Suislaw National Forests (Figure 44). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 1,352 drops with a peak of 534 fire retardant applications in 2018. At similar application rates, we would anticipate four intrusions over a 10-

year period with multiple intrusions in 12% of years. Based on data since 2000 on these national forests, over 99% of fires are expected from July through September with approximately 96% in July and August. During this time, only juvenile fish would be present and possibly exposed to fire retardants.

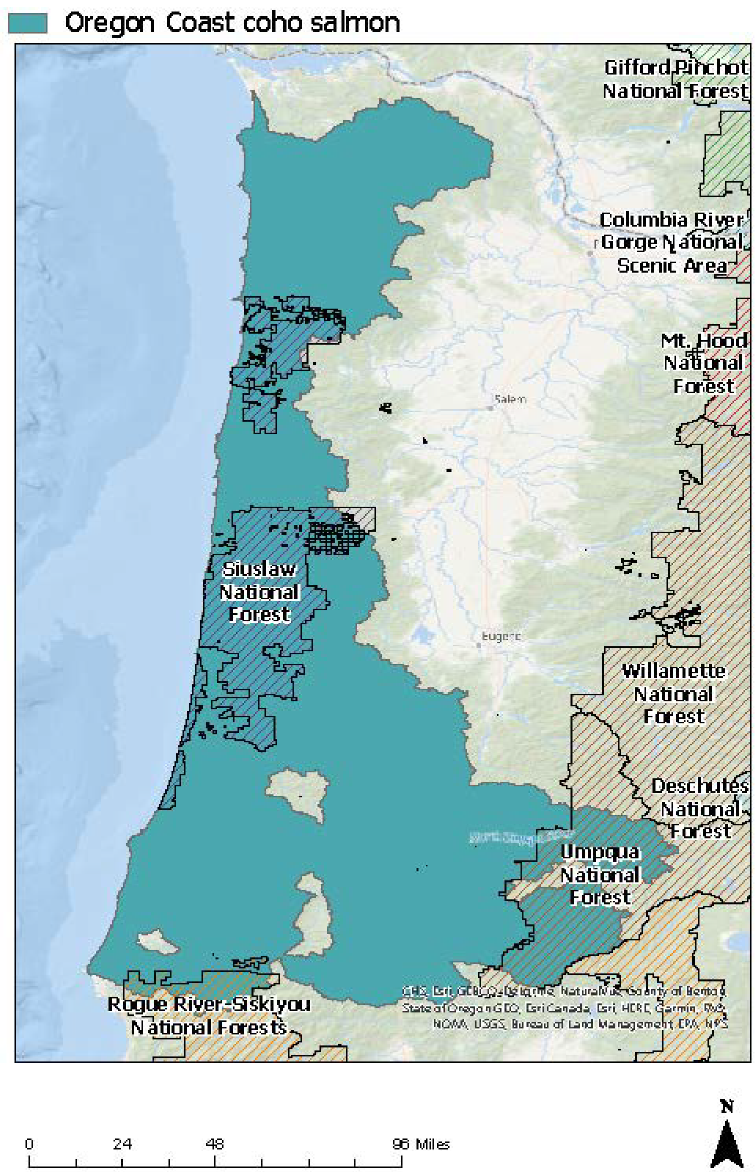


Figure 44. Oregon Coast coho salmon occupy habitat that overlaps with the Umpqua, Siskiyou, and Suislaw National Forests.

7.1.4.13 Snake River Sockeye

Snake River sockeye salmon freshwater habitat reaches upriver into the Wallowa-Whitman, Salmon-Challis, Sawtooth, and Nez Perce National Forests (Figure 45). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 2,199 drops with a peak of

363 fire retardant applications in 2016. At similar application rates, we would anticipate six intrusions over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected from July through September with approximately 95% in July and August. During this time, all life stages except fry would be present and possibly exposed to fire retardants.

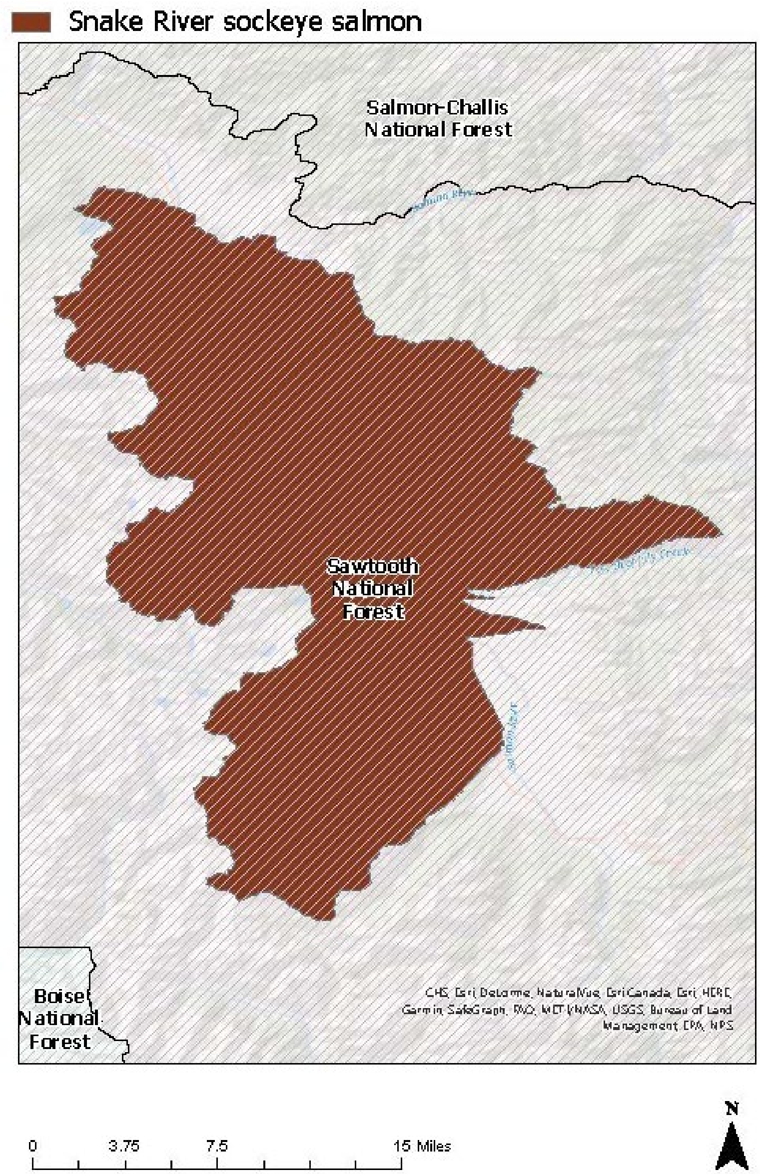


Figure 45. Snake River sockeye salmon occupy habitat that overlaps with the Wallowa-Whitman, Salmon-Challis, Sawtooth, and Nez Perce National Forests.

7.1.4.14 California Central Valley steelhead

California Central Valley DPS steelhead freshwater habitat reaches upriver or adjacent to the Eldorado, Lassen, Mendocino, Tahoe, Shasta-Trinity, and Plumas National Forests (Figure 46).

Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 4,923 drops with a peak of 915 fire retardant applications in 2012. At similar application rates, we would anticipate 13 intrusions over a 10-year period with multiple intrusions in 75% of years. Based on data since 2000 on these national forests, approximately 99% of fires are expected from June through October. During this time, adult and juvenile fish would be present and possibly exposed to fire retardants.

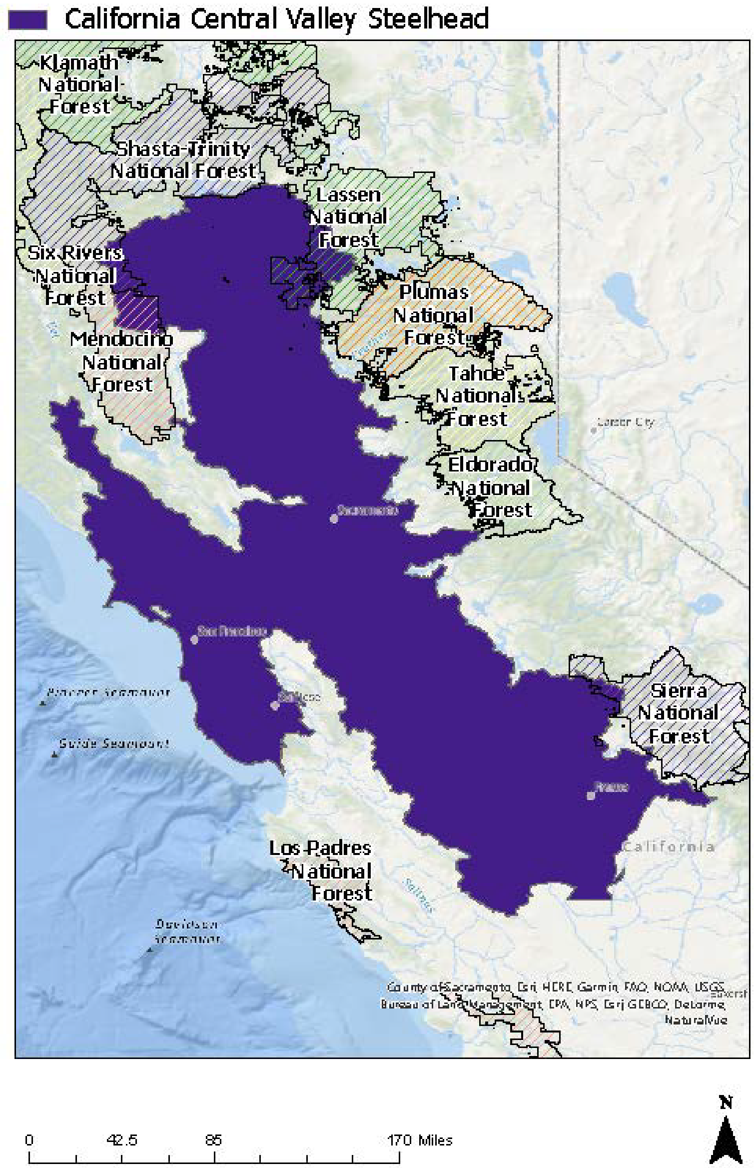


Figure 46. California Central Valley DPS steelhead occupy habitat that overlaps with the Eldorado, Lassen, Mendocino, Tahoe, Shasta-Trinity, and Plumas National Forests.

7.1.4.15 Lower Columbia River Steelhead

LCR steelhead freshwater habitat reaches upriver into the Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area (Figure 47).

Between 2012 and 2019, those three USFS managed areas experienced cumulative fire retardant applications of 179 drops with a peak of 112 fire retardant applications in 2012. At that application rate, we would anticipate one intrusion over a 10-year period. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages of fish would be present and possibly exposed to fire retardants.

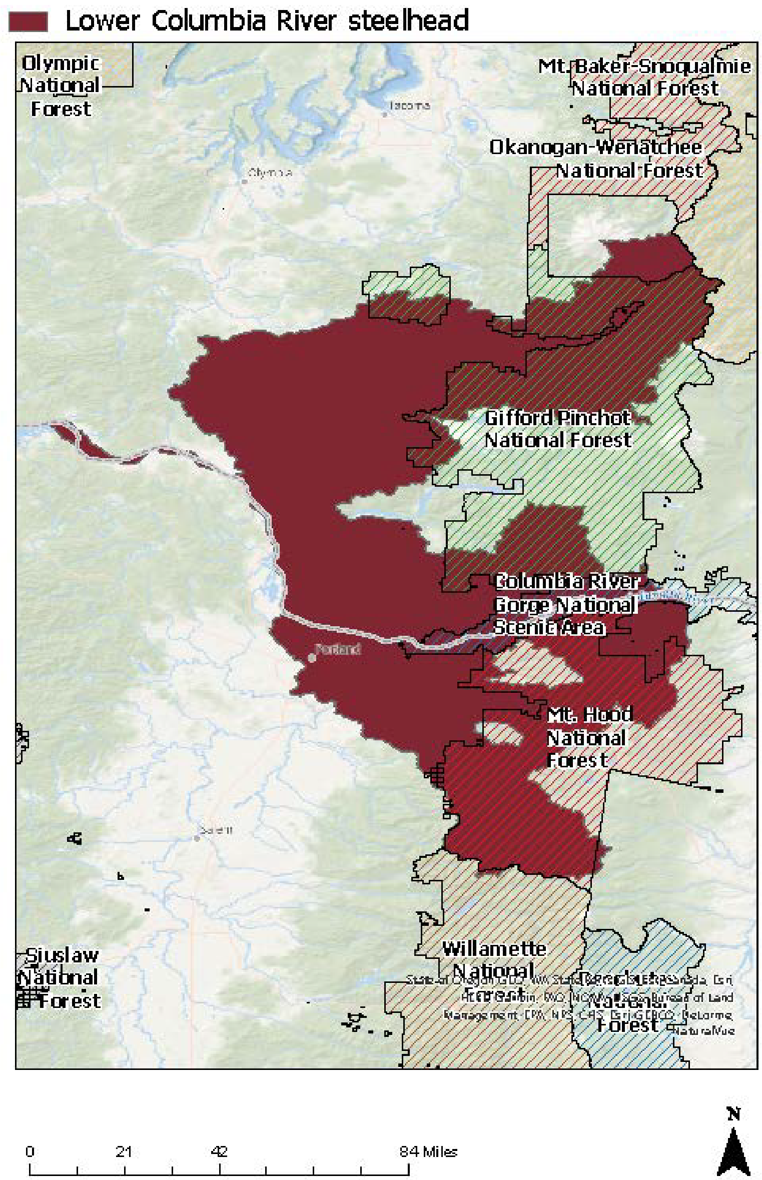


Figure 47. Lower Columbia River DPS steelhead occupy habitat that overlaps with Mt. Hood and Gifford Pinchot National Forests as well as the Columbia River Gorge National Scenic Area.

7.1.4.16 Middle Columbia River Steelhead

MCR DPS steelhead freshwater habitat reaches upriver into the Umatilla, Ochoco, Malheur, Okanogan-Wenatchee National Forests as well as the Columbia River Gorge National Scenic

Area (Figure 48). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 3,301 drops with a peak of 867 fire retardant applications in 2018. At similar application rates, we would anticipate nine intrusions over a 10-year period with multiple intrusions in 38% of years. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages of fish would be present and possibly exposed to fire retardants.

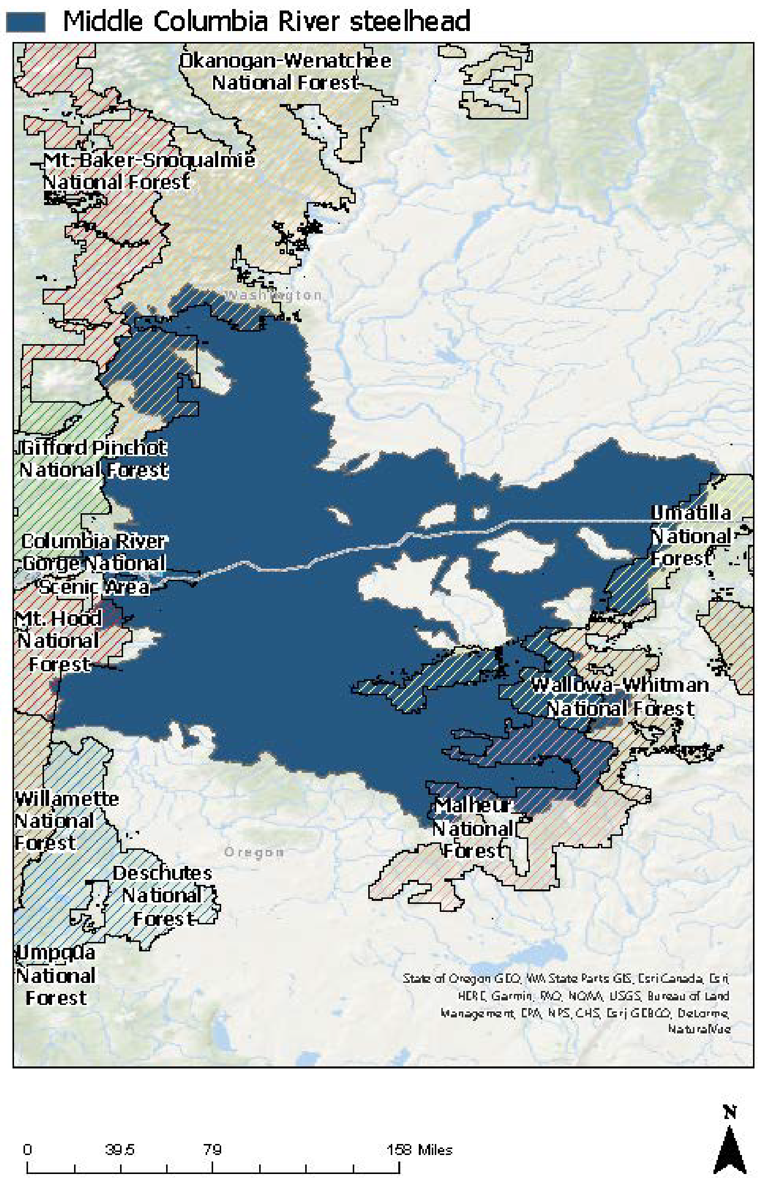


Figure 48. Middle Columbia River DPS steelhead occupy habitat that overlaps with the Umatilla, Ochoco, Malheur, Okanogan-Wenatchee National Forests as well as the Columbia River Gorge National Scenic Area.

7.1.4.17 Northern California Steelhead

Northern California DPS steelhead freshwater habitat reaches upriver into the Six Rivers, Shasta-Trinity, and Mendocino National Forests (Figure 49). Between 2012 and 2019, those three forests experienced cumulative fire retardant applications of 3,124 drops with a peak of 925 fire retardant applications in 2015. At that application rate, we would anticipate nine intrusions over a 10-year period with at least one intrusion occurring in any given year about half the time. Based on data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, only juvenile fish would be present and possibly exposed to fire retardants.

