UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Silver Spring, MD 20910

JUL 25 2008

Abigail R. Kimball
Chief,
U.S.D.A. Forest Service
1400 Independence Avenue SW, 4NW
Washington, D.C. 20250-0003

Dear Ms. Kimball:

Enclosed is NOAA's National Marine Fisheries Service (NMFS) reinitiated biological opinion, issued under the authority of section 7(a)(2) of the Endangered Species Act (ESA), on the effects of the U.S. Forest Service's National Fire Retardant Programmatic Consultation, which proposed the continued aerial application of eight long-term fire retardants on National Forest system lands. The reinitiated biological opinion has not changed from its original format and still assesses the effects of the proposed activities on all NMFS species that spend any portion of their lives in fresh water. The project was reinitiated because Oregon Coast coho salmon were listed under the ESA on February 11, 2008, after the biological opinion was completed on October 9, 2007.

The reinitiated biological opinion addresses the effects of continuing the use of eight long term fire retardants to all freshwater NMFS trust resources. Similar to the original biological opinion, NMFS concluded that the proposed action is likely to jeopardize the continued existence of 27 endangered and threatened salmon and trout, threatened green sturgeon, and endangered shortnose sturgeon. NMFS also concluded that the proposed action is likely to destroy or adversely modify designated critical habitat for 23 threatened and endangered salmonids.

There is no incidental take identified or exempted in this reinitiated biological opinion.

If you have questions regarding the biological opinion, please contact me or Jason Kahn at (301) 713-1401 x146.

Sincerely,

James H. Lecky
Director, Office of Protected Resources

National Marine Fisheries Service
Endangered Species Act Section 7 Consultation

Biological Opinion

Agencies:	United States Department of Agriculture, Forest Service
Activities Considered:	Reinitiation to include consideration of the Oregon coast coho during the aerial application of eight long-term fire retardants on all Forest Service lands
Consultation Conducted by:	Endangered Species Division of the Office of Protected Resources, National Marine Fisheries Service
Approved by:	______________________
Date:	JUL 25 2008

Section 7(a)(2) of the Endangered Species Act (ESA), as amended requires each Federal agency to ensure that any action they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of critical habitat of such species (16 U.S.C. 1531 *et seq*.). When the action of a Federal agency "may affect" a threatened or endangered species or critical habitat that has been designated for them, that agency is required to consult with either the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS) (together, "the Services"), depending upon the species that may be affected by the action.

This document represents NMFS' biological opinion (Opinion) on the U.S. Forest Service's (USFS) proposal to aerially apply eight long-term fire retardants to all USFS lands (Appendix A). The purpose of this consultation is to evaluate the effectiveness of the USFS' 2000 *Guidelines for Aerial Delivery of Retardant or Foam near Waterways* (2000 Guidelines) for preventing eight long-term fire retardants from entering U.S. waters, and to analyze any risks associated with accidental input. This is both a programmatic and a national consultation that does not assess the consequences of the USFS proposed action for specific sites or listed resources that occur at those sites. Rather, this Opinion analyses the general environmental consequences that are likely to result from the USFS' proposed action to continue to aerially apply eight long-term fire retardants according to the guidelines. Other actions taken in response to a fire including the application of foams or other fire fighting chemicals were not proposed as part of the Federal action. Subsequent consultations that "tier" off of this programmatic consultation, specifically emergency consultations, when warranted, would analyze the site specific effects of fire retardants, as well as foams and other fire fighting activities authorized, funded, or carried out by the USFS.

This Opinion has been prepared in accordance with section 7(a)(2) of the ESA of 1973, as amended (16 U.S.C. 1531 et seq.) and implementing regulations at 50 CFR 402. However, consistent with a decision rendered by the Ninth Circuit Court of Appeals on August 6, 2004, we did not apply the regulatory definition of "destruction or adverse modification of critical habitat" at 50 CFR 402.02. Instead, we relied on the statutory provisions of the ESA to complete our analysis of the effects of the action on designated critical habitat. Essential fish habitat (EFH) consultations, in accordance with Section 305(b)(2) of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (16 U.S.C. 1801, *et seq.*) and implementing regulations at 50 CFR. 600, are conducted at a regional level. The MSA section at the end of this document explains the process of the EFH consultation.