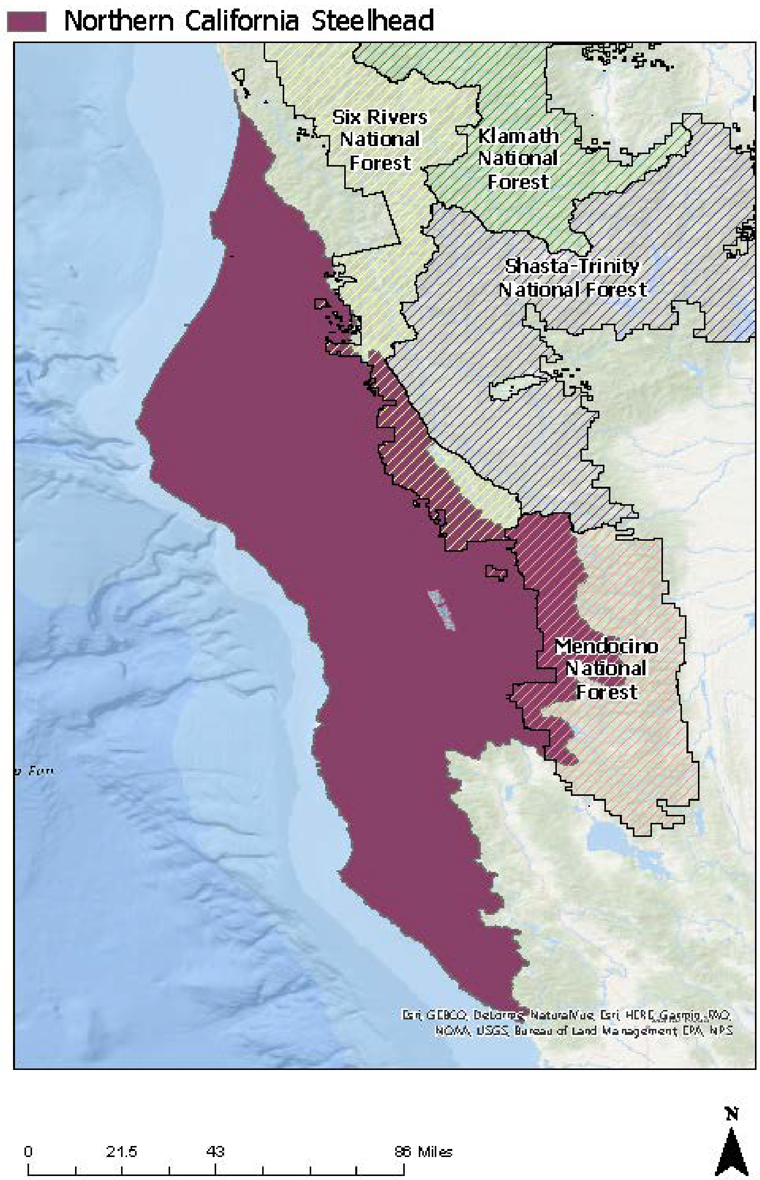


Figure 49. Northern California DPS steelhead occupy habitat that overlaps with the Six Rivers, Shasta-Trinity, and Mendocino National Forests.

7.1.4.18 Snake River Steelhead

Snake River Basin DPS steelhead freshwater habitat reaches upriver into the Boise, Payette, Salmon-Challis, Sawtooth, Nez Perce, Clearwater, Umatilla, Bitterroot, and Wallowa-Whitman National Forests as well as the Columbia River Gorge National Scenic Area (Figure 50). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 5,306 drops with a peak of 1,183 fire retardant applications in 2016. At similar application rates, we would anticipate 14 intrusions over a 10-year period with multiple intrusions in 62% of years. Based on data since 2000 on these national forests, approximately 99% of fires are expected from July through September with over 95% of fires in July and August. During this time, adult, fry, and juvenile fish would be present and possibly exposed to fire retardants.

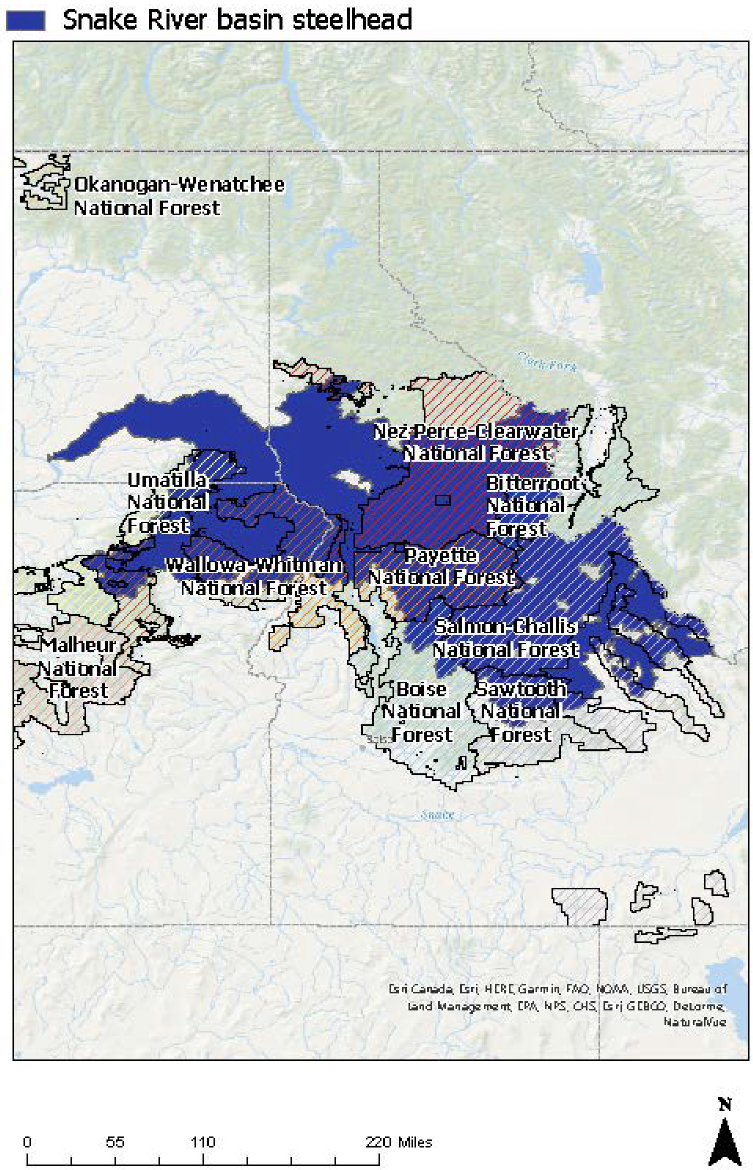


Figure 50. Snake River Basin DPS steelhead occupy habitat that overlaps with the Boise, Payette, Salmon-Challis, Sawtooth, Nez Perce, Clearwater, Umatilla, Bitterroot, and Wallowa-Whitman National Forests as well as the Columbia River Gorge National Scenic Area

7.1.4.19 South Central California Coast Steelhead

SCCC DPS steelhead freshwater habitat reaches upriver into the Los Padres National Forest (Figure 51). Between 2012 and 2019, this forest experienced cumulative fire retardant applications of 5,160 drops with a peak of 3,685 fire retardant applications in 2016. At similar application rates, we would anticipate 14 intrusions over a 10-year period with multiple intrusions in 25% of years. Based on data since 2000 on this national forest, approximately 80% of fires are expected from May through October with almost all of the rest occurring in a

secondary season in December. During this time, fry and juvenile fish would be present and possibly exposed to fire retardants.

Figure 51. South-Central California Coast DPS steelhead occupy habitat that overlaps with the Los Padres National Forest.

7.1.4.20 Southern California Steelhead

Southern California DPS steelhead freshwater habitat reaches upriver into the Los Padres and Cleveland National Forests (Figure 52). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 6,457 drops with a peak of 3,741 fire retardant applications in 2016. At similar application rates, we would anticipate 17 intrusions over a 10-year period with multiple intrusions in 38% of years. Based on data since 2000 on these national

forests, approximately 99% of fires are expected from May through December. During this time, all life stages of fish would be present and possibly exposed to fire retardants.

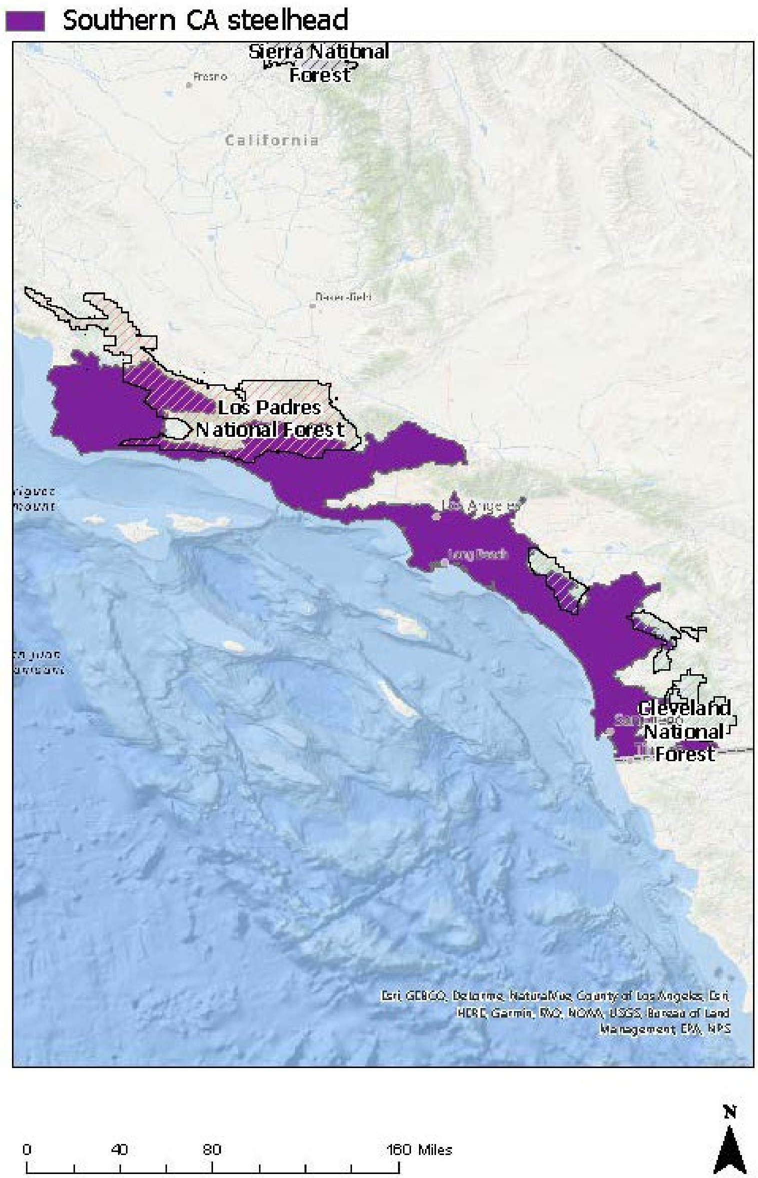


Figure 52. Southern California DPS steelhead occupy habitat that overlaps with the Los Padres and Cleveland National Forests.

7.1.4.21 Upper Columbia River Steelhead

UCR DPS steelhead freshwater habitat reaches upriver into the Okanogan-Wenatchee National Forest as well as the Columbia River Gorge National Scenic Area (Figure 53). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 1,663 drops with a peak of 735 fire retardant applications in 2018. At similar application rates, we would anticipate four intrusions over a 10-year period with multiple intrusions in 12% of years. Based on data

since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages of fish would be present, but no spawning would be occurring when fire retardants are being applied.

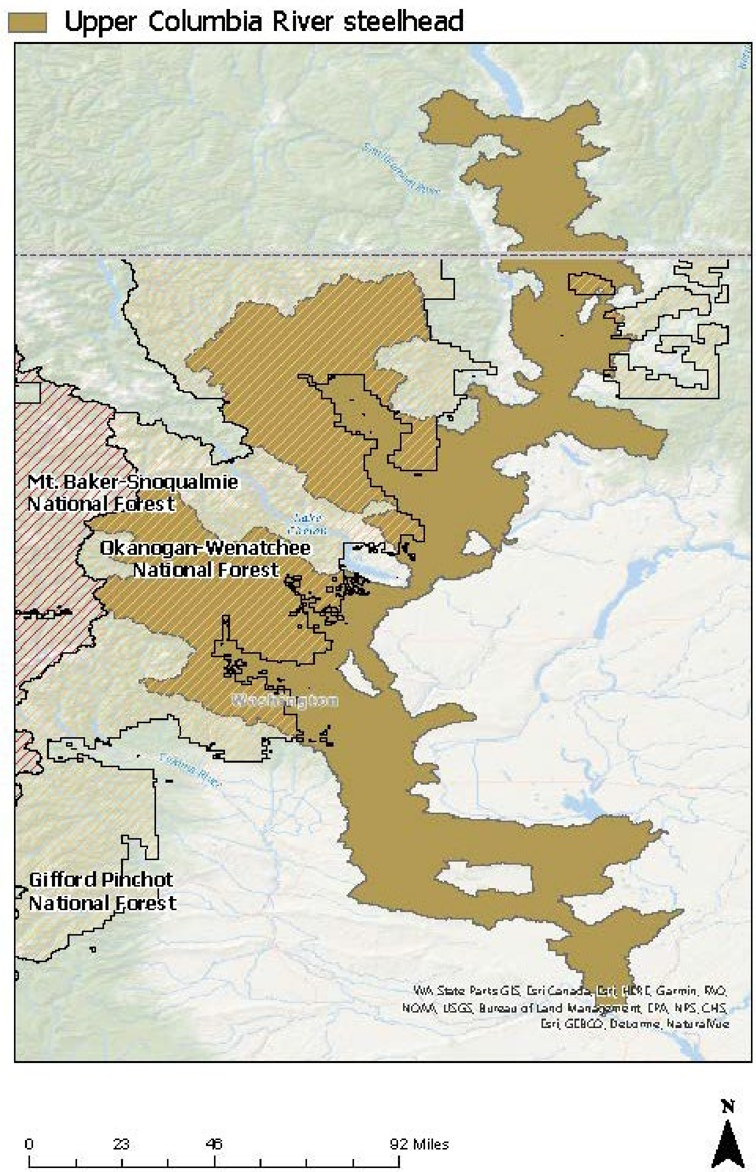


Figure 53. Upper Columbia River DPS steelhead occupy habitat that overlaps with the Okanogan-Wenatchee National Forest as well as the Columbia River Gorge National Scenic Area.

7.1.4.22 Upper Willamette River Steelhead

UWR DPS steelhead freshwater habitat reaches upriver into the Willamette National Forest (Figure 54). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 88 drops with a peak of 42 fire retardant applications in 2014. At similar application rates, we would anticipate one intrusion over a 10-year period. Based on data since

2000 on this national forest, over 99% of fires are expected from July through September. During this time, fry and juvenile fish would be present and possibly exposed to fire retardants.

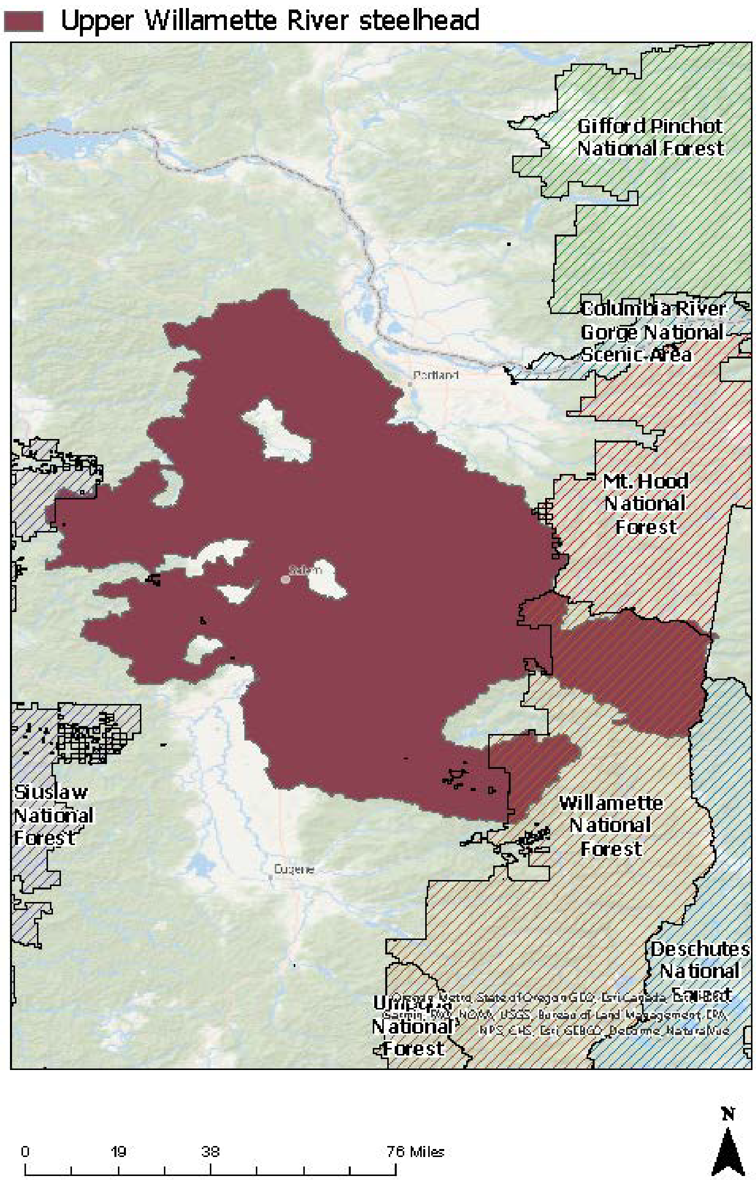


Figure 54. Upper Willamette River DPS steelhead occupy habitat that overlaps with the Willamette National Forest.

7.1.4.23 Green Sturgeon

Southern DPS green sturgeon freshwater habitat reaches upriver into the Shasta-Trinity, Rogue, Mendocino, Siskiyou, and Siuslaw National Forests (Figure 55). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 3,457 drops with a peak of 968 fire retardant applications in 2018. At similar application rates, we would anticipate nine intrusions over a 10-year period with multiple intrusions occurring approximately half the time. Based on

data since 2000 on these national forests, over 99% of fires are expected from June through September. During this time, all life stages of fish would be present and possibly exposed to fire retardants.

Figure 55. Southern DPS green sturgeon occupy habitat that overlaps with the Shasta-Trinity, Rogue, Siskiyou, and Siuslaw National Forest.

7.1.4.24 Pacific Eulachon Smelt

Southern DPS Pacific eulachon freshwater habitat reaches upriver into the Six Rivers, Mt. Hood, Gifford Pinchot, Siuslaw, and Siskiyou National Forests as well as the Columbia River Gorge NSA (Figure 56). Between 2012 and 2019, those forests experienced cumulative fire retardant applications of 2,082 drops with a peak of 630 fire retardant applications in 2017. At similar application rates, we would anticipate six intrusions over a 10-year period with multiple

intrusions occurring approximately 38% of years. Based on data since 2000 on these national forests, 15% of fires are expected from February through June. During this time, adults and eggs would be present and possibly exposed to fire retardants.

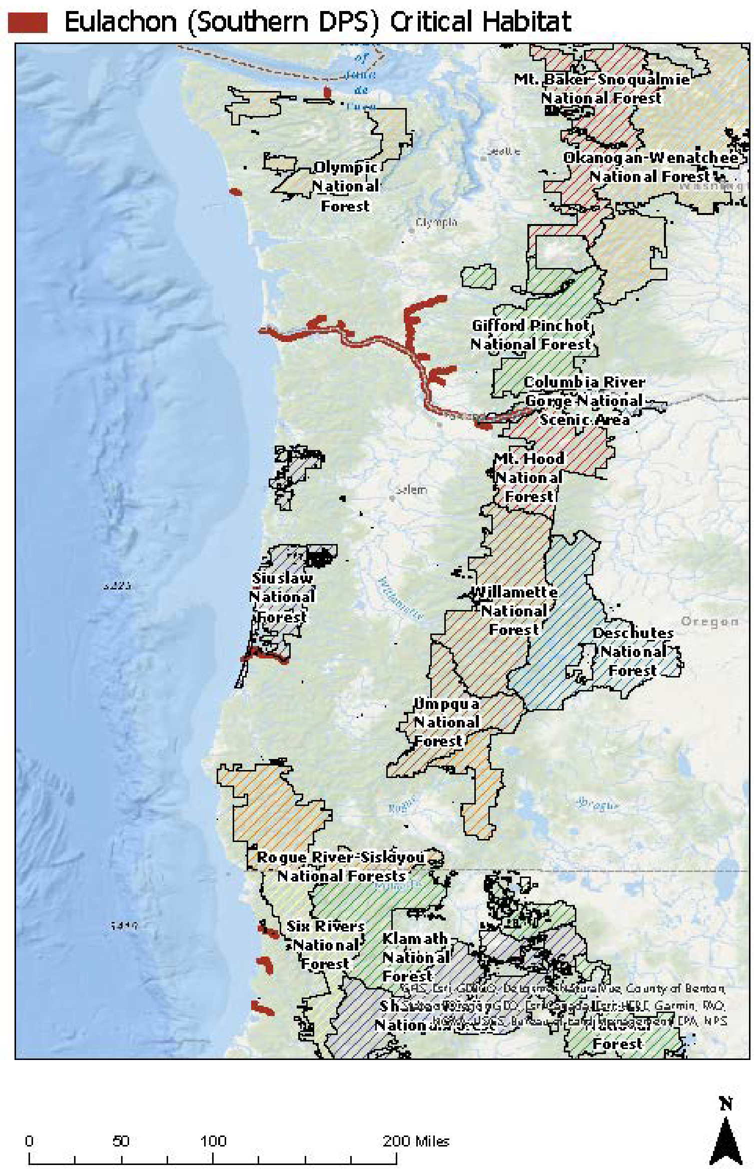


Figure 56. Southern DPS Pacific eulachon occupy habitat that overlaps with the Six Rivers, Mt. Hood, Gifford Pinchot, Siuslaw, and Siskiyou National Forests as well as the Columbia River Gorge NSA.

7.1.4.25 East Coast Sturgeon

In national forest land along the East Coast, Atlantic and shortnose sturgeon are likely present on the Francis Marion (Santee-Cooper System), Sumter, Croatan, and Ocala (St. Johns River) National Forests (Figures 57 and 58). Shortnose sturgeon are expected to be found on all four of these forests, while Atlantic sturgeon would only be expected to occur on the Croatan and

Francis Marion National Forests. Because wildfires and fire retardant applications are so rare on east coast forests, the data were compiled at the state level. Even using data from the state level, which would include applications made on national forests with listed species as well as those without, therefore likely over-estimating exposure of listed species, only a single intrusion for any of those East Coast species would be anticipated in any 10-year period (Table 61). Based on data since 2000 on these national forests, most fires occur during the dry periods of overwinter dormancy from November through April. During this time, adult and juvenile fish would be present and possibly exposed to fire retardants.

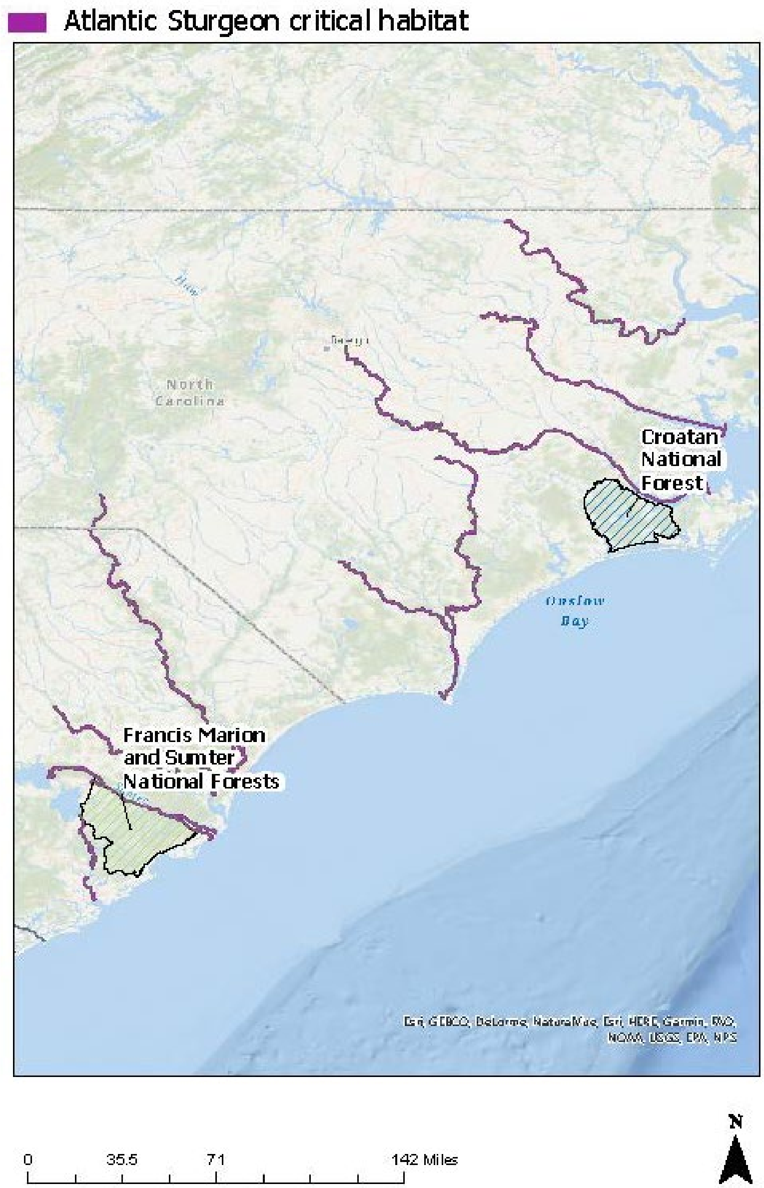


Figure 57. Depiction of Atlantic sturgeon critical habitat adjacent to the Croatan and Francis Marion National Forests.

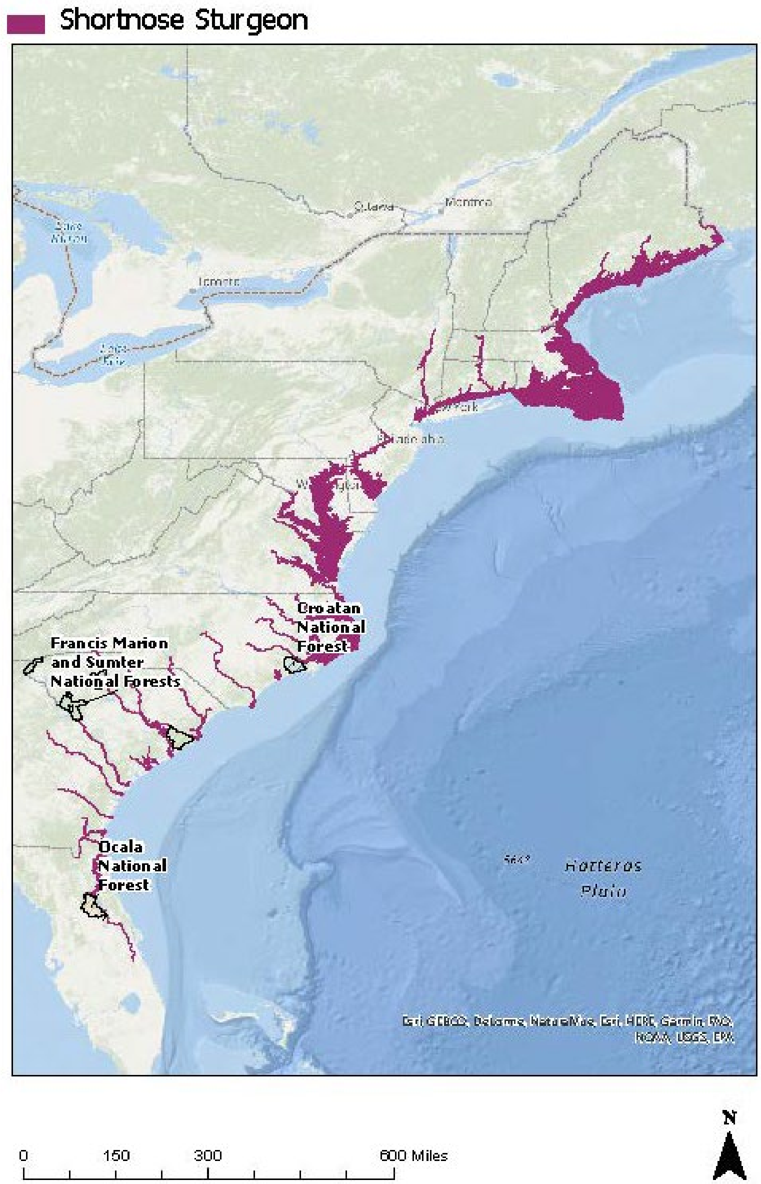


Figure 58. Depiction of shortnose sturgeon habitat within the northern and southern range extents of the range.

7.1.4.26 Southern Resident Killer Whales

Exposure for this species results from more limited food resources. SRKWs rely on Chinook salmon for a large part of their diets. The Chinook salmon they rely on are primarily from the Puget Sound area, which are not likely to be adversely affected by this action, but also Chinook salmon ranging from as far south as California and north into Canada. Non-listed populations of Chinook salmon are more abundant than threatened and endangered populations, and therefore more important to annual consumption by SRKWs. The listed populations of Chinook salmon

that are known to be consumed by SRKWs are LCR ESU, Upper Columbia River spring-run ESU, Snake River fall-run ESU, Snake River spring/summer-run ESU, and California Central Valley spring-run ESU (NOAA and WDFW 2018). While not documented as part of their diet, SRKWs overlap with UWR ESU and California Coastal ESU Chinook salmon and may also rely on those species as a food resource. Because these seven ESUs are expected to be exposed to aerially applied long-term fire retardants, SRKWs may be exposed to fire retardants through a loss of these prey resources.

Responses of Chinook salmon to fire retardant intrusions are discussed in the next section, but for the purposes of understanding SRKW exposure, we need to better understand Chinook salmon responses to exposure. If Chinook salmon were impacted by all intrusions on national forest lands and then likely to die following all anticipated exposures, the reduction in Chinook salmon abundance for SRKWs could be considerable. However, in monitoring since 2011, intrusions into waterways inhabited by Chinook salmon have been very rare and no Chinook salmon are thought to have been injured or killed by fire retardant intrusions based on follow-up monitoring and the use of the spill calculator. This is likely primarily due to Chinook salmon occupying larger bodies of water that are less likely to receive an intrusion and more voluminous, making dilution more rapid, minimizing the overall toxicity of any intrusions, as well as making the fish habitat more visible from planes.

All life stages of SRKWs would be exposed to a reduction in food resources. Once weened, all SRKWs are predatory and large enough to consume Chinook salmon. When being nursed, any food scarcity affecting the lactating mother would also affect the nursing calf.

SRKW critical habitat could also be exposed because of fire retardant intrusions. The applicable PBF for SRKWs in this biological opinion, as discussed above, relates to salmonid availability as a prey resource. The loss of Chinook salmon from non-listed, as well as those seven listed ESUs, would constitute an exposure of SRKW critical habitat to the fire retardant program. The likelihood of exposure of individuals to lost prey resources would be the same as the likelihood of exposure affecting this PBF of their critical habitat.

7.2 Response

In a formal ESA consultation, the response analysis is limited to the possible responses because of exposure to a stressor (those remaining stressors identified in Section 5.1). While this section will discuss the range of possible responses to exposure, it will narrow that range and identify the probable response or proportional range of responses that are likely to occur to allow an assessment of the ultimate risk of this program.

7.2.1 Response of Listed Species to Exposure

NMFS trust resources are likely to be exposed to three stressors with unique responses. As such, the next three sections will explore the possible and probable responses to exposure from nitrogen-based aerial fire retardants (ammonia), magnesium chloride-based aerial fire retardants

(salinity), and reduced food supply (loss of Chinook salmon). In later sections, we will explore the responses of critical habitat to the same stressors.

7.2.1.1 Response to Ammonia

There are two important factors to understand when assessing the likely response of fish to fire retardants. The two main factors are, first, the amount of retardant that enters the system and second, the physical parameters of the system such as volume and slope. The peak of the ammonia concentration and area affected depends on many factors, such as volume of retardant to hit the water, volume of water to dilute the retardant, and turbulence/flow of the stream.

When nitrogen-based fire retardants initially enter a stream, there is an immediate spike in ammonia concentration in the receiving stream. For instance, when Phos Chek 259-F hits the surface of the water, it is 22.9% ammonia (Buhl and Hamilton 2000). In simulations of 267 gallons of fire retardants hitting the surface of a stream, peak ammonia concentrations reached 5,026 mg/L (Buhl and Hamilton 1998). Based on intrusion amounts since 2011, the maximum initial concentration was 9,050 mg/L (Rehmann et al. 2021). This is only the ammonia concentration caused directly by the fire retardant, but in a natural situation during a fire, ammonia levels will also be elevated due to smoke adsorption (Gresswell 1999). To further complicate what would actually occur during a wildfire, the application of fire retardants increases the amount of smoke produced by the fire (Kalabokidis 2000), which ultimately leads to more ammonia in the system.

When nitrogen-based fire retardants enter a stream and cause the initial spike in ammonia, it immediately begins to form a chemical equilibrium between un-ionized ammonia, which is the more toxic form, and ionized ammonia, eventually breaking down into nitrates. The chemical balance between these two forms of ammonia is determined by pH, hardness, temperature, and total ammonia concentration (Dietrich et al. 2010). Buhl and Hamilton (2000) reported ammonia-induced mortality is the result of the un-ionized component of the equilibrated mixture. In most streams, the pH is sufficiently low that ionized ammonia predominates. However, in highly alkaline waters, un-ionized ammonia concentrations increase and can reach toxic levels. Most research analyzes the lethal levels of ionized ammonia, the least toxic form that will be present in the river.

Norris et al. (1978) applied a variety of Phos Chek that is no longer in use directly to a California stream but the maximum allowable application was 0.5 mg/l. In the natural environment, after 30 minutes, the concentration had been reduced by 90% at the point of entry, but there was no determination of whether there could be similar expectations in the speed of dilution of extremely large introductions of retardant or under actual fire conditions with heat, smoke, and ash. The highest concentrations of ammonia were detected 148 ft downstream of the point of contact and had dissipated to 1% of their peak concentration (in Buhl and Hamilton's [1998] research, 50.26 mg/l) after almost four hours, which is the same as was found more recently by Rehmann et al. (2021). After one year, there were still detectable, albeit slight, changes to the

stream's water chemistry (Norris et al. 1978). Discernable levels of ammonia were detected at the farthest downstream (as much as 2,730 m) sampling sites when only a fraction of an actual load was placed in the stream (Norris et al. 1978). Simulations run by Norris and Webb (1989) showed ammonia concentrations could remain at lethal levels between 0 and 6.2 mi downstream, depending on stream characteristics and the size of the retardant load. Van Meter and Hardy (1975) also found that concentrations of retardant high enough to kill 10% of the fish population were measurable over four miles downstream. Fire retardants used today are less toxic than those tested during the 1970s and 1980s; however, the immediate spike in ammonia in the first five hours after an intrusion is the likely cause of a response (Rehmann et al. 2021). The spike in total ammonia and un-ionized ammonia caused by modern fire retardant chemicals is less toxic compared to those tested previously.

For rainbow trout, more is known about their responses to fire retardants than for any other fish species. Rainbow trout LC_{50}s for total ammonia range from 100 to 112 mg/L. Rainbow trout LC_{50}s for un-ionized ammonia ranged from 0.08 to 1.1 mg/L (Ball 1967, Thurston et al. 1981, Russo 1985). The differences in reported LC_{50}s are likely due to differences in pH or water hardness. The LC_{50} for juvenile coho salmon has been recorded as 0.45 mg/L un-ionized ammonia (Buckley 1978). Johnson and Sanders (1977) found that, for rainbow trout, most mortality occurs in the first 24 hours. As a result, the 24-hour and 96-hour LC_{50}s were not significantly different, meaning that the values given below represent both the 24-hour and 96-hour LC_{50}s. No studies have assessed five or fewer hour LC_{50}s.

The USFS, prior to purchasing a new long-term fire retardant chemical, uses rainbow trout as a surrogate to infer effects to other salmonids. Given the information presented below, we propose the same. When exposed to a different formulation of Phos Chek 259 than is currently used, the LC_{50} caused by unionized ammonia (the less toxic form) was between 94 and 250 mg/L (Johnson and Sanders 1977). Buhl and Hamilton (2000) found the LC_{50} of rainbow trout to Phos Chek 259-F was 168 mg/L. In research on Phos Chek D75-R, the rainbow trout 96-hour LC_{50} was 168 mg/L (between 142 and 194 mg/L; Calfee and Little 2003). Calfee and Little (2003) also showed that Phos Chek D75-F has a 96-hour LC_{50} of 228 mg/L (between 184 and 271 mg/L). Gaikowski et al. (1996) also tested Phos Chek D75-F and found similar results with a 96-hour LC_{50} of 218 mg/L (170 to 280 mg/L). Calfee and Little (2003) were also able to show that D75-R is equally toxic in UV light or dark, while D75-F is most toxic in UV light. Even though D75-F is affected by UV light, even in its most toxic environment, it is still less toxic than D75-R. Poulton et al. (1993) found that Phos Chek D75-F was twice as toxic to rainbow trout in hard water compared to soft water. The USFS, relying on their section 7(a)(1) program that strives to use the least toxic fire retardant chemicals on the market, has phased out the above chemicals. In 2011, the fire retardant program required all retardants' toxicities to exceed 100 mg/L but that has increased and the currently approved fire retardant toxicities are listed in Table 62.

Table 62. Current fire retardant formulations and their 96-hour LC_{50} concentrations for rainbow trout.