This Opinion is based on our review of the Aquatics Report, previous environmental assessments (EAs), and supporting documentation; the draft U.S. recovery plan for Upper Columbia River (UCR) spring Chinook salmon and steelhead trout and smalltooth sawfish; the U.S. recovery plan for Pacific salmonids, Puget Sound Chinook salmon, Hood Canal chum salmon, shortnose sturgeon, Kemp's ridley turtle, loggerhead turtle, Pacific populations of the loggerhead turtle, Atlantic populations of green turtles, Pacific populations of the green turtle, hawksbill turtle in the Atlantic, Pacific populations of the hawksbill turtle, leatherback turtle in the Atlantic, Pacific populations of the leatherback turtle, Pacific populations of the olive ridley turtle; white papers; primary literature; past and current research, both published and unpublished; the documents that were used to list green sturgeon and smalltooth sawfish as threatened and endangered species (respectively); and monitoring reports from prior fires and misapplications of fire retardants.

Consultation History

On November 16, 2006, in a conference call between the USFS, USFWS, and NMFS, the USFS informed the two consulting agencies that due to a court decision in 2005, consultation on this issue needed to be complete by August 8, 2007. The USFS informed the Services that a draft EA would be provided by December 1, 2006. At this time the USFS also provided a spreadsheet (Misapplication List) with information on fish kills caused by unintentionally introducing retardants to rivers between 2001 and 2005 (Appendix B).

On December 8, 2006, the USFS provided a draft Aquatics Report to the Services with a promise to provide the EA on December 28, 2006.

On January 21, 2007, the USFS sent an email asking for comments on the Aquatics Report. NMFS replied that it had questions on the report but was waiting for the EA to see if many of the questions raised in the Aquatics Report were addressed in the EA.

On January 22, 2007, the USFS provided draft versions of the first and second chapters of the EA to NMFS.

On January 25, 2007, NMFS provided comments on the Aquatics Report and the first two chapters of the EA and held a conference call later that day to discuss the comments and the section 7 consultation.

On February 6, 2007, the Services and the USFS held another conference call to discuss several outstanding issues including the scope of the proposed action. The USFS stated that it wanted to consult only on its use of the 2000 Guidelines, whereas NMFS noted that the use of that document was part of the larger action that involved the use of fire retardants on National Forest System (NFS) lands, and therefore was part of the agency action subject to consultation.

On March 13, 2007, NMFS contacted the USFS to see if it had updated the proposed action in the EA and whether a new draft was being developed. Later that day, the USFS notified the Services that the final EA had been submitted to the editor so the USFS was waiting to get it back.

On March, 20, 2007, the USFS provided the final EA to the Services and requested any additional comments be provided promptly so it could make any changes that would be necessary.

On March 23, 2007, the USFS provided the final Aquatics Report to the Services.

On April 7, 2007, NMFS provided comments to the USFS, addressing the final EA and the final Aquatics Report. There were two primary comments; one addressed the fact that the use of fire retardant needed to be the proposed action in the EA and the second indicated that the effects of using retardant needed to be addressed in the effects section of the EA.

On July 2, 2007, NMFS received a formal request to initiate consultation from the USFS along with a final EA. This document did not analyze any of the chemicals proposed for use, but did note that if retardant entered water, fish kills would be possible.