Fire Retardant Formulation	Rainbow Trout Toxicity (LC_{50}, mg/L)
Phos-Chek LC-95A-R	386
Phos-Chek LC-95A-Fx	399
Phos-Chek LC-95-W	465
Phos-Chek MVP-Fx	2,024
Phos-Chek 259-Fx	860
Phos-Chek LCE20-Fx	983

While un-ionized ammonia is likely the lethal portion of the mixture, rainbow trout response to fire retardants currently in use or those developed in the future may be different because there are additional ingredients along with ammonium phosphate or diammonium phosphate that may be confounding or synergistic. Those ingredients are referred to as inert, which means they do not affect the function of the fire retardant but that doesn't mean they have no effect to listed species. These ingredients thicken the retardant or provide anti-corrosive properties making their transport on aircraft safer. As Little and Calfee (2003) showed, Phos Chek D75-R and D75-F have different toxicities despite being identical in every way except the colorant.

For Chinook salmon, less is known about their response to fire retardants, but there is still comparative information available based on chemicals no longer in use. Additionally, there is also information about how current fire retardants affect smolts that does not exist for other salmonids. In studies by Buhl and Hamilton (1998), there was no difference in the responses of Chinook salmon to Phos Chek D75-F in hard or soft water. Poulton et al. (1993) likewise found no significant difference in the response of Chinook salmon to Phos Chek D75-F in hard and soft water. Buhl and Hamilton (1998) also found that the LC_{50} of D75-F is approximately 218 mg/L (between 170 and 280 mg/L) for all early life stages from swim up fry to 90 days post hatch. These tolerance numbers are very similar to rainbow trout tolerances (also 218 mg/L), but with some differences in effects to life stage, pH level, and UV light. Poulton et al. (1993) also found that there was no significant difference between the LC_{50}s of rainbow trout and Chinook salmon to the same chemicals.

When testing smolts specifically, Dietrich et al. (2014) found LC_{50}s for Chinook salmon exposed to 259F and LC-95A to be 186 and 542.2 mg/L, respectively. As seen in Table 62, these values are lower than what would be expected for non-smolts. However, these values are only slightly lower than the calculated values for juveniles in their study, which were 191.9 and 656.1 mg/L, respectively. The acute mortality of 259F was the result of un-ionized ammonia, confirming previous reports by Buhl (2000), but the LC-95A toxicity was the result of additional factors working synergistically with un-ionized ammonia (Dietrich et al. 2010).

While long-term fire retardants are more acutely toxic to smolt stages, they also present sub-lethal risks and can result in additional delayed mortality. Ammonia has been shown to affect eulachon and salmonid gill tissue (Dietrich et al. 2010, Connon et al. 2011). While juvenile

eulachon are not likely to be subjected to intrusions of long-term fire retardants, juvenile salmonids can be present in freshwater systems all year. During toxicity tests, juvenile Chinook salmon subjected to fire retardant levels low enough to cause less than five percent mortality in freshwater were shown to suffer 35 to 40% mortality when transitioning to saltwater due to impaired gill tissue (Dietrich et al. 2010, Dietrich et al. 2014).

Very little research has been conducted on coho salmon and their response to fire retardant chemicals. In research by Johnson and Sanders (1977), coho were found to have the same LC_{50}s in response to a different formulation of Phos Chek 259 as rainbow trout, which was between 94 and 250 mg/L. Again, it is assumed that Phos Chek 259, studied by Johnson and Sanders (1977), is comparable to the Phos Chek brands 259-F and 259-R, as seems to be indicated by Buhl and Hamilton's (2000) research.

There is no information on Atlantic, green, or shortnose sturgeon response to fire retardants and very little information on how sturgeon would respond to elevated levels of ammonia. Fontenot et al. (1998) showed that shortnose sturgeon have a 96-hour LC_{50} of under 150 mg/L for total ammonia. This is less tolerant than rainbow trout, Chinook salmon, or coho salmon, whose minimal tolerance is 168 mg/L. For un-ionized ammonia, the most toxic form to fish, the 96-hour LC_{50} for shortnose sturgeon was as toxic as 0.37 mg/L with a mean of 0.58 mg/L for shortnose sturgeon (Fontenot et al. 1998). The rainbow trout LC_{50} for un-ionized ammonia is between 0.03 and 0.2 mg/L (Alabaster et al. 1983, Wicks et al. 2002). The response of shortnose sturgeon, and presumably other sturgeon species, to total ammonia and un-ionized ammonia is very similar to the response of salmonids.

Pacific eulachon response to long-term fire retardants has not been studied. There is also no information on eulachon response to ammonia toxicity. However, the delta smelt is in the same family and is a reasonable surrogate species to estimate the response of eulachon to a sudden spike in total ammonia and un-ionized ammonia. Research on 57-day old delta smelt revealed an LC_{50} caused by total ammonia of 13 mg/L and an LC_{50} caused by un-ionized ammonia of 0.147 mg/L (Connon et al. 2011). The LC10 (the point at which 10% of the affected population is killed) was reported as 6.77 mg/L of total ammonia and 0.105 mg/L of un-ionized ammonia to 47-day old delta smelt (Werner 2009). However, a New Zealand species, the common smelt, is more tolerant of ammonia with LC_{50}s of 1.76 mg/L un-ionized ammonia at a pH of 7.5 and an LC_{50} of 0.97 mg/L un-ionized ammonia at a pH of 8.1 (Richardson 1997). The response of smelt to total ammonia and un-ionized ammonia is more severe than salmonids or sturgeon.

Depending on the time of year the long-term fire retardant accidental intrusion occurs, any ESA-listed fish life stage could be affected. Eulachon juveniles do not spend much time in freshwater, so it is less likely that any stage other than adult would be affected by fire retardant intrusions into freshwater. Most toxicological research focuses on juvenile fish because of the cost associated with raising a fish to adulthood. While the LC_{50}s for adult salmonid, sturgeon, or eulachon have not been determined, recent research on smolting salmon provides additional

information about how different life stages respond to ammonia and fire retardants (Dietrich et al. 2014).

There is very little information on the sub-lethal response of salmonids, Pacific eulachon, green sturgeon, Atlantic sturgeon, or shortnose sturgeon to long-term fire retardant compounds. Guar gum is a known respiratory inhibitor, while the sub-lethal impacts of ammonia range from skin, eye, and gill damage to reduced hatching success; reduced growth rate; impaired morphological development; injury to liver and kidneys; and the development of hyperplasia. Ammonia can have sub-lethal impacts to delta smelt also, causing cell membrane impairment and gene replication errors at levels between 5 and 10 mg/L (Connon et al. 2011).

7.2.1.2 Response to Magnesium Chloride

There is limited information about salmonid or sturgeon vulnerability to exposure to magnesium chloride. The best available information for this analysis is provided by the manufacturer of the fire retardant formulations. That information is supplemented with the limited information we were able to find, primarily about the toxicity of deicing chemicals that are formulated in part with magnesium chloride (less than 2%). Furthermore, because the magnesium-based chloride formulations are more expensive, they are often mixed with sodium chloride salts, so ecological studies about effects assessing the impacts of chlorides aren't exclusively assessing magnesium chloride. Also, as an anti-caking agent, most road deicers rely on sodium ferrocyanide (Fischel 2001), which was once used in fire retardants and is no longer allowed.

There are several ways the magnesium chloride fire retardant can affect fish. First, it can be directly lethal to individuals. There have been a number of assessments of LC_{50} values for several fish species. The next is an assessment of sub-lethal effects and dosage amounts required to produce sub-lethal effects. This is followed by minimal information about the no effect concentration. The last effect is a response due to biochemical oxygen demand of the mixture itself that may reduce DO levels. Because there are so few studies on the effects of magnesium chloride, there is limited information about its effects to all of the species considered in this assessment. Kunz et al. (2021) compared the effects of magnesium chloride to rainbow trout, freshwater mussels, crayfish, snails, and larval amphibians. They found the response of rainbow trout was similar to that of the other tested species, making rainbow trout a good surrogate for a wide range of species. The reported toxicity for rainbow trout by Kunz et al. (2021) is also similar to that reported in mosquito fish (McKee and Wolf 1963), fathead minnow (McKee and Wolf 1963, Birge et al. 1985, Pilgrim 2013), shiners (Wiebe et al. 1934, Doudoroff and Katz 1953, Mount et al. 1997), bluegill (Patrick et al. 1968, Birge et al. 1985), and for rainbow trout in other studies (Mueller 2018). No information could be found for effects of magnesium chloride to other salmonids, sturgeon, or smelt. However, given the broad overlap in toxicological endpoints for a wide range of taxa and the fact that the magnesium chloride appears to be less toxic than ammonia, we believe relying on the response of rainbow trout is a reasonable surrogate for other listed species.

The most important information about magnesium chloride appears to be that it is rapidly diluted to 100-500 times in just a few hundred yards (Lewis 1999) and less toxic than sodium chloride (Hintz and Relyea 2017). Therefore, while there are possible lethal and sub-lethal effects, the area affected is much smaller than for nitrogen- and phosphorous-based fire retardants. Studies on road deicer show that the deicer mixture has a 96-hour LC_{50} when 1.4% of the mixture is magnesium chloride. However, in real world conditions, deicers applied at the level of magnesium chloride are only 0.2% magnesium chloride by the time they are at the edge of the road and less than 0.1% within 20 ft of the road edge (Lewis 1999). Not magnesium chloride specifically, but chlorine-based deicers have been shown to have an effect to streams up to 300 ft from roadways (Fischel 2001). Therefore, magnesium chloride fire retardants are not likely a major concern even if they are dropped within the 300-ft buffer unless in a large concentration, which is relatively rare. Monitored intrusions between 2012 and 2019 were typically large in buffer zones but generally fewer than 60 gallons of retardant estimated to enter waterways (USDA Forest Service 2020).

Rainbow trout, when they receive an elevated dose of magnesium chloride, are able to regulate their internal levels of magnesium and chloride using their kidneys (Oikari and Rankin 1985). They are able to regulate the magnesium levels and prevent the uptake of additional chloride. This may explain some of the studies on sub-lethal effects identifying no effects to rainbow trout growth or development (Hintz and Relyea 2017).

The LC_{50} values reported for magnesium chloride are relatively wide ranging. These tests are 96 hours in length and test rainbow trout, unless otherwise stated below. For magnesium chloride found in fire-fighting gels, the 96-hour LC_{50} was reported to range between 541 and 2,119.3 mg/L (Dadashov et al. 2018). Assessing egg mortality, rainbow trout eggs suffered 25% mortality over seven days at 989 mg/L (Tiwari and Rachlin 2018). The lethal concentration that was protective of 95% of fish over a 2-week period calculated from the LC_{50} was 51 mg/L. This would adjust to an LC_{50} of approximately 1,020 mg/L (Jooste 2002). An assessment of rainbow trout tolerance to chlorides generally showed a 24-hour LC_{50} of 6,743 mg/L (Tiwari and Rachlin 2018). In the only other study on toxicity that we could find, the golden shiner (*Notemigonus crysoleucas*) survived for an average of 4.6 hours in 10,000 mg/L magnesium chloride (Evans and Frick 2001).

Sub-lethal effects of magnesium chloride have also been studied. Joote (2002) estimated that 5% of the LC_{50} was approximately 15 mg/L, which would protect about 95% of fish from sub-lethal effects. Hintz and Relyea (2017) assessed a range of concentrations of the three primary road deicing salts and found that magnesium chloride was the only salt that had no effect to rainbow trout growth or development at any concentrations. Other comparative studies have shown that magnesium chloride is a relatively safe road salt (Gubanova et al. 2020, Kunz et al. 2021). The no effect concentration has been calculated at 3.21 mg/L (Dadashov et al. 2018).

Indirect consequences of magnesium chloride also need to be considered. Studies have assessed the effects of road deicers on biochemical oxygen demand (BOD) to assess whether there are effects to DO concentrations associated with run-off. Others have looked at the risk of photoenhanced toxicity or assessed the toxicity or magnesium chloride to macroinvertebrates. The BOD of magnesium chloride ranges from 0.04 to 0.11 mg oxygen (O_2) per L per day (Lewis 1999). During low flow conditions, when DO is most likely to be adversely affected, there was no significant decrease in DO levels due to magnesium chloride introduction (Lewis 1999, Fischel 2001). There was also no evidence of photoenhanced toxicity under the same conditions (Kunz et al. 2021). Invertebrates, an important food resource for juvenile salmonids, have a similar tolerance to magnesium chloride as rainbow trout (Kunz et al. 2021) with 96-hour LC_{50}s between 140 and 548.4 mg/L (Dadashov et al. 2018).

Fortress' long-term fire retardants, FR-100 and FR-200, each have a 96-hour LC_{50} of 1,762 mg/L in rainbow trout (Auxilio 2021a). The risk assessment determined there was a risk to rainbow trout because of spilling the concentrate and the mixed product into a stream, however, applying it at a rate of 6 gpc did not rise to the level of being a lethal risk (Auxilio 2021a).

As above, because more information is available about magnesium chloride toxicity to rainbow trout, they are considered a proxy for other salmonids, Pacific eulachon, green sturgeon, Atlantic sturgeon, and shortnose sturgeon. Further, the other components of magnesium chloride fire retardant formulations are the same as other fire retardant formulations. Therefore, the effects caused by guar gum, colorant, and other components is expected to be similar, but not synergistic.

7.2.1.3 Response to Loss of Chinook Salmon

Threats to SRKWs were reviewed by Murray et al. (2019), who found a "cumulative effects" model was better at determining population impacts compared to separately analyzing individual threats. The "cumulative effects" model indicated that Chinook salmon abundance was the most sensitive model parameter; however, the authors highlighted the importance of considering threats collectively. Lacy et al. (2017) developed a population viability assessment (PVA) that attempts to quantify and compare the three primary threats affecting the whales (e.g. prey availability, vessel noise and disturbance, and high levels of contaminants). The Lacy et al. (2017) model found that Chinook salmon abundance was the most important threat to SRKW population growth. They also emphasized that prey increases alone would likely not be sufficient to recover the whales and that the other threats would need to be addressed as well.

The most recent effort to review the relationships of SRKW vital rates and Chinook salmon abundance was conducted by an ad hoc workgroup through the Pacific Fisheries Management Council (PFMC 2020). However, the workgroup did not assess the cumulative threats, and found that the small population size limited their ability to detect a quantitative relationship between Chinook salmon abundance and SRKW demographic metrics (e.g. fecundity and survival) to input into their PVA and the relationship is likely not linear or constant over time (PFMC 2020).

Although there are challenges to detecting quantitative relationships and others have cautioned against overreliance on correlative studies (see Hilborn et al. 2012) given the status of the species (endangered with low abundance and productivity) and their strong preference for Chinook salmon prey, the continued existence and potential for recovery of the species is highly dependent on healthy numbers of Chinook salmon throughout its range.

Prey availability changes seasonally, and SRKWs appear to depend on different prey species/populations and habitats throughout the year. The seasonal timing of salmon returns to different river systems likely influences their movements (NMFS 2019b). Whales may travel significant distances to locate prey aggregations sufficient to support their numbers. Diet data indicate that Chinook salmon is the primary prey of SRKWs across all seasons and areas (Hanson et al. 2010, Ford et al. 2010, Ford et al. 2016, NMFS 2019b). Chinook salmon have the highest value of total energy content compared to other salmonids because of their larger body size and higher energy density (O'Neill et al. 2014). Although diet data in offshore waters is sparse, juvenile salmon are not anticipated to be a preferred target prey item for SRKWs, which likely seek out adult Chinook salmon (Hilborn et al. 2012) due to the higher nutritional value of the larger fish (O'Neill et al. 2014). While juvenile Chinook salmon mortality may not result in the same immediate impacts on prey availability as adult mortality, the loss of juveniles represents the loss of future adult prey availability, as well as future reproductive potential within the population.

For fire retardants to affect Chinook salmon availability to SRKWs, the intrusions would have to affect juveniles or pre-spawning adults, resulting in either fewer outmigrants or fewer larvae produced. Adults are semelparous and those affected in freshwater would not be available as a prey source. Further, Chinook salmon, unlike species like steelhead, reside and spawn in larger mainstem rivers as opposed to smaller tributaries, making their occupied habitat less likely to receive an intrusion and, when an intrusion occurs, more likely to quickly be diluted. Therefore, the effects of intrusions would be less severe for Chinook salmon than other salmonids and take years to affect SRKWs. The life cycle for Chinook salmon is discussed in the Status of the Species (Section 5.3).

SRKWs require a lot of salmon in their diets. By assuming the average caloric density of each Chinook they consume to be 16,386 calories per fish, which is the average value for adults from Fraser River, Noren (2011) estimated the number of salmon needed to support individual killer whales as well as pods of SRKWs. The daily prey energy requirements for individual SRKW females and males range from 41,376 to 269,458 calories per day and 41,376 to 217,775 calories per day, respectively (Noren 2011). This is roughly between 3 and 17 Chinook salmon per day. Noren (2011) estimated the daily consumption rate of a population with 82 individuals over the age of one that consumes solely Chinook salmon would consume 289,131–347,000 Chinook salmon each year. Similarly, Williams et al. (2011) and Chasco et al. (2017a) modeled annual SRKW prey requirements and found that the whole population requires approximately (95%

credible limits) 211,000 to 364,100 and 190,000 to 260,000 Chinook salmon per year, respectively. Most of these individuals would be from Puget Sound Chinook salmon and non-listed Chinook salmon populations, which are either in closer proximity to SRKWs or in higher abundance than threatened or endangered populations. Reported intrusions possibly affecting Chinook salmon populations since 2011 are shown in Table 63. Of the nine reported intrusions, none were into water with Chinook salmon. One crossed the bed of an ephemeral stream, two were upstream of Chinook salmon habitat with no observed downstream effects, and six affected buffer zones with no run off effects observed.

Table 63. Chinook salmon ESUs affected by fire retardants in the past decade (From Table BA-18 in USDA Forest Service 2020).

Chinook Salmon ESU	Intrusions	Intrusions into Water	Estimated Take
Snake River Fall Run	0	0	0
Snake River Spring/Summer	8	0	0
Upper Columbia River Spring Run	0	0	0
CA Coastal Chinook	0	0	0
Central Valley spring-run Chinook	1	0	0
LCR Chinook	0	0	0
Upper Willamette River Chinook	0	0	0
Sacramento winter run Chinook	0	0	0

Monitoring by the USFS since 2011 has reported no effects of fire retardants on any listed populations of Chinook salmon. Because of delays in monitoring due to safety, scavenging, and delayed mortality responses, the actual number of Chinook salmon killed by intrusions is likely higher than this. Further, intrusions into buffers around Chinook salmon streams have occurred approximately every year. It is likely at some point in the future an intrusion will occur that will either result in mortality of Chinook salmon or increase the likelihood of delayed mortality (increasing the likelihood of mortality as the result of retardant exposure earlier in life). However, while each SRKW requires several thousand Chinook salmon each year, most of those fish come from the Puget Sound region, where fire retardants have not been applied in the last decade, or from more abundant non-ESA-listed populations. Given the observed mortalities prior to 2011, the increasing trend in fire retardant use, and the toxicity of fire retardants, it is likely that the effects of fire retardants on listed populations of Chinook salmon will occur during this program, but the extent of that effect and the importance of other populations to SRKW diets would mitigate the effects of any Chinook salmon lethal or sub-lethal effects.

7.2.1.4 Response to Wildfire

While the natural condition of wildfire does not undergo section 7 consultation, it is worth considering that the use of fire retardants in some cases is less harmful than the effects of wildfire on those systems. It is also valuable to understand that the analyses above consider fish in good condition, which is not the most likely case during a wildfire. Fish are likely stressed by increasing temperatures. This makes fish affected by fire retardants more likely to die from that

exposure and more likely for there to be much lower densities of fish in the area, as many fish would be expected to move out of the area affected by wildfires before fire retardants are ever applied.

Minshall and Brock (1991) believe that increased water temperatures associated with wildfires, which can range from four to 10°C (Gresswell 1999), can kill fish in first and second order streams, but doubt third order streams get hot enough to cause mortality. Mortality in second and third order streams could be caused by smoke and ash (Minshall et al. 1989). In larger streams, the impacts of wildfires are likely less (Gresswell 1999) for many of the same reasons and anticipated impacts of fire retardant are less. The quality of the critical habitat in all reaches of stream that experience changes in water quality will be reduced. Small, isolated populations of fish have been extirpated by fires (Rieman and Clayton 1997), and to achieve a similar response to intrusions, the extent of intrusions would need to match the extent of the wildfire effects in a headwater system. Larger, better-connected populations are more resilient to the effects of wildfires (Rieman et al. 1995, Dunham et al. 2003) so individuals from downstream that are not harmed may migrate back into the headwater system to spawn, helping fish re-establish in those areas.

Other impacts of wildfire could make salmonids more susceptible to fire retardants. Gresswell (1999) showed that smoke in the air is adsorbed by water and increases the ammonia concentrations in rivers even without an intrusion of retardant. Crouch et al. (2006) showed that in burning watersheds, prior to treatment with retardants, there is increased ammonia, phosphorous, and total cyanide. Because there is a greater background level of ammonia during a fire, the ammonia levels created by an accidental drop may be higher than experienced in a controlled setting and as the fire retardants are diluted, they may take longer to reach non-toxic levels. Because of the smoke-induced ammonia concentration, it is likely fish begin avoiding areas affected by wildfires (Wicks et al. 2002, Little et al. 2006) regardless of whether fire retardant is ever used.

7.2.2 Response of Critical Habitat to Fire Retardant Exposure

Fire retardants affect critical habitat for different species in different ways. Freshwater critical habitats for salmonids (Tables 5 and 15), sturgeon (Sections 5.3.26.4, 5.3.27.4, and 5.3.28.4) and Pacific eulachon protect spawning, rearing, and migration and each of which could be affected by fire retardants. Because fire retardants adversely affect water quality, the effects to spawning, rearing, and migratory PBFs would depend on the extent of changes in water quality and how those changes would affect the utility of the critical habitat.

Ammonia and magnesium chloride can be toxic in large amounts, directly affecting listed fish but also compromising critical habitat until water quality returns to non-toxic levels. As discussed above, Rehmann et al. (2021) showed fire retardant toxicity persists for between 1.5 and five hours following an intrusion. Risk assessments addressing run-off show none of the

retardants on the QPL pose a significant risk from run-off (Auxilio 2021a, b). Therefore, for each intrusion, critical habitat protecting spawning, rearing, and migratory habitat is likely to be affected for between 1.5 and 5 hours. There are no lasting effects of fire retardants to critical habitat because the fire retardants dissipate and move downstream. As the retardants dissipate, they may drift along the benthos of a system but as a non-toxic flocculate (H. Puglis, unpublished data). This condition can last for a few days, typically affecting areas of lower flow where the flocculate can settle as it dissipates.

Interestingly, all of the primary chemicals used to fight fires have beneficial effects at lower doses. Most fires are fought in the intermountain west, where water tends to be oligotrophic (nutrient poor, limiting productivity). Nitrogen and phosphorous are limiting nutrients and their addition increases productivity following a wildfire. Magnesium is an essential nutrient for salmonids and sturgeon and provides benefits for early life stages of fish as they grow. Therefore, following the adverse effects of an intrusion, there are beneficial effects that also result from these retardant chemicals.

SRKW critical habitat does not exist in freshwater, but an aspect of their critical habitat is sufficient prey resources in the marine environment. Because Chinook salmon are the preferred prey item for SRKWs, any removals of Chinook salmon as the result of fire retardant intrusions would affect SRKW critical habitat. In this case, because the effect to SRKWs is the same as the effect to critical habitat, the response of the species is the same as the response of critical habitat to the effects of this program.

7.2.2.1 Salmonids, Pacific Eulachon, and Sturgeons

Fire retardant intrusions affect water quality primarily. Water quality is protected for spawning, rearing, and migrating in freshwater environments. Furthermore, in the event of an intrusion, the short-term presence of fire retardants in the system could act as a barrier. Fire retardants act on the environment in two ways: 1) toxicologically, and 2) physically.

The toxicological response of individuals to fire retardant intrusions is covered above. Because the anticipated exposure is expected to be very short-lived, in many cases, only a few hours, we do not anticipate the brief changes in water quality from an intrusion to have lasting effects on critical habitat that would cause changes to the physical or biological features of critical habitat.

This habitat may be inaccessible for a few hours until water quality improves. Additionally, these toxic conditions create passage barriers separating upstream and downstream habitats for several hours until the area of poor water quality has returned to normal. Passage barriers that last for approximately five hours are not expected to have significant or long-lasting effects to critical habitat.

The physical changes to critical habitat caused by fire retardant intrusions are slightly different from those changes to water quality that cause toxicological changes. Fire retardants have thickeners that are inert, added to make their application to the terrestrial environment more

effective under different scenarios. When these accidentally reach the aquatic environment, they change the way fire retardants disperse moving downstream. The retardants do not mix with water the way other liquid chemicals would mix, but instead the retardant will sink to the bottom in slower moving sections of streams, typically pools (H. Puglis, unpublished data). While this thickened retardant moves more slowly through the environment, it does not remain toxic, but it does cover the benthic habitat in the affected areas for days rather than hours. This can affect benthic foraging and fry rearing areas. Because salmonids produce redds at the tails of pools and in runs with faster flow to provide plenty of oxygen to their eggs, fire retardants would not be expected to settle over spawning habitat.

7.2.2.2 Southern Resident Killer Whales

Because the only PBF of SRKW habitat that could be affected by fire retardant intrusions is the same as the exposure and response discussed above for effects to individual fish, the considerations for the response to critical habitat are the same. If SRKWs relied exclusively on Chinook salmon, which they do not, then approximately 350,000 fish would need to be available for consumption each year to sustain slightly more killer whales than currently exist (Noren 2011, Williams et al. 2011, Chasco et al. 2017). Most of SRKW dietary Chinook salmon come from the Puget Sound rivers and Fraser River in Canada, neither of which are affected by this action. However, prey capture probability is likely somewhat dependent on the overall densities of Chinook salmon, where dense schools would improve the probability of capturing sufficient food.

There have been no reported effects of fire retardants on any listed populations of Chinook salmon since 2011. However, intrusions into buffers around Chinook salmon streams have occurred approximately every year. It is likely at some point in the future an intrusion will occur that will either result in mortality of Chinook salmon or increase the likelihood of mortality during future life stages for those fish exposed to the retardant. While the effects of fire retardants on listed populations of Chinook salmon are likely to occur at some point during this program, the extent of that effect and the importance of other populations to SRKW diets would mitigate the effects of any Chinook salmon lethal or sub-lethal effects.

7.3 Estimating Take due to Exposure and Response

The exposure section identifies the likelihood of individual listed species being exposed to fire retardant chemicals as a result of intrusions into waterways. The response section discusses the range of responses that may result from those exposures. Anticipating the take that is likely to result is the process of combining the calculated exposures with the probable responses. In this section, we would typically identify the life stages to be affected (adult, sub-adult, smolt, egg, etc.) and the numbers of each life stage likely to be taken, as defined in the ESA, section 3(19).

It is not possible to identify the location where each wildfire will start. While it is possible to anticipate the likelihood of fire spreading, the direction of spread, and the area likely to be

affected once a wildfire has started, at this time, we cannot predict where fire retardant will be applied. Intrusions, being the unplanned consequence of an aerial application of fire retardant, and, for the purposes of assessing effects to listed species, only those intrusions that reach water, can also not be anticipated with specificity. Because the precise locations of intrusions cannot be anticipated, we cannot be sure of the densities of species in the area that will be affected by a future intrusion. Beyond whether the species is present or not, the resulting toxicity depends on a number of factors that will affect the actual response to the intrusion. The main factors affecting response are the amount of retardant to reach water, the volume of water (width, depth, and flow rate) in the receiving location, turbulence of the water and slope of the area, pool frequency, and downstream tributaries. Because of this, it is not practical to quantify the anticipated take of individuals, and we instead rely on a surrogate and follow up monitoring to understand the effects of intrusions through time. The surrogate for take of listed species at the time of the intrusion is the intrusion itself, which meets the requirement for determining an effect of the action because no take will occur without the intrusion and the amount of take that is reasonably certain to occur can be calculated once the intrusion occurs by using the USFS spill calculator (Rehmann et al. 2021). We can then understand in detail the area affected by the intrusion based on the abiotic factors described above. As described in the response section, only intrusions with a modelled spike in toxicity that exceeds 10% of the LC_{50} concentration (the estimated concentration below which would have no effect) would result in "take" of listed species. Each intrusion is therefore causally linked to the take of each listed species analyzed in this programmatic biological opinion.

8 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 (50 CFR 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(a)(2) of the ESA.

The action area for this consultation is limited to NFS lands and areas immediately downstream, as well as Puget Sound, Washington, and Cook Inlet, Alaska (Section 4.2). There are no state or private actions that will occur on USFS land without the approval of the USFS, and, therefore, the need for consultation under section 7(a)(2) of the ESA. At the large spatial scale of this consultation, we could not identify specific future non-federal actions that would take place along rivers immediately downstream of the national forests considered herein. It is likely that residential development will continue to affect riparian habitats adjacent to USFS lands, but there are no large-scale developments planned. We conducted electronic searches of business journals, trade journals, and newspapers using Google, Yahoo, and Microsoft. We are not aware of any actions besides fire-fighting that are likely to occur in the action area during the foreseeable future.

There are a number of ongoing state and private actions that may affect SRKWs. These are discussed in the Environmental Baseline (Section 6). The primary consideration is the loss of Chinook salmon as a prey resource. State authorized commercial fisheries are the largest competitors with these species. In eastern Puget Sound, from 2007 to 2011, approximately 6,600 Chinook salmon were harvested each year. A draft management plan for Chinook salmon harvest in the entire Puget Sound proposes upper harvest limits of just over 45,000 adults per year, made up nearly entirely of non-listed Skagit, Snohomish, Skokomish, Skykomish, and Elwha River spawners. The harvest rates reported for eastern Puget Sound between 2007 and 2011 would be reduced under this plan. These proposed harvest levels vary between six and 17% of anticipated adult Chinook salmon from each system. The anticipated abundance of Chinook salmon in Puget Sound is therefore approximately 300,000 adults from non-listed US river sources (Puget Sound Indian Tribes and WDFW 2017). If this density of Chinook salmon is available annually in Puget Sound, SRKWs will have just barely enough food to support their population. SRKWs will move along the West Coast to target Chinook salmon runs into other river systems as they occur and consume smaller marine mammals, supplementing their dietary needs.

9 Integration and Synthesis

The Integration and Synthesis section is the final step in our assessment of the risk posed to species and critical habitat because of implementing the action. In this section, we add the probability of exposure (Section 7.1) with the likely response (section 7.2) to the environmental baseline (Section 6) and the cumulative effects (Section 8), taking into account the status of the species and critical habitat (Section 5.3), to formulate the agency's biological opinion as to whether the action is likely to: (1) Reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its numbers, reproduction, or distribution; or (2) appreciably diminish the value of designated or proposed critical habitat as a whole for the conservation of the species.

9.1 California Coastal ESU Chinook salmon

California coastal ESU Chinook salmon are listed as threatened. All six spring-run populations have been extirpated, however 32 fall populations are extant. The primary threats they face affect freshwater locations and spawning and rearing success. The main anthropogenic threats are channel modification, roads, logging, and water diversions.

Over the next 10 years, we anticipate nine intrusions of fire retardants into rivers on national forests occupied by California coastal ESU Chinook salmon. We expect multiple intrusions in approximately half of those years. Those intrusions are expected to affect only juvenile fish. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The

anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of California coastal ESU Chinook salmon (USDA Forest Service 2020), it is expected that all nine anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for California coastal ESU Chinook salmon that could be affected by aerial fire retardant intrusions are reducing habitat destruction and addressing natural and anthropogenic factors affecting the population. In the case of wildfire events, they are a natural factor affecting the species and fire retardants are an anthropogenic factor that may affect the species in response to the wildfire. Climate change is likely to continue causing larger and more dangerous wildfires in California. It is likely fire retardants will continue to become less toxic, but also be needed to address wildfires more often in the future. Further, the areas affected by wildfire endure short-term water quality degradation. The short-term effects of ammonia toxicity (generally about five hours or less) or magnesium chloride are minimal given the natural conditions in the area at the time of the intrusion. However, without impairments from wildfires, the short-term effects to listed species are limited to the effects on individuals and are not expected to have lasting effects on water quality or cause long-term degradation.

Designated critical habitat for California coastal ESU Chinook salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on nine occasions for up to five hours each over a 10-year period. Only juvenile California coastal ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect rearing habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The nine anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For California coastal ESU Chinook salmon, we anticipate no more than nine intrusions over the next decade with responses ranging from temporary avoidance to mortality of juveniles (Table 63; USDA Forest Service 2020). California coastal ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. Further, because only juveniles would be present at the time of peak fire activity, only individuals from a portion of one year class would be affected by an intrusion. Nine intrusions over the next decade, even if they all occurred in the same system in the same year, are not likely to jeopardize the likelihood of either survival or recovery of California coastal ESU Chinook salmon because they have multiple populations that occur over large geographic areas in relatively voluminous waterways. The temporary loss of this critical habitat on nine occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify California coastal ESU Chinook salmon critical habitat.

9.2 Central Valley Spring-run ESU Chinook Salmon

CV spring-run ESU Chinook salmon are listed as threatened. The primary threats they face are loss of historic spawning habitat, impaired freshwater habitat, and genetic introgression from hatchery fish. Only three spawning systems still have self-sustaining, non-hybridized populations. Recent trends in abundance reveal half the systems are increasing and half are decreasing with only 6 populations still numbering in the thousands.

Over the next 10 years, we anticipate 19 intrusions of fire retardants into rivers on national forests occupied by CV spring-run ESU Chinook salmon. We expect multiple intrusions in approximately 62% of those years. Those intrusions are expected to affect all life stages except fry. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of CV spring-run ESU Chinook salmon (USDA Forest Service 2020), it is expected that all 19 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic

pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for CV spring-run ESU Chinook salmon that could be affected by aerial fire retardant intrusions revolve around increasing and maintaining appropriate abundances. Because of this, the same risks facing CV spring-run Chinook salmon survival also apply to their recovery.

Designated critical habitat for CV spring-run ESU Chinook salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on 19 occasions for up to five hours each over any 10-year period. Adult, juvenile, and egg life stages of CV spring-run ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 19 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For CV spring-run ESU Chinook salmon, we anticipate no more than 19 intrusions over the next decade with responses ranging from temporary avoidance to mortality of adults, smolts, and juveniles (Table 63; USDA Forest Service 2020). CV spring-run ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. Nineteen intrusions over the next decade, even if they all occurred in one of the three self-sustaining systems in the same year, are not likely to jeopardize the likelihood of either survival or recovery of CV spring-run ESU Chinook salmon because they have multiple populations that occur over large geographic areas in relatively voluminous waterways. The temporary loss of this critical habitat on 19 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify CV ESU Chinook salmon critical habitat.

9.3 Lower Columbia River ESU Chinook Salmon

Lower Columbia River ESU Chinook salmon are listed as threatened. The primary threats they face are warming ocean conditions caused by climate change, low abundance, poor productivity,

and habitat degradation. While there are 32 extant populations, only two are considered viable. Most populations have fewer than 100 adults, though there is still a robust juvenile population of over 12 million individuals.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by LCR ESU Chinook salmon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect any life stage except fry. The response to that intrusion will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of LCR ESU Chinook salmon (USDA Forest Service 2020), it is expected that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for LCR ESU Chinook salmon that could be affected by aerial fire retardant intrusions are related to abundance and probability of persistence. One specifically discusses distribution so the species is protected from catastrophic events. Protection from catastrophic events is one of the objectives of this program. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for LCR ESU Chinook salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult, juvenile, and egg life stages of LCR ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five

hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For LCR ESU Chinook salmon, we anticipate no more than one intrusion over the next decade with responses ranging from temporary avoidance to mortality of adults, smolts, and juveniles (Table 63; USDA Forest Service 2020). LCR ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of LCR ESU Chinook salmon because a single intrusion would only affect a small segment of the population in a single year over the next decade. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify LCR ESU Chinook salmon critical habitat.

9.4 Snake River Fall-run ESU Chinook Salmon

Snake River fall-run ESU Chinook salmon are listed as threatened. The primary threats they face are lost historical spawning habitat, impaired migratory pathways in the lower Columbia River, and competition with hatchery origin fish on the spawning grounds. There are approximately 10,000 spawning adults and over 5 million juveniles in this ESU, all of which rely on 5 spawning areas in the Snake River.

Over the next 10 years, we anticipate seven intrusions of fire retardants into rivers on national forests occupied by Snake River fall-run ESU Chinook salmon. We expect multiple intrusions about twice each decade. Those intrusions are expected to affect adult and juvenile fish. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are

relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of Snake River fall-run ESU Chinook salmon (USDA Forest Service 2020), it is expected that the seven anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The sole recovery goal for Snake River fall-run ESU Chinook salmon is to improve the ecosystem upon which they depend to the point where this ESU is self-sustaining in the wild. Wildfires are a natural part of the ecosystem, but catastrophic wildfires can cause long-term damage to terrestrial habitats, impairing spawning, rearing, and migration. Fire retardants are used to combat catastrophic wildfires. In the event of an intrusion, the impacts to ecosystem function are relatively short-lived, lasting for approximately five hours. The short-term water quality degradation will have no lasting effect to ecosystem function.