On July 13, 2007, a conference call was held between the Services and the USFS. The USFWS volunteered to send a USGS map of nationwide alkalinities which could be overlaid with USFS lands since many retardants are more toxic in soft water. The Services' main concern was that the retardants hadn't been analyzed and the Services didn't know if some retardants may pose more risk than others in various regions of the country. The Services also questioned the decision tree and how the decision to use certain chemicals for certain fires was reached. During this conversation, NMFS told the USFS that it had drafted a letter stating that the USFS had not provided sufficient information to initiate consultation, but USFS requested 30 days before sending the letter so it could request an extension on the project from the court. NMFS stated that formal consultation could not be initiated because three of the six criteria for initiation had not yet been met (50 CFR 402.14). In the following two months, the USFS worked to incorporate the available information on fire retardants.

On July 24, 2007, NMFS requested an update on the USFS' progress.

On July 30, 2007, NMFS received an updated Aquatics Report that made note of the fact that if retardants enter higher pH streams, the chance of a fish kill is greater. But the introduction of retardants was not addressed any further as the USFS indicated that it would not be their intention to introduce any retardants to any streams. The USFS concluded that if retardant did enter streams, fish would die and therefore it made a "may affect, likely to adversely affect" determination.

On August 7, 2007, NMFS provided the USFS with six journal articles on the effects of fire retardants to fish that would help them complete their analysis. At this time, NMFS also requested any information the USFS might have about the fire return frequency to their various National Forest lands.

On August 29, 2007, the USFS sent a combined Aquatics Report and Biological Assessment (Aquatics Report) to the Services. The report provided a "programmatic analysis of effects to aquatic species, habitat, and upland vegetation." Despite concerns that the effects of the program warranted a more comprehensive evaluation, the Services agreed to initiate consultation without responses to all of the requested information in an effort to meet the USFS deadline of October 15, 2007.

On September 20, 2007, NMFS notified the USFS that the draft Opinion found the action, as proposed, was likely to jeopardize the continued existence of several anadromous fish species and would destroy or adversely modify their designated critical habitat. That same evening, NMFS provided a suggested reasonable and prudent alternative (RPA) to the USFS.

On September 25, the Services met with the USFS to discuss NMFS' effects determination and RPA. The USFS provided additional information to the Services, including some information on its decision making process and post-fire evaluation that is apparently standard within the USFS, but not relayed to the Services earlier in the consultation.

On October 9, 2007, the final Opinion was signed and delivered to the USFS concluding the actions of the USFS were likely to jeopardize the continued existence of 26 species and the adverse modification of critical habitat to 22 species.

On February 11, 2008, Oregon coast coho salmon were listed as threatened (73 FR 7816) under the ESA.

On June 9, 2008, NMFS received a request to reinitiate consultation from the USFS that consisted of the final aquatics report and EA that had been completed on September 14, 2007. The USFS requested the NMFS evaluate the effects of its actions on the Oregon coast coho salmon. On June 9, 2008, NMFS initiated consultation with the USFS.

BIOLOGICAL OPINION

Description of the Proposed Action

The USFS has requested programmatic consultation on its continued aerial application of eight long-term fire retardants on NFS lands. The USFS approves long-term fire retardants for use under its fire management program after the fire retardant products and their ingredients have been evaluated by the Wildland Fire Chemical Systems (WFCS) provided they meet USFS requirements. Once approved, the WFCS maintains the long-term fire retardant Qualified Products List (QPL), which is one of three QPLs. Several fire fighting products are approved for use and listed on the QPL, this Opinion analyzes the effects of eight aerially applied long-term fire retardants. Other fire fighting chemicals, such as foams, and activities authorized, funded, or carried out in response to wildland fires were not proposed as part of the Federal action and are not analyzed herein. The eight aerially applied long-term fire retardants analyzed in this Opinion and their specifications for mixing and use are listed in Appendix A. Additionally, the USFS informed NMFS that retardants with sulfate bases will not be used after 2010, leaving only three of these eight retardants on the QPL at that point.