Designated critical habitat for Snake River fall-run ESU Chinook salmon in freshwater locations addresses migration of adults and juveniles, as well as habitat free of contaminants (Table 15). Under worst-case conditions, critical habitat may be temporarily affected on seven occasions for up to five hours each over any 10-year period. Adult and juvenile life stages of Snake River fall-run ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect rearing and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The seven anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Snake River fall-run ESU Chinook salmon, we anticipate no more than seven intrusions, each lasting five hours over the next decade, with responses ranging from temporary avoidance to mortality of adults and juveniles (Table 63; USDA Forest Service 2020). Snake River fall-run ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. Seven intrusions over the next decade, even if they all occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of Snake River fall-run ESU Chinook salmon because they have multiple populations that occur over large geographic areas in relatively voluminous waterways. The temporary loss of this critical habitat on seven occasions

for five hours at a time over the course of a decade is not likely to destroy or adversely modify Snake River fall-run ESU Chinook salmon critical habitat.

9.5 Snake River Spring/Summer-run ESU Chinook Salmon

Snake River spring/summer-run ESU Chinook salmon are listed as threatened. The primary threats they face are impacts to freshwater habitat affecting migrating and rearing, toxic chemicals, and warming ocean conditions associated with climate change. This ESU has a low probability of persistence over the next 100 years. There are now approximately 15,000 adults and 6 million juveniles in this population. Abundance has been increasing since reaching lows in the mid 1990s.

Over the next 10 years, we anticipate 10 intrusions of fire retardants into rivers on national forests occupied by Snake River spring/summer-run ESU Chinook salmon. We expect multiple intrusions in approximately 62% of those years. Those intrusions are expected to affect all life stages except fry. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of Snake River spring/summer-run ESU Chinook salmon (USDA Forest Service 2020), it is expected that the 10 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for Snake River spring/summer-run ESU Chinook salmon that could be affected by aerial fire retardant intrusions revolve around increasing and maintaining appropriate abundances. Because of this, the same risks facing Snake River spring/summer-run ESU Chinook salmon survival also apply to their recovery.

Designated critical habitat for Snake River spring/summer-run ESU Chinook salmon in freshwater locations addresses migration of adults and juveniles, as well as habitat free of contaminants (Table 15). Under worst-case conditions, critical habitat may be temporarily

affected on 10 occasions for up to five hours each over any 10-year period. Adult, juvenile, and egg life stages of Snake River spring/summer-run ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 10 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Snake River spring/summer-run ESU Chinook salmon, we anticipate no more than 10 intrusions, each lasting five hours over the next decade, with responses ranging from temporary avoidance to mortality of adults, smolts, and juveniles (Table 63; USDA Forest Service 2020). Snake River spring/summer-run ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. Ten intrusions over the next decade, even if they all occurred in the same year in the same system, are not likely to jeopardize the likelihood of either survival or recovery of Snake River spring/summer-run ESU Chinook salmon because they have multiple populations that occur over large geographic areas in relatively voluminous waterways. The temporary loss of this critical habitat on 10 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Snake River spring/summer-run ESU Chinook salmon critical habitat.

9.6 Upper Columbia River Spring-run ESU Chinook Salmon

Upper Columbia River spring-run ESU Chinook salmon are listed as endangered. Only three populations remain. These populations support approximately 10,000 hatchery and wild adults along with just over a million juveniles. The abundance of this ESU has been declining since the 1980s and continues to do so. The primary threats they face are lack of diversity and impaired habitat.

Over the next 10 years, we anticipate five intrusions of fire retardants into rivers on national forests occupied by UCR spring-run ESU Chinook salmon. We expect multiple intrusions in approximately 12% of those years. Those intrusions are expected to affect all life stages except fry. The response to those intrusions will depend on whether this ESU is near the location of the

intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of UCR spring-run ESU Chinook salmon (USDA Forest Service 2020), it is expected that the five anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for UCR spring-run ESU Chinook salmon that could be affected by aerial fire retardant intrusions revolve around increasing and maintaining appropriate abundances and distributions. Because of this, the same risks facing UCR spring-run ESU Chinook salmon survival also apply to their recovery.

Designated critical habitat for UCR spring-run ESU Chinook salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on five occasions for up to five hours each over any 10-year period. Adult, juvenile, and egg life stages of UCR ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The five anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For UCR ESU Chinook salmon, we anticipate no more than five intrusions, each lasting five hours over the next decade, with responses ranging from temporary avoidance to mortality of adults, smolts, and juveniles (Table 63; USDA Forest Service 2020). UCR ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. Five intrusions over the next decade, even if they all occurred in the same system in the same year, are not likely to jeopardize the likelihood of either survival or recovery of UCR ESU Chinook salmon because they have multiple populations that occur over large geographic areas in relatively voluminous waterways. The temporary loss of this critical habitat on five occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify UCR ESU Chinook salmon critical habitat.

9.7 Upper Willamette River ESU Chinook Salmon

UWR ESU Chinook salmon are listed as threatened. Only one small population remains. The primary threats they face are dams (reduced spawning habitat and migration impediments), water temperatures, and water quality. Historically, this ESU supported over 300,000 adults, but now is down to approximately 40,000 with only 10,000 being wild (non-hatchery) fish. There is only one self-sustaining natural population left in this ESU.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by UWR ESU Chinook salmon. That intrusion is expected to affect any life stages except fry. The response to that intrusion will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of UWR ESU Chinook salmon (USDA Forest Service 2020), it is expected that the one anticipated intrusion on average per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for UWR ESU Chinook salmon that could be affected by aerial fire retardant intrusions revolve around minimizing extinction risk in the two main populations, while improving the other populations. This is essentially a matter of increasing abundance and productivity while minimizing threats. Because of this, the same risks facing UWR ESU Chinook salmon survival also apply to their recovery.

Designated critical habitat for UWR ESU Chinook salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult, juvenile, and egg life stages of UWR ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For UWR ESU Chinook salmon, we anticipate no more than one intrusion over the next decade, with responses ranging from temporary avoidance to mortality of adults, smolts, and juveniles (Table 63; USDA Forest Service 2020). UWR ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of UWR ESU Chinook salmon because a single intrusion would only affect a small segment of the population in a single year over the next decade. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify UWR ESU Chinook salmon critical habitat.

9.8 Sacramento Winter-run ESU Chinook Salmon

Sacramento River winter-run ESU Chinook salmon are listed as endangered. Only one small population remains. The primary threats they face are droughts and warming ocean conditions associated with climate change and impacts of hatchery fish. This ESU is at high risk of extinction. There are approximately 6,000 adults in this ESU with approximately 66% of those being of hatchery origin.

Over the next 10 years, we anticipate eight intrusions of fire retardants into rivers on national forests occupied by Sacramento River winter-run ESU Chinook salmon. We expect multiple intrusions in approximately 38% of those years. Those intrusions are expected to affect all life stages of fish, thought eggs, alevin, and juveniles most likely. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While monitoring of intrusions over the past decade has found no evidence of mortality of Sacramento River winter-run ESU Chinook salmon (USDA Forest Service 2020), it is expected that the eight anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Sacramento River winter-run ESU Chinook salmon focus on increasing the number of populations to alleviate the pressure of having only one population left. Nothing in this proposed action would prevent that from occurring, nor would this action facilitate that in any way. However, ensuring this population does not trend downward is essential to the opportunity to recover this population and establish new populations. Because of this, the same risks facing Sacramento River winter-run ESU Chinook salmon survival also apply to their recovery.

Designated critical habitat for Sacramento River winter-run ESU Chinook salmon in freshwater locations addresses migration of adults and juveniles, as well as habitat free of contaminants (Section 5.3.5.4). Under worst-case conditions, critical habitat may be temporarily affected on eight occasions for up to five hours each over any 10-year period. Adult, juvenile, and egg life stages of Sacramento River winter-run ESU Chinook salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal

within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The eight anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Sacramento River winter-run ESU Chinook salmon, we anticipate no more than eight intrusions, each lasting five hours over the next decade, with responses ranging from temporary avoidance to mortality of adults, smolts, juveniles, and fry (Table 63; USDA Forest Service 2020). Sacramento River winter-run ESU Chinook salmon are buffered from catastrophic events by having individuals from a population in rivers, estuaries, and oceans at any given time. Therefore, any intrusion affecting USFS lands would only affect a segment of any population. Eight intrusions over the next decade, even if they all occurred in the same system in the same year, are not likely to jeopardize the likelihood of either survival or recovery of Sacramento River winter-run ESU Chinook salmon because they occupy mainstem waterways, which should help disperse the retardant minimizing the area of toxic exposure. The temporary loss of this critical habitat on eight occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Sacramento River winter-run ESU Chinook salmon critical habitat.

9.9 Columbia River ESU Chum Salmon

Columbia River ESU chum salmon are listed as threatened. Approximately 11,000 adults and over 7 million juveniles still comprise this ESU with most being naturally produced wild fish. The primary threats they face are warming ocean conditions and impaired freshwater habitat affecting rearing success. This ESU is considered to be at moderate to high risk of extinction.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by Columbia River ESU chum salmon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect any life stage except fry. The response to that intrusion will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause

lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. While no intrusions were reported in the past decade in Columbia River ESU Chum salmon habitat, it is expected that the one anticipated intrusion on average per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for Columbia River ESU chum salmon that could be affected by aerial fire retardant intrusions are improving tributary habitat conditions. This and the other improvements are intended to increase abundance, productivity, diversity, and spatial structure. As discussed in the next paragraph, tributary habitat conditions are addressed in this biological opinion and the operation of this program will have no lasting impact to freshwater spawning, rearing, or migratory habitat.

Designated critical habitat for Columbia River ESU chum salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult Columbia River ESU chum salmon will be present during 38% of fires, therefore these temporary impairments will likely only affect migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Columbia River ESU chum salmon, we anticipate no more than one intrusion over the next decade. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of Columbia River ESU chum salmon because a single intrusion would only affect a small segment of the population in a single year over the next decade. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify Columbia River ESU chum salmon critical habitat.

9.10 Lower Columbia River ESU Coho Salmon

Lower Columbia River ESU coho salmon are listed as threatened. The primary threats they face are low abundance, warming ocean conditions, and degraded freshwater habitat.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by LCR ESU coho salmon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect any life stage except fry. The response to that intrusion

will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion on average per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for LCR ESU coho salmon that could be affected by aerial fire retardant intrusions are related to abundance and probability of persistence. One specifically discusses distribution so the species is protected from catastrophic events. Protection from catastrophic events is one of the objectives of this program. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for LCR ESU coho salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Freshwater critical habitat protects habitat essential for spawning, rearing, and migration. Adult, juvenile, and egg life stages of LCR ESU coho salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For LCR ESU coho salmon, we anticipate no more than one intrusion over the next decade. Coho salmon reach maturity more quickly than other salmonids, so in the next decade, approximately 3 generations will have the opportunity to reproduce. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of LCR ESU coho salmon because a single intrusion would only affect a small segment of the population in a single year over the next decade. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify LCR ESU coho salmon critical habitat.

9.11 Southern Oregon Northern California Coast ESU Coho Salmon

Southern Oregon/Northern California Coast ESU coho salmon are listed as threatened. The primary threats they face are warming ocean conditions, drought, and degraded freshwater habitat. It does not appear that any populations are currently considered viable (low risk of extinction) and as an ESU, they face a high risk of extinction in the next 100 years. While abundance trends are generally stable (no clear trend), it does appear that some populations are increasing and some decreasing.

Over the next 10 years, we anticipate 18 intrusions of fire retardants into rivers on national forests occupied by SONCC ESU coho salmon. We expect multiple intrusions in approximately 62% of those years. Those intrusions are expected to affect adult and juvenile fish. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the 18 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for SONCC ESU coho salmon focus on increasing abundance, productivity, spatial structure, and diversity. Because of this, the same risks facing SONCC ESU coho salmon survival also apply to their recovery.

Designated critical habitat for SONCC ESU coho salmon in freshwater locations addresses migration of adults and juveniles, as well as habitat free of contaminants (Table 15). Under worst-case conditions, critical habitat may be temporarily affected on 18 occasions for up to five hours each over any 10-year period. Adult and juvenile life stages of SONCC ESU coho salmon will be present during 99% of fires, therefore these temporary impairments will likely affect rearing and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 18 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For SONCC ESU coho salmon, we anticipate no more than 18 intrusions, each lasting up to five hours over the next decade. Coho salmon reach maturity more quickly than other salmonids, so in the next decade, approximately 3 generations will have the opportunity to reproduce. This spawning will take place across seven national forests as well as downstream of USFS lands. Eighteen intrusions over the next decade, even if in the same river system in a single year, are not likely to jeopardize the likelihood of either survival or recovery of SONCC ESU coho salmon because they spawn over such a large geographical area relatively frequently. The temporary loss of this critical habitat on 18 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify SONCC ESU coho salmon critical habitat.

9.12 Oregon Coast ESU Coho Salmon

Oregon coast ESU coho salmon are listed as threatened. The primary threats they face are warming ocean conditions and complex freshwater habitat for overwintering survival. In recent years, spawning abundance has exceeded 280,000 adults, but in years with poor spawning abundance, the primary factor appears to be poor ocean conditions.

Over the next 10 years, we anticipate four intrusions of fire retardants into rivers on national forests occupied by Oregon coast ESU coho salmon. We expect multiple intrusions in approximately 12% of those years. Those intrusions are expected to only affect juvenile fish. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average.

Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the four anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Oregon coast ESU coho salmon focus on improving demographic conditions such that there is sufficient abundance and growth coupled with reduced or eliminated threats. Because of this, the same risks facing Oregon coast ESU coho salmon survival also apply to their recovery.

Designated critical habitat for Oregon coast ESU coho salmon in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on four occasions for up to five hours each over a 10-year period. Only juvenile Oregon coast ESU coho salmon will be present during 99% of fires, therefore these temporary impairments will likely affect rearing habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The four anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Oregon coast ESU coho salmon, we anticipate no more than four intrusions, each lasting up to five hours over the next decade. Coho salmon reach maturity more quickly than other salmonids, so in the next decade, approximately 3 generations will have the opportunity to reproduce. This spawning will take place across three national forests as well as downstream of USFS lands. Four intrusions over the next decade, even if they all occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of Oregon coast ESU coho salmon. The temporary loss of this critical habitat on four occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Oregon coast ESU coho salmon critical habitat.

9.13 Snake River ESU Sockeye Salmon

Snake River ESU sockeye salmon are listed as endangered. In the recent past, there were more people studying this ESU than there were adults returning to spawn. The total number of wild

adults remains under 1,000, though there are approximately 20,000 hatchery-origin adults, though they are slowly increasing in abundance. All Snake River ESU sockeye salmon reproduce in the same location. The primary threats they face are warming ocean conditions, dams, and habitat degradation. This ESU is considered to be at extreme risk of extinction.

Over the next 10 years, we anticipate six intrusions of fire retardants into rivers on national forests occupied by Snake River ESU sockeye salmon. Those intrusions are expected to affect all life stages except fry. The response to those intrusions will depend on whether this ESU is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this ESU, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the six anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Snake River ESU sockeye salmon focus on increasing the number of individuals by improving the water quality and quantity in lakes and migratory corridors. Because of this, the same risks facing Snake River ESU sockeye salmon survival also apply to their recovery.

Designated critical habitat for Snake River ESU sockeye salmon in freshwater locations addresses migration of adults and juveniles, as well as habitat free of contaminants (Table 15). Under worst-case conditions, critical habitat may be temporarily affected on six occasions for up to five hours each over any 10-year period. Adult, juvenile, and egg life stages of Snake River ESU sockeye salmon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat

impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The six anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Snake River ESU sockeye salmon, we anticipate no more than six intrusions, each lasting five hours over the next decade. Because this ESU reproduces in a lake, we would expect their spawning habitat to be easily visible from the air. More likely, any intrusions affecting this species would occur in migratory or downstream rearing habitat. Six intrusions over the next decade, even if they all occurred in the same location in the same year, are not likely to jeopardize the likelihood of either survival or recovery of Snake River ESU sockeye salmon because the most sensitive life stages are least likely to be exposed and life stages most likely affected would be highly mobile when exposed (migrating or foraging). The temporary loss of this critical habitat on six occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Snake River ESU sockeye salmon critical habitat.

9.14 California Central Valley DPS Steelhead

California CV DPS steelhead are listed as threatened. Historically, they are believed to have numbered between 1 and 2 million adults spawning each year. Recent abundance estimates suggest fewer than 2,000 wild adults return each year along with another 4,000 hatchery-reared adults. Another 2 million juveniles will become the spawning adults of the population in 2-4 years. The primary threats they face are low abundance, habitat degradation, and competition with hatchery fish.

Over the next 10 years, we anticipate 13 intrusions of fire retardants into rivers on national forests occupied by California CV DPS steelhead. We expect multiple intrusions in approximately 75% of those years. Those intrusions are expected to affect adult and juvenile fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We

expect that the 13 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for California CV DPS steelhead focus on improving demographic conditions such that there is sufficient abundance and growth coupled with reduced or eliminated threats in multiple populations. Because of this, the same risks facing California central valley DPS steelhead survival also apply to their recovery.

Designated critical habitat for California CV DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on 13 occasions for up to five hours each over a 10-year period. Adult and juvenile California CV DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect rearing and migratory habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 13 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For California CV DPS steelhead, we anticipate no more than 13 intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Thirteen intrusions over the next decade, even if they all occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of California CV DPS steelhead because they use headwater tributaries along with lower order mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on 13 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify California CV DPS steelhead critical habitat.

9.15 Lower Columbia River DPS Steelhead

Lower Columbia River DPS steelhead are listed as threatened. There are approximately 13,000 wild adults and another 22,000 hatchery-reared adults. There are another 1.5 million juvenile steelhead. The primary threats they face are low abundance, dams, and habitat degradation.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by LCR DPS steelhead. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect all life stages of fish. The response to that intrusion will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The applicable recovery goals for LCR DPS steelhead that could be affected by aerial fire retardant intrusions are related to abundance and probability of persistence. One specifically discusses distribution so the species is protected from catastrophic events. Protection from catastrophic events is one of the objectives of this program. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for LCR DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult, juvenile, and egg life stages of LCR DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation

value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For LCR DPS steelhead, we anticipate no more than one intrusion, lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of LCR DPS steelhead because a single intrusion would only affect a small segment of the population in a single year over the next decade. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify LCR DPS steelhead critical habitat.

9.16 Middle Columbia River DPS Steelhead

MCR DPS steelhead are listed as threatened. There are approximately 5,000 adults and nearly a million juveniles in this DPS. The primary threats they face are low abundance, migration disruptions, and loss of spawning habitat. This DPS is estimated to have less than a 5% chance of survival in the next 100 years.