The decision where and when to use a particular fire retardant is left to the discretion of the Incident Commander, 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 (see the subsequent section in this Opinion on the *Legal and Policy Framework for Fire Retardant Use by the USFS).* The decision to approve particular retardants as a Qualified Product, however, is made at the Washington Office of the USFS. The *Guidelines for Aerial Application of Fire Retardant and Foams in Waterways* established in April 2000 (outlined below) were also established in cooperation with the Bureau of Land Management, National Park Service, and the USFWS, and apply to all USFS field offices. The 2000 Guidelines were written to minimize the amount of fire retardant entering visible bodies of water.

Guidelines for Aerial Delivery of Retardant or Foam near Waterways

Definition:
WATERWAY – Any body of water including lakes, rivers, streams and ponds whether or not they contain aquatic life.

Guidelines:
Avoid aerial application of retardant or foam within 300 feet of waterways.
These guidelines do not require the helicopter or airtanker pilot-in-command to fly in such a way as to endanger his or her aircraft, other aircraft, or structures or compromise ground personnel safety.

Guidance for pilots: To meet the 300-foot buffer zone guideline, implement the following:

Medium/Heavy Airtankers: When approaching a waterway visible to the pilot, the pilot shall terminate the application of retardant approximately 300 feet before reaching the waterway. When flying over a waterway, pilots shall wait one second after crossing the far bank or shore of a waterway before applying retardant. Pilots shall make adjustments for airspeed and ambient conditions such as wind to avoid the application of retardant within the 300-foot buffer zone.

Single Engine Airtankers: When approaching a waterway visible to the pilot, the pilot shall terminate application of retardant or foam approximately 300 feet before reaching the waterway. When flying over a waterway, the pilot shall not begin application of foam or retardant until 300 feet after crossing the far bank or shore. The pilot shall make adjustments for airspeed and ambient conditions such as wind to avoid the application of retardant within the 300-foot buffer zone.

Helicopters: When approaching a waterway visible to the pilot, the pilot shall terminate the application of retardant or foams 300 feet before reaching the waterway. When flying over a waterway, pilots shall wait five seconds after crossing the far bank or shore before applying the retardant or foam. Pilots shall make adjustments for airspeed and ambient conditions such as wind to avoid the application of retardant or foam within the 300-foot buffer zone.

Exceptions:

1. When alternative line construction tactics are not available due to terrain constraints, congested area, life and property concerns or lack of ground personnel, it is acceptable to anchor the foam or retardant application to the waterway. When anchoring a retardant or foam line to a waterway, use the most accurate method of delivery in order to minimize placement of retardant or foam in the waterway (e.g., a helicopter rather than a heavy airtanker).

2. Deviations from these guidelines are acceptable when life or property is threatened and the use of retardant or foam can be reasonably expected to alleviate the threat.

3. When potential damage to natural resources outweighs possible loss of aquatic life, the unit administrator may approve a deviation from these guidelines.

Threatened and Endangered Species:
The following provisions are guidance for complying with the emergency section 7 consultation procedures of the ESA with respect to aquatic species. These provisions do not alter or diminish an action agency's responsibilities under the ESA.

Where aquatic threatened and endangered species or their habitats are potentially affected by aerial application of retardant or foam, the following additional procedures apply:

1. As soon as practicable after the aerial application of retardant or foam near waterways, determine whether the aerial application has caused any adverse effects to a threatened and endangered species or their habitat. This can be accomplished by the following:

    a. Aerial application of retardant or foam outside 300 ft of a waterway is presumed to avoid adverse effects to aquatic species and no further consultation for aquatic species is necessary.

    b. Aerial application of retardant or foam within 300 ft of a waterway requires that the unit administrator determine whether there have been any adverse effects to threatened and endangered species within the waterway.

These procedures shall be documented in the initial or subsequent fire reports.

2. If there were no adverse effects to aquatic threatened and endangered species or their habitats, there is no additional requirement to consult on aquatic species with USFWS or NMFS.

3. If the action agency determines that there were adverse effects on threatened and endangered species or their habitats then the action agency must consult with USFWS and NMFS, as required by 50 CFR 402.05 (Emergencies). Procedures for emergency consultation are described in the Interagency Consultation Handbook, Chapter 8 (March, 1998). In the case of a long duration incident, emergency consultation should be initiated as soon as practical during the event. Otherwise, post-event consultation is appropriate. The initiation of the consultation is the responsibility of the unit administrator.

According to the 2000 Guidelines, the USFS and each cooperating agency is responsible for insuring that the appropriate guides and training manuals reflect these guidelines.

Retardants and Methods Proposed for Aerial Delivery of Retardants on NFS Lands

The USFS is proposing to authorize the continued use of eight long-term fire retardants. The QPL is provided in the Aquatics Report for this consultation and is also available on the USFS webpage. Each chemical is listed at a specific mix ratio and for use through qualified applications. Additional information on these chemicals can be found at http://www.fs.fed.us/rm/fire/wfcs/index.htm. The trade names of the eight retardants are: Phos-Chek D75-R, Phos-Chek D75-F, Phos-Chek 259-R, Phos-Chek 259-F, Phos-Chek G75-F, Phos-Chek G75-W, Phos-Chek LV-R, and Phos-Chek LC-95A-R. In general all eight fire retardants approved for use are ammonium phosphate compounds mixed with gum thickeners and bactericides. The precise chemical make-up is proprietary and was not provided for review in this consultation.

The USFS uses three primary kinds of firefighting aircraft to dispense the eight long-term fire retardants: multi-engine airtankers, single engine airtankers, and helicopters. Multi-engine airtankers are comprised of ex-military and retired commercial transport aircraft. They carry 800 to 3,600 gallons of retardant. The speed, range, and retardant delivery capacity of the large (2,000 to 3,000 gallon) airtankers make them very effective in both initial attack and support to large fires. These airtankers typically make retardant drops from a height of 150 to 200 feet above vegetation and terrain. They move at airspeeds of 125 to 150 knots. Large fixed-wing airtankers have complex, computer controlled retardant dispersal systems capable of both precise incremental drops and long-trailing drops one-fourth of a mile or more in length. Retardant flow rates are controlled to vary the retardant coverage level. Retardant and foam is dispersed as needed after consideration of a fire's intensity/behavior and the vegetative fuel type(s) involved. Large airtankers can load or reload retardant at established or temporary bases, which are located strategically across the country. Normally, large airtankers can be loaded within a 10-minute period.

Single engine airtankers (SEATS) are small, fixed-wing aircraft that carry from 400 to 800 gallons of foam or retardant. SEATS can operate from remote airstrips and open fields or closed roads, reloading at portable retardant bases. SEATS are predominately modified agricultural aircraft although some have been designed specifically for wildland firefighting. SEATS are most effective in initial attack of small wildfires within 50 miles of a reload base where turn-around times are short and repetitive drops can be made.

Small, medium, and large helicopters carry from 100 to 3,000 gallons of water, foam, or retardant. This can be carried either in buckets slung beneath the aircraft or in mounted (fixed) tanks. Large heli-tankers can be very cost effective, making rapid, multiple drops of 2,000 gallons or more on escaping wildfires by refilling at nearby water sources or at portable retardant bases. They also provide a unique capability to those urban/wildland interface situations near water sources where they can bring to bear a combination of rapid revisit times and precision drops. Small and medium helicopters are most effective in the direct support of firefighters on the ground where they are directed to specific targets.

Approach to the Assessment

NMFS approaches its program specific section 7 analyses through a series of steps. The first step identifies those aspects of proposed actions that are likely to have direct and indirect effects on the physical, chemical, and biotic environment of an action area. As part of this step, we identify the spatial extent of these direct and indirect effects, including changes in the spatial extent over time. The results of this step represent the action area for the consultation. The second step of our analyses identifies the listed species and designated critical habitat that are likely to co-occur with these effects in space and time and the nature of that co-occurrence (these represent our exposure analyses). In this step of our analyses, we try to identify the primary constituent elements (PCEs), number, age, life stage, and gender of the listed resources that are likely to be exposed to an Action's effects and the populations or subpopulations those individuals represent. Once we identify the listed resources that are likely to be exposed to an action's effects and the nature of that exposure, we examine the whether and how those listed resources are likely to respond given their exposure (these represent our response analyses).