Over the next 10 years, we anticipate nine intrusions of fire retardants into rivers on national forests occupied by MCR DPS steelhead. We expect multiple intrusions in approximately 38% of those years. Those intrusions are expected to affect all life stages of fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the nine anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for MCR DPS steelhead focus on increasing the number of populations and the abundance within those populations. Because of this, the same risks facing MCR DPS steelhead survival also apply to their recovery.

Designated critical habitat for MCR DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on nine occasions for up to five hours each over a 10-year period. Adult, juvenile, and egg life stages of MCR DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The nine anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For MCR DPS steelhead, we anticipate no more than nine intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Nine intrusions over the next decade, even if they occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of MCR DPS steelhead because they use headwater tributaries along with lower order mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on nine occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify MCR DPS steelhead critical habitat.

9.17 Northern California DPS Steelhead

Northern California DPS steelhead are listed as threatened. There are lots of small rivers supporting spawning populations in this DPS, but many of them are at low abundances. There are only about 7,000 adults and 800,000 juveniles in this DPS. The primary threats they face are warming ocean conditions, habitat degradation, habitat loss, and migration impediments.

Over the next 10 years, we anticipate nine intrusions of fire retardants into rivers on national forests occupied by Northern California DPS steelhead. We expect multiple intrusions in approximately half of those years. Those intrusions are expected to only affect juvenile fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the

system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the nine anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Northern California DPS steelhead focus on increasing the number of populations and the abundance within those populations. Because of this, the same risks facing Northern California DPS steelhead survival also apply to their recovery.

Designated critical habitat for Northern California DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on nine occasions for up to five hours each over a 10-year period. Only juvenile Northern California DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect rearing habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The nine anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Northern California DPS steelhead, we anticipate no more than nine intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Nine intrusions over the next decade, even if they occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of Northern California DPS steelhead because they use headwater tributaries along with lower order

mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on nine occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Northern California DPS steelhead critical habitat.

9.18 Snake River DPS Steelhead

Snake River DPS steelhead are listed as threatened. There are over 10,000 wild and another 95,000 hatchery-origin adults in this DPS. There are nearly 5 million juveniles. The primary threats they face are warming ocean conditions, habitat degradation, habitat loss, and migration impediments.

Over the next 10 years, we anticipate 14 intrusions of fire retardants into rivers on national forests occupied by Snake River DPS steelhead. We expect multiple intrusions in approximately 62% of those years. Those intrusions are expected to affect adult, fry, and juvenile fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for f identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the 14 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Snake River DPS steelhead focus on all five major population groups having a mix of large, very large, intermediate, and basic population sizes with high levels of productivity. Because of this, the same risks facing Snake River DPS steelhead survival also apply to their recovery.

Designated critical habitat for Snake River DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on 14 occasions for up to five hours each over a 10-year period. Adult and juvenile Snake River DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect rearing and migratory habitat. This habitat is expected

to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 14 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Snake River DPS steelhead, we anticipate no more than 14 intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Fourteen intrusions over the next decade, even if they occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of Snake River DPS steelhead because they use headwater tributaries along with lower order mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on 14 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Snake River DPS steelhead critical habitat.

9.19 South Central California Coast DPS Steelhead

SCCC DPS steelhead are listed as threatened. Currently there are only about 700 adults and 80,000 juveniles supporting this DPS, but recent habitat improvements, such as the removal of San Clemente Dam, are expected to increase the capacity of spawning and rearing habitat. The primary threats they face are low abundance and blocked access to spawning habitats.

Over the next 10 years, we anticipate 14 intrusions of fire retardants into rivers on national forests occupied by SCCC DPS steelhead. We expect multiple intrusions in approximately 25% of those years. Those intrusions are expected to affect fry and juvenile fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate,

the number of intrusions, for estimating the risk posed to the species. We expect that the 14 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for SCCC DPS steelhead focus on increasing the number of populations and the abundance within those populations. Because of this, the same risks facing SCCC DPS steelhead survival also apply to their recovery.

Designated critical habitat for SCCC DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on 14 occasions for up to five hours each over a 10-year period. Only juvenile SCCC DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect rearing habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 14 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For SCCC DPS steelhead, we anticipate no more than 14 intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Fourteen intrusions over the next decade, even if they occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of SCCC DPS steelhead because they use headwater tributaries along with lower order mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on 14 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify SCCC DPS steelhead critical habitat.

9.20 Southern California DPS Steelhead

Southern California DPS steelhead are listed as endangered. Historically, this DPS is at the southern range of steelhead habitat and only supported approximately 30 to 46,000 adult steelhead. Today it is estimated the four main spawning rivers support fewer than 500 adults total. While this DPS uses upriver habitat on two fire-prone national forests, most of their riverine habitat traverses some of the most densely populated human habitat in the United States.

The primary threats they face are warming ocean conditions, habitat degradation, habitat loss, and migration impediments.

Over the next 10 years, we anticipate 17 intrusions of fire retardants into rivers on national forests occupied by Southern California DPS steelhead. We expect multiple intrusions in approximately 38% of those years. Those intrusions are expected to affect all life stages of fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the 17 anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Southern California DPS steelhead focus on increasing the number of populations and abundance within those populations in each of the five major population groups to achieve long-term viability. Because of this, the same risks facing Southern California DPS steelhead survival also apply to their recovery.

Designated critical habitat for Southern California DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on 17 occasions for up to five hours each over a 10-year period. Adult, juvenile, and egg life stages of Southern California DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable

effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The 17 anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Southern California DPS steelhead, we anticipate no more than 17 intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Seventeen intrusions over the next decade, even if they occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of Southern California DPS steelhead because only a portion of the population spawns each year and they use headwater tributaries along with lower order mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on 17 occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Southern California DPS steelhead critical habitat.

9.21 Upper Columbia River DPS Steelhead

Upper Columbia River DPS steelhead are listed as endangered. This DPS comprises approximately 6,500 adults and 900,000 juveniles. Spawning occurs in four primary locations. The primary threats they face are warming ocean conditions, habitat degradation, habitat loss, and migration impediments.

Over the next 10 years, we anticipate four intrusions of fire retardants into rivers on national forests occupied by UCR DPS steelhead. We expect multiple intrusions in approximately 12% of those years. Those intrusions are expected to affect all life stages of fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activities as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the four anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally.

Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for UCR DPS steelhead focus on increasing abundance, productivity, spatial structure, and diversity. Because of this, the same risks facing UCR DPS steelhead survival also apply to their recovery.

Designated critical habitat for UCR DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected on four occasions for up to five hours each over a 10-year period. Freshwater critical habitat protects habitat essential for spawning, rearing, and migration. Adult, juvenile, and egg life stages of UCR DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The four anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For UCR DPS steelhead, we anticipate no more than four intrusions, each lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. Four intrusions over the next decade, even if they occurred in the same system during the same year, are not likely to jeopardize the likelihood of either survival or recovery of UCR DPS steelhead because they use headwater tributaries along with lower order mainstem systems for reproduction and rearing, preventing any intrusion from affecting more than a small segment of the population. The temporary loss of this critical habitat on four occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify UCR DPS steelhead critical habitat.

9.22 Upper Willamette River DPS Steelhead

UWR DPS steelhead are listed as threatened. There are approximately 3,000 adults and 144,000 juveniles in this DPS. Despite seemingly low abundances, three populations were deemed to be

at low risk of extinction. The primary threats they face are warming ocean conditions, habitat degradation, habitat loss, and migration impediments.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by UWR DPS steelhead. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect fry and juvenile fish. The response to that intrusion will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for UWR DPS steelhead focus on improving demographic conditions such that there is sufficient abundance and growth coupled with reduced or eliminated threats in multiple populations. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for UWR DPS steelhead in freshwater locations addresses spawning, rearing, and migration (Table 5). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Only juvenile UWR DPS steelhead will be present during 99% of fires, therefore these temporary impairments will likely affect rearing habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For UWR DPS steelhead, we anticipate no more than one intrusion, lasting up to five hours over the next decade. Steelhead spawn in higher order, shallow tributaries, making them more at risk of individual intrusions (less dilution), but also more spread out than other species of salmonids because their spawning areas are isolated from other small tributaries. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of UWR DPS steelhead because a single intrusion would only affect a small segment of the population in a single year over the next decade. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify UWR DPS steelhead critical habitat.

9.23 Southern DPS Green Sturgeon

Southern DPS green sturgeon are listed as threatened. Only a single spawning population is thought to remain extant, but it supports about 3,000 adults with a total abundance of approximately 17,500 individuals. Sturgeon are long-lived and reproduce repeatedly throughout their lives. The primary threats they face are loss of spawning habitat, water diversions, and degradation of habitat.

Over the next 10 years, we anticipate nine intrusions of fire retardants into rivers on national forests occupied by Southern DPS green sturgeon. Those intrusions are expected to affect all life stages of fish. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the nine anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations, the use of large river habitat exclusively, and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Southern DPS green sturgeon focus on increasing the number of spawning populations as well as increasing the abundance of adults and sub-adults. Because of this, the same risks facing Southern DPS green sturgeon survival also apply to their recovery.

Designated critical habitat for Southern DPS green sturgeon in freshwater locations addresses spawning, rearing, and migration (Table 50). Under worst-case conditions, critical habitat may be temporarily affected on nine occasions for up to five hours each over a 10-year period. Adult, juvenile, and egg life stages of Southern DPS green sturgeon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The rearing habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The nine anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Southern DPS green sturgeon, we anticipate no more than nine intrusions, each lasting up to five hours over the next decade. Because intrusions affecting green sturgeon would be made to a mainstem river system, the retardant should dilute quickly and have a smaller area of toxicity than an intrusion in a smaller volume of water. Nine intrusions over the next decade are not likely to jeopardize the likelihood of either survival or recovery of Southern DPS green sturgeon because adults spawn intermittent iteroparous (repeat spawners) species that range widely along the Pacific Coast most of their lives. The temporary loss of this critical habitat on nine occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Southern DPS green sturgeon critical habitat.

9.24 Southern DPS Pacific Eulachon Smelt

Southern DPS Pacific eulachon are listed as threatened. They are quick to reach maturity and return to spawn, where they briefly move into freshwater, spawn, and die. The eggs then drift downriver, hatch, and the young fish immediately move to the ocean. The primary threats they face are warming ocean conditions, poor spawning success, and bycatch.

Over the next 10 years, we anticipate six intrusions of fire retardants into rivers on national forests occupied by Southern DPS Pacific eulachon. We expect multiple intrusions in approximately 38% of those years. Those intrusions are expected to affect adults and eggs. The response to those intrusions will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant

within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the six anticipated intrusions on average per decade are likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations, the use of lower reaches of large rivers, and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for Southern DPS Pacific eulachon focus on increasing abundance, genetic and spatial diversity, and reducing threats. Because of this, the same risks facing Southern DPS Pacific eulachon survival also apply to their recovery.

Designated critical habitat for Southern DPS Pacific eulachon in freshwater locations addresses spawning, rearing, and migration (Table 52). Under worst-case conditions, critical habitat may be temporarily affected on six occasions for up to five hours each over a 10-year period. Adult and egg life stages of Southern DPS Pacific eulachon will be present during 99% of fires, therefore these temporary impairments will likely affect spawning and migratory habitat. This habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The six anticipated intrusions are expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Southern DPS Pacific eulachon, we anticipate no more than six intrusions, each lasting up to five hours over the next decade. Pacific eulachon are typically present in rivers from February through June, which is when only 15% of fires occur. Assuming a proportional relationship between fire acreage and fire retardant use, it is likely that about 85% of fire retardant applications are made during a time of year when no Pacific eulachon are present. However, fire seasons are gradually increasing in duration, so it is likely that Pacific eulachon will be affected by fire retardant intrusions in the next decade. If they are affected by six intrusions, even if all were in the same location during the same year, that would not likely jeopardize the likelihood of either survival or recovery of Southern DPS Pacific eulachon. The temporary loss of this critical habitat on six occasions for five hours at a time over the course of a decade is not likely to destroy or adversely modify Southern DPS Pacific eulachon critical habitat.

9.25 South Atlantic DPS Atlantic Sturgeon

South Atlantic DPS Atlantic sturgeon are listed as endangered. The largest population in this DPS comprises approximately 1,000 adults, though at least three healthy populations persist in this DPS. The primary threats they face are ship strikes, bycatch, poor water quality, and dredging. Climate change poses a long-term threat to these populations as the rivers near a sturgeon's critical thermal maxima in the summer months at today's temperatures.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by South Atlantic DPS Atlantic sturgeon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect adult and juvenile fish. The response to that intrusion will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations, the exclusive use of large mainstem rivers, and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

While there are no recovery goals identified for South Atlantic DPS Atlantic sturgeon, because populations are less than 5% of their historic abundances and were listed due to the current threats they face, it is anticipated that any future recovery goals will focus on increasing abundance and minimizing threats to the species. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for South Atlantic DPS Atlantic sturgeon in freshwater locations addresses spawning, rearing, and migration (Section 5.3.28.4). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult, juvenile, and egg life stages of South Atlantic DPS Atlantic sturgeon will be present when fires could occur, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as

a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For South Atlantic DPS Atlantic sturgeon, we anticipate no more than one intrusion, lasting up to five hours over the next decade. Sturgeon occupy large, mainstem reaches of rivers when in freshwater. These are likely to help dilute the retardant and minimize the area of toxicity. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of South Atlantic DPS Atlantic sturgeon. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify South Atlantic DPS Atlantic sturgeon critical habitat.

9.26 Carolina DPS Atlantic Sturgeon

Carolina DPS Atlantic sturgeon are listed as endangered. Little is known about the abundance of any populations in the Carolina DPS, though they are all assumed to be smaller than 300 adults (NMFS 2012). The primary threats they face are ship strikes, bycatch, dams, poor water quality, and dredging.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by Carolina DPS Atlantic sturgeon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect adult and juvenile fish. The response to that intrusion will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad

distribution of individuals within populations, the exclusive use of large mainstem rivers, and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

While there are no recovery goals identified for Carolina DPS Atlantic sturgeon, because populations are less than 5% of their historic abundances and were listed due to the current threats they face, it is anticipated that any future recovery goals will focus on increasing abundance and minimizing threats to the species. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for Carolina DPS Atlantic sturgeon in freshwater locations addresses spawning, rearing, and migration (Section 5.3.27.4). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult, juvenile, and egg life stages of Carolina DPS Atlantic sturgeon will be present when fires could occur, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Carolina DPS Atlantic sturgeon, we anticipate no more than one intrusion, lasting up to five hours over the next decade. Sturgeon occupy large, mainstem reaches of rivers when in freshwater. These are likely to help dilute the retardant and minimize the area of toxicity. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of Carolina DPS Atlantic sturgeon. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify Carolina DPS Atlantic sturgeon critical habitat.

9.27 Chesapeake Bay DPS Atlantic Sturgeon

Chesapeake Bay DPS Atlantic sturgeon are listed as endangered. There are two primary spawning populations in this DPS, with the James River likely supporting more than 1,000 adults and the York River supporting approximately 450. The primary threats they face are ship strikes, bycatch, poor water quality, and dredging.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by Chesapeake Bay DPS Atlantic sturgeon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect adult and juvenile fish. The response to that intrusion will depend on whether this DPS is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity, as well as the geographic distribution of this DPS, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations, the exclusive use of large mainstem rivers, and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

While there are no recovery goals identified for Chesapeake Bay DPS Atlantic sturgeon, because populations are less than 5% of their historic abundances and were listed due to the current threats they face, it is anticipated that any future recovery goals will focus on increasing abundance and minimizing threats to the species. Because abundance for recovery is affected by the same risks as abundance for survival, those risks are addressed above.

Designated critical habitat for Chesapeake Bay DPS Atlantic sturgeon in freshwater locations addresses spawning, rearing, and migration (Section 5.3.26.4). Under worst-case conditions, critical habitat may be temporarily affected once for up to five hours over any 10-year period. Adult, juvenile, and egg life stages of Chesapeake Bay DPS Atlantic sturgeon will be present when fires could occur, therefore these temporary impairments will likely affect spawning, rearing, and migratory habitat. The habitat is expected to return to normal following the pulse of fire retardant moving downstream and have no long-term effect to the conservation value of critical habitat as a whole. A five-hour impairment of spawning habitat, particularly for egg development, could be enough to kill individual eggs. Even though spawning habitat would be expected to return to normal within five hours, an intrusion during spawning season on spawning grounds could have implications that exceed the short five-hour habitat impairment. Displacement from habitat for a few hours at a time is not expected to have any detectable effects on habitat occupation or individual growth. The short-term water quality degradation will have no associated longer-term impacts to spawning, rearing, or migratory habitat. The

anticipated intrusion is expected to temporarily impair the conservation value of designated critical habitat in the location of an intrusion and immediately downstream but have no long-term effect to the conservation value of critical habitat as a whole.

For Chesapeake Bay DPS Atlantic sturgeon, we anticipate no more than one intrusion, lasting up to five hours over the next decade. Sturgeon occupy large, mainstem reaches of rivers when in freshwater. These are likely to help dilute the retardant and minimize the area of toxicity. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of Chesapeake Bay DPS Atlantic sturgeon. The temporary loss of this critical habitat for five hours over the course of a decade is not likely to destroy or adversely modify Chesapeake Bay DPS Atlantic sturgeon critical habitat.

9.28 Shortnose Sturgeon

Shortnose sturgeon are listed as endangered. The primary threats they face are dams, poor water quality, dredging, water withdrawals, and bycatch.

Over the next 10 years, we anticipate one intrusion of fire retardants into rivers on national forests occupied by shortnose sturgeon. We do not expect multiple intrusions in this species' range. The intrusion is expected to affect adult and juvenile fish. The response to that intrusion will depend on whether this species is near the location of the intrusion, the formulation and toxicity of fire retardant causing the intrusion, the volume affecting the system, the volume of the river at the intrusion site, and the slope of the river. Each intrusion will rely on the spill calculator developed by the USGS for identifying movement of fire retardant within a river to understand the extent of effects of individual intrusions. The anticipated number of intrusions is a reflection of past fire activity as well as the geographic distribution of this species, where species covering larger areas are more likely to be present on multiple national forests, affecting the reported application rates this species faces on average. Intrusions, regardless of the chemical base of the fire retardant, cause a spike in aquatic toxicity to a level likely to cause lethal or sub-lethal effects following relatively short exposures. Because the intrusion location is unpredictable and the response to an intrusion could vary widely, we are relying on a surrogate, the number of intrusions, for estimating the risk posed to the species. We expect that the one anticipated intrusion per decade is likely to affect individuals either lethally or sub-lethally. Due to the broad distribution of individuals within populations, the exclusive use of large mainstem rivers, and the expected mosaic pattern of applications and resulting intrusions, it is unlikely however that the effects to those individuals rise to a point of having effects to an entire population or at the species level.