The final steps of our analyses—establishing the risks those responses pose to listed resources—are different for listed species and designated critical habitat (these represent our risk analyses). Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species as those "species" were listed, which may encompass the biological species, subspecies, or distinct population segments of vertebrate species. Because the continued existence of listed species depends on the fate of the populations that comprise them, the viability (probability of extinction or probability of persistence) of listed species depends on the viability of the populations that comprise the species. Similarly, the continued existence of populations are determined by the fate of the individuals that comprise them; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). Our destruction or adverse modification determinations must be based on an action's effects on the conservation values of the essential features of critical habitat.

A programmatic review, however, typically analyses the general environmental consequences of a broad scope of actions or policy alternatives under consideration by an agency program. Similarly, interagency (and intra-agency) consultations on programmatic actions (that is, programmatic consultations) focus on the general patterns associated with an agency's program and the broad scope of actions proposed under the Federal agency's preferred alternative. Subsequent consultations that "tier" off of these programmatic consultations, when warranted, would analyze the project and site specific effects typical of most consultations. Any subsequent section 7 consultations conducted by NMFS personnel would be designed to determine whether and to what degree the specific action under review fits within the general pattern identified in the "parent" or national programmatic consultation, and would determine whether the specific action, is or is not likely to jeopardize the continued existence of endangered and threatened species or result in the destruction or adverse modification of designated critical habitat.

The conceptual model NMFS uses for programmatic consultations focuses on four main elements of an action agency's program: (1) the decision-making process an action agency proposes to use for specific actions the program will authorize, fund, or carry out; (2) the classes of actions or activities the program would authorize, fund or carry out; (3) the types of intended and unintended consequences that are likely to result from authorized activities; and (4) the mechanisms that improve the program's implementation over time. We begin our programmatic consultations by recognizing that an agency's program normally represents the agency's decision to authorize, fund, or carry out a suite or class of activities that may require specific actions undergo subsequent review and decision-making (or they may not require subsequent review).

An agency's decision-making process will normally identify certain standards that an action must satisfy before an agency would authorize, fund or carry them out. Generally decision-making involves hard or formal procedures (such as public noticing requirements), soft or flexible information standards (the information an applicant might submit or the information agency personnel would gather and review to evaluate a submittal), and outlines how the agency would decide whether or not to authorize, fund or carry out specific actions. Typically an agency's decision-making process is shaped to respond to:

a. the statutory and regulatory standards an action must satisfy before the agency would authorize, fund, or carry them out;

b. any data and other information the agency must gather and evaluate to satisfy their statutory and regulatory requirements, as well as requirements of the Administrative Procedure Act, National Environmental Policy Act, Information Quality Act, and related administrative statutes (e.g., the Paperwork Reduction Act, Regulatory Flexibility Act, etc.);

c. the agency's obligation to review and analyze the relevant information within the context of applicable standards to ensure that specific actions satisfy all applicable statutory and regulatory requirements;

d. the results of the agency's efforts to monitor specific actions the agency has authorized, funded, or carried out, and the consequences of those decisions;

e. and any other feedback mechanisms an agency has created to ensure that a program satisfies its statutory mandates, regulatory requirements, and applicable goals and objectives.