The recovery goals for shortnose sturgeon focus on improving habitat and abundance within the 19 identified populations. Because of this, the same risks facing shortnose sturgeon survival also apply to their recovery.

For shortnose sturgeon, we anticipate no more than one intrusion, lasting up to five hours over the next decade. Sturgeon occupy large, mainstem reaches of rivers when in freshwater. These are likely to help dilute the retardant and minimize the area of toxicity. One intrusion over the next decade is not likely to jeopardize the likelihood of either survival or recovery of shortnose sturgeon.

9.29 Southern Resident Killer Whales

We review the effects on SRKW using abundance, productivity, spatial structure, and distribution as parameters for viability. This DPS comprises three groups, J, K, and L pods. There are currently only 76 individuals in this DPS, distributed across the three pods. Productivity is likely to be impaired by the relatively high number of males to females (26 females of reproductive age). Spatial distribution has high inter-annual variability, and diversity is at risk because of the low abundance. The major threats facing this species are vessel noise, ship strikes, body condition, and genetic bottlenecks. The entire population of SRKWs requires approximately 300,000 adult Chinook salmon for forage. The Puget Sound fisheries are managed for approximately 300,000 adult Chinook to be able to return and spawn. SRKWs rely on Chinook salmon populations outside of Puget Sound, mathematically providing sufficient food resources to support this population, though obviously the denser the schools of Chinook salmon, the less energy SRKWs would need to exert to capture their prey.

SRKWs rely primarily on abundant non-listed Chinook salmon ESUs, as well as those natal to the Puget Sound area where SRKWs primarily reside. All weened whales prey on Chinook salmon, so both adults and juveniles could be affected by a reduction in prey resources. Of the threatened and endangered Chinook salmon ESUs that make up some of their diets are the LCR ESU, Upper Columbia River spring-run ESU, Snake River fall-run ESU, Snake River spring/summer-run ESU, and California Central Valley spring-run ESU (NOAA and WDFW 2018). While not documented as part of their diet, SRKWs overlap with UWR ESU and California Coastal ESU Chinook salmon and may rely on those species as a food resource. Over the next decade, we anticipate the salmon populations, including those from the Puget Sound area, to be subjected to 52 intrusions, or approximately five per year. As discussed previously, because of the habitat occupied by Chinook salmon, in the previous decade of monitoring, there have been no reports of lethal or sub-lethal effects caused by intrusions, though we believe both lethal and sub-lethal effects may have occurred given the modeled toxicity and areas affected. A lack of observations of mortalities suggests the majority of intrusions into large waterbodies dissipate rapidly, have a smaller area of toxicity, and more space for any fish in the area to seek refuge/avoid the intrusion, but also deeper water for carcasses to sink without being observed. The life stages to be affected will be primarily adults and juveniles, and importantly not newly emerging fry, which would probably be the most at risk of adverse effects and the most difficult to observe during monitoring. It is likely there are some delayed effects on exposed Chinook salmon as they outmigrate into ocean water, which would be extremely difficult to monitor. This may limit somewhat the available forage resources for SRKWs.

The recovery goals for SRKWs focus on increasing abundance and productivity while minimizing threats to the species. Because of this, the same risks facing SRKW survival also apply to their recovery.

For SRKWs, we anticipate the Chinook salmon food resources affected by fire retardant intrusions resulting from USFS fire retardant applications to be negatively affected, but most intrusions are likely to result in no adverse effects or delayed adverse effects as the smolts leave the river for the ocean. As above, the surrogate for take resulting from the loss of prey resources is an intrusion into each of the listed Chinook salmon ESU habitats. Cumulative intrusions affecting the seven Chinook salmon ESUs are expected to occur 52 times in a decade. That amounts to approximately five times per year over the next decade where fire retardant intrusions may affect prey resources. Any losses to adult Chinook salmon would occur after the individuals had returned to their natal rivers and were no longer available as a prey resource. Losses of juvenile Chinook salmon prior to outmigration may reduce the number of adults later available as prey if there are no density dependent increases in survival as a result of the fire retardant intrusions. The individuals affected however would be a small portion of their natal population, which are a small portion of the mixed schools of different Chinook salmon populations at sea. Because prey resources are considered limiting for SRKWs, the loss of any Chinook salmon would pose threats to individual SRKWs. However, because the effect of fire retardant intrusions would affect juveniles, take years to have an effect on the adult abundance, affect a small segment of the overall composition of marine Chinook salmon, and allow managers to modify other demands on the adult Chinook salmon resource (such as fisheries, which are regulated to ensure a sufficient number of Chinook salmon are able to return and reproduce [Section 6]), it is possible, but unlikely, some individual SRKWs could be sub-lethally affected by this action. Further, there are no anticipated effects from fire retardant intrusions to SRKW populations (pods) or to the SRKW species. Therefore, the effects to Chinook salmon prey resources caused by the USFS aerial application of fire retardants is not likely to jeopardize the likelihood of either survival or recovery of SRKWs.

Because the applicable PBF for SRKW critical habitat is also prey resources, the anticipated intrusions could also affect designated critical habitat. However, as above, there are many mitigating factors that make an intrusion to a small portion of a Chinook salmon population a risk to the conservation value of SRKW critical habitat. The effects of fire retardant intrusions through time is not likely to impair the conservation value of critical habitat as a whole. The effects to Chinook salmon prey resources caused by the USFS aerial application of fire retardants is not likely to destroy or adversely modify the designated critical habitat of SRKWs.

10 Conclusions

After reviewing and analyzing the current status of the listed species and critical habitat, the environmental baseline within the action area, the effects of the proposed action, the effects of other activities caused by the proposed action, and cumulative effects, it is NMFS' biological

opinion that the aerially applied long-term fire retardant program is not likely to jeopardize the continued existence of California Coastal Chinook salmon, Central Valley spring-run Chinook salmon, LCR Chinook salmon, Snake River fall-run Chinook salmon, Snake River spring/ summer-run Chinook salmon, UCR spring-run Chinook salmon, UWR Chinook salmon, Sacramento winter run Chinook salmon, Columbia River chum salmon, Lower Columbia River coho salmon, Southern Oregon Northern California Coast coho salmon, Oregon Coast coho salmon, Snake River Sockeye salmon, California Central Valley steelhead, LCR steelhead, MCR steelhead, Northern California steelhead, Snake River steelhead, South Central CA Coast steelhead, Southern California steelhead, UCR steelhead, UWR steelhead, green sturgeon, Pacific eulachon smelt, South Atlantic DPS Atlantic sturgeon, Carolina DPS Atlantic sturgeon, Chesapeake Bay DPS Atlantic sturgeon, shortnose sturgeon, or SRKW.

This action will not destroy or adversely modify the designated critical habitat for California Coastal Chinook salmon, Central Valley spring-run Chinook salmon, LCR Chinook salmon, Snake River fall-run Chinook salmon, Snake River spring/ summer-run Chinook salmon, UCR spring-run Chinook salmon, UWR Chinook salmon, Sacramento winter run Chinook salmon, Columbia River chum salmon, Lower Columbia River coho salmon, Southern Oregon Northern California Coast coho salmon, Oregon Coast coho salmon, Snake River Sockeye salmon, California Central Valley steelhead, LCR steelhead, MCR steelhead, Northern California steelhead, Snake River steelhead, South Central CA Coast steelhead, Southern California steelhead, UCR steelhead, UWR steelhead, green sturgeon, Pacific eulachon smelt, South Atlantic DPS Atlantic sturgeon, Carolina DPS Atlantic sturgeon, Chesapeake Bay DPS Atlantic sturgeon, or SRKW.

11 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 actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102). “Incidental take” is defined by regulation as takings that result from, but are not the purpose of, carrying out an otherwise lawful activity conducted by the federal agency or applicant (50 CFR 402.02). Section 7(b)(4) and 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 ITS.

11.1 Amount or Extent of Take

In this biological opinion, we were unable to anticipate the actual numbers of individuals of listed species that would be taken because of this programmatic action. First, intrusions are

monitored on a forest-by-forest basis, meaning listed species may be found on the national forest being monitored without occupying the waterbody that receives an intrusion. It is also likely, due to conditions created by the presence of wildfires, that if a species would normally be present, they may temporarily vacate the area to seek lower temperatures or cleaner water, unaffected by ash and smoke. Further, if a species is present at the time of an intrusion, it would likely be at a different density than observed during non-fire conditions. Beyond whether the species is present or not, the resulting toxicity depends on a number of factors that will affect the actual response to the intrusion. The main factors are the amount of retardant to reach water, the volume of water (width, depth, and flow rate) in the receiving location, turbulence of the water and slope of the area, pool frequency, and downstream tributaries. Because of this, it is not practical to quantify the anticipated take of individuals, and we instead rely on a surrogate and follow up monitoring to understand the effects of intrusions through time.

The surrogate we will monitor is the number of intrusions into waterways, including where the intrusion happens later in time via run-off. Intrusions are the relatively rare (0.21% frequency) events that produce stressors that are reasonably likely to adversely affect listed species and their designated critical habitat. Follow-up monitoring allows for an estimate of the volume of retardant that entered a system and the spill calculator can produce an estimate of the spike in chemical concentration that would affect listed species. Only intrusions with a spike that exceeds 10% of the LC_{50} concentration (the estimated concentration below which would have no effect) would count as "take" of listed species. Each intrusion is therefore causally linked to the take of each listed species analyzed in this programmatic biological opinion.

Specifically, each intrusion will rely on the spill calculator for identifying movement of fire retardant within a river to understand the extent of effects of and take caused by each intrusion (Rehmann et al. 2021). The program will use this as a monitoring tool to identify intrusions that create conditions likely to have adversely affected and taken listed species and then to track the effects of all intrusions through time.

Wildfires burn fuel and then require time for the fuel to rebuild before another fire. This results in peak seasons followed locally by mild seasons in a mosaic pattern across the landscape. The peak seasons are mirrored by the use of fire retardants to fight those wildfires. Assessing the likely impacts to listed species and critical habitat on an annual basis as an average anticipated effect made less sense than allowing for peak fire seasons followed by mild seasons over a longer time. Therefore, take of listed species is assessed over a decade to account for variable burning intensities and use of fire retardants.

The following table (Table 64) identifies the number of intrusions as the extent of anticipated incidental take over the next ten years onto national forests occupied by each of the species considered herein, as well as the life stages that may be present during the peak fire season, and the current status of the species under consideration. The SRKW will not be directly exposed to fire retardants; therefore, the surrogate used to monitor the take caused by removal of prey

resources are intrusions that affect the seven listed Chinook salmon ESUs considered in this biological opinion.

Table 64. A list of affected species, number of intrusions per 10-year period as a surrogate for take, and the life stages to be affected by each intrusion.

ESU/DPS	Anticipated intrusions (Extent of anticipated "take")	Life Stages Affected	Status
California Coastal Chinook	9	Juvenile	Threatened
Central Valley spring-run Chinook	19	Adult Spawning Eggs Juvenile	Threatened
LCR Chinook	1	Adult Spawning Eggs Juvenile	Threatened
Snake River fall-run Chinook	7	Adult Juvenile	Threatened
Snake River spring/ summer-run Chinook	10	Adult Spawning Eggs Juvenile	Threatened
UCR spring-run Chinook	5	Adult Spawning Eggs Juvenile	Endangered
Upper Willamette River Chinook	1	Adult Spawning Eggs Juvenile	Threatened
Sacramento winter run ESU Chinook salmon	8	Adult Spawning Eggs Fry Juvenile	Endangered
Columbia River ESU chum salmon	1	Adult Spawning Eggs Juvenile	Threatened
LCR ESU coho salmon	1	Adult Spawning Eggs Juvenile	Threatened
SONCC ESU coho salmon	18	Adult Juvenile	Threatened
Oregon Coast ESU coho salmon	4	Juvenile	Threatened
Snake River ESU Sockeye salmon	6	Adult Spawning Eggs Juvenile	Endangered
CA Central Valley steelhead	13	Adult Juvenile	Threatened
LCR steelhead	1	Adult	Threatened

		Spawning Eggs Fry Juvenile	
MCR steelhead	9	Adult Spawning Eggs Fry Juvenile	Threatened
Northern California steelhead	9	Juvenile	Threatened
Snake River steelhead	14	Adult Fry Juvenile	Threatened
South Central CA Coast steelhead	14	Fry Juvenile	Threatened
Southern California steelhead	17	Adult Spawning Eggs Fry Juvenile	Endangered
UCR steelhead	4	Adult Spawning Eggs Fry Juvenile	Threatened
Upper Willamette River steelhead	1	Fry Juvenile	Threatened
Green sturgeon	9	Adult Eggs Juvenile	Threatened
Pacific eulachon smelt	6	Adult Eggs	Threatened
South Atlantic DPS Atlantic sturgeon	1	Adult Juvenile	Endangered
Carolina DPS Atlantic sturgeon	1	Adult Juvenile	Endangered
Chesapeake Bay DPS Atlantic sturgeon	1	Adult Juvenile	Endangered
Shortnose sturgeon	1	Adult Juvenile	Endangered
Southern resident killer whale	52 Chinook salmon habitat intrusions	Adult Juvenile	Endangered

11.2 Reasonable and Prudent Measures

"Reasonable and prudent measures" are measures that are necessary or appropriate to minimize the impact of the amount or extent of incidental take. (50 CFR 402.02). The aerial fire retardant program, having been developed and modified since 2007, has monitoring and coordination built in. Therefore, the RPMs here identify the appropriate procedures and contacts at each step of the cooperative process to minimize incidental take and to avoid being duplicative.

NMFS believes that the following RPMs are necessary and appropriate to minimize take of listed species resulting from implementation of this program.

The USFS shall:

1. Monitor and report aerially applied long-term fire retardant intrusions on each forest identified in this Opinion.
2. Contact NMFS in the event the amount or extent of take identified in Table 64 is exceeded in order to request reinitiation or site-specific consultation to address the particular species affected within the program.

11.3 Terms and Conditions

In order to be exempt from the prohibitions of section 9 of the ESA, the federal action agency must comply (or must ensure that any applicant complies) with the following terms and conditions.

1. To implement RPM 1 (monitoring and reporting):
    a. The Washington (DC) Office of the USFS must compile records of the annual number of fire retardant applications and intrusions on each forest identified in this Opinion.
    b. The USFS Washington Office must record and report annually to NMFS HQ (Office of Protected Resources, NMFS HQ, 1315 East West Highway, Silver Spring, Maryland, 20910; Division Chief and lead biologist [Cathy.Tortorici@noaa.gov and Jason.Kahn@noaa.gov currently]) the number of long-term fire retardant applications and whether the application entered the buffer or intruded into water. These reports will be provided by May 1 each year following completion of consultation.
    c. To track with the ITS and Table 64, cumulative records from annual reports will be maintained on a rolling 10-year basis and 10-year reports will be provided every year along with the annual reports starting in 2032.
    d. The USFS Washington Office must contact NMFS HQ in the event of an intrusion. Our national offices will contact the appropriate regional offices to coordinate on the next steps. Our four representatives (from NMFS HQ, the appropriate NMFS field office, the USFS Washington Office, and the local USFS office) will identify the appropriate inputs for the USGS spill calculator and disseminate the estimated effects to each species of each intrusion to update baseline conditions following each fire season.
2. To implement RPM 2 (reinitiation/consultation):
    a. In the event site-specific consultations within the programmatic framework are required for any species (addressed in this opinion or listed in the future), the USFS must coordinate with NMFS HQ to identify how to proceed to incorporate any new information into the framework of this programmatic consultation.

12 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. Specifically, conservation recommendations are suggestions regarding discretionary measures to minimize or avoid adverse effects of a proposed action on listed species or critical habitat or regarding the development of information (50 CFR 402.02).

The following are discretionary measures NMFS believes are consistent with this obligation and therefore may be considered by the USFS in relation to their section 7(a)(1) responsibilities:

1. In accordance with the fire retardant program objectives described as the action (Section 3), the USFS should phase out more toxic fire retardant formulations in favor of less toxic formulations.
2. Because endangered species generally need greater protections than threatened species, the USFS should consider wider buffer zones around endangered species habitat.
3. 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, USFS should notify NMFS of any conservation recommendations they implement.

13 Reinitiation Criteria

This concludes formal consultation for the USFS aerially applied long-term fire retardant program. Consistent with 50 CFR §402.16(a), reinitiation of formal consultation is required and shall be requested where discretionary federal agency involvement or control over the action has been retained or is authorized by law. Under the framework of this mixed programmatic action, a targeted reinitiation may be required when:

(1) The amount or extent of incidental taking specified in the ITS is exceeded;

(2) New information reveals effects of the agency action that may affect 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 the listed species or critical habitat that was not considered in this opinion; or

(4) A new species is listed or critical habitat designated under the ESA that may be affected by the action.

14 Magnuson Stevens Fishery Conservation and Management Act

The Magnuson Stevens Fishery Conservation Management Act (MSA) requires federal agencies to consult with the Secretary of Commerce, through NMFS, with respect to “any action

authorized, funded, or undertaken, or proposed to be authorized, funded, or undertaken, by such agency that may adversely affect any essential fish habitat (EFH) identified under this Act." 16 U.S.C. § 1855(b)(2). When a federal action agency determines that an action may adversely affect EFH, the federal action agency must initiate consultation with NMFS (16 U.S.C. §1855(b)(2)). In order to carry out this EFH consultation, NMFS regulations at 50 CFR 600.920(e)(3) call for the federal action agency to submit to NMFS an EFH assessment containing "a description of the action; an analysis of the potential adverse effects of the action on EFH and the managed species; the federal agency's conclusions regarding the effects of the action on EFH; and proposed mitigation, if applicable." NMFS may request the federal action agency include additional information in the EFH assessment such as results of on-site inspections, views of recognized experts, a review of pertinent literature, an analysis of alternatives and any other relevant information (50 CFR 600.920(e)(4)). Depending on the degree and type of habitat impact, compensatory mitigation may be necessary to offset permanent and temporary effects of the project. Should the project result in substantial adverse impacts to EFH, an expanded EFH consultation may be necessary (50 CFR 600.920(i)).

Promulgating regulations and implementing this proposed action may result in future, site-specific project applications that, if authorized by USFS, could have impacts on EFH and thereby trigger the requirements of the MSA. The analysis provided in the USFS Biological Assessment and this biological opinion will be used to guide the development of any required EFH assessments for future EFH consultations on site-specific proposals. For any future, site-specific proposal requiring an authorization from USFS, USFS will make a determination on whether the proposal may adversely affect any EFH in the project area. If a proposal may adversely affect EFH, USFS will initiate an EFH consultation by providing an EFH assessment to the appropriate NMFS regional office.

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