Specifically, in consultation we would ask whether and to what degree the decision-making process can ensure that actions taken under the program are not likely to, individually or cumulatively, jeopardize the continued existence of endangered or threatened species or are not likely to result in the destruction or adverse modification of designated critical habitat. An agency can satisfy this requirement when the program contains features that: (1) prevent listed resources from being exposed to actions or their direct or indirect effects; (2) mitigate how listed resources respond to that exposure, when listed resources are exposed to the program's actions and their effects; or (3) mitigate the risks any responses pose to listed individuals, populations, species, or designated critical habitat, when listed resources are likely to be exposed and respond to that exposure. Our programmatic consultation would focus on the evidence available to determine whether and to what degree the agency's decision-making process is likely to prevent exposure, or mitigate responses or the risks any responses would pose to listed species or their designated critical habitat.

In examining an agency's decision process, we would examine the classes of actions or activities the program would authorize, fund or carry out. During this step of our assessment, we identify the geographic distribution, timing, and constraints of the different classes of activities that would be authorized, funded or carried out by a program. The area directly and indirectly affected by the class of actions that would be authorized, funded or carried-out by a program represents the *action area* of a programmatic consultation.

The next step of our analyses identifies the listed resources that are likely to co-occur in this geographic area, and the nature of their co-occurrence with the classes of activities authorized, funded or carried out by the program. We use the best scientific and commercial data available to identify the intended and unintended consequences that are likely to result from those activities. This step of our assessment is designed to determine whether and to what degree listed resources under our jurisdiction are likely to be exposed to these different classes of activities that would be authorized, funded or carried out under a program. As part of this step we try to identify the populations and subpopulations, ages (or life stages), and gender of the individuals that are likely to be exposed to an action's effects and the populations or subpopulations those individuals represent. Once we conclude that listed resources are likely to be exposed to the effects of a program's action, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure.

Similar to a project specific consultation, the next step of our analysis in a programmatic consultation establishes the risks that the responses pose to listed species and their designated critical habitat. A programmatic consultation, however, is necessarily focused on whether and to what degree a program can ensure that actions taken under the program are not likely to, individually or cumulatively, jeopardize the continued existence of endangered or threatened species and are not likely to result in the destruction or adverse modification of designated critical habitat. Our description of the probable responses and the risks the program poses to listed resources is at the core of our evaluation, and is informed by the program's decision structure and by the general patterns we observed through prior experience with a program or a class of activities.

When individual listed plants or animals are expected to experience reductions in fitness, we would expect those reductions to also reduce the abundance, reproduction rates, or growth rates (or increase variance in one or more of those rates) of the populations those individuals represent (see Stearns 1992). Reductions in one or more of these variables (or one of the variables we derive from them) is a *necessary* condition for reductions in a population's viability, which is itself a *necessary* condition for reductions in a species viability. On the other hand, when listed plants or animals exposed to an action's effects are *not* expected to experience reductions in fitness, we would *not* expect the action to have adverse consequences on the viability of the populations those individuals represent or the species those populations comprise (for example, see Anderson 2000, Mills and Beatty 1979, and Stearns 1992). If we conclude that listed species are not likely to experience reductions in their fitness, we would conclude our assessment.

If, however, we conclude that listed animals are likely to experience reductions in their fitness, we examine whether the program included sufficient safeguards to ensure that the actions they authorize, fund, or otherwise carry out would not reduce the viability of the populations those individuals represent (typically measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). For those species likely to be adversely affected by the activities conducted under a program, we would examine their status and the environment in which the species exists (in this Opinion, the *Environmental Baseline* and *Status of the Species* are examined in the section titled *Listed Resources in the Action Area*), in detail, as a point of reference for determining if changes in population viability are likely, and if, in turn, any changes in population viability would be sufficient to reduce the viability of the species.

Evidence Available for this Consultation

To conduct our analyses we considered the information contained in the Aquatics Report, *Ecological Risk Assessment: Wildland Fire-Fighting Chemicals* (Labat 2007), *the Interagency Standards for Fire and Aviation Operations - Redbook 2007* (Redbook 2007), *Interagency Strategy for the Implementation of Federal Wildland Fire Management Policy*, and the Forest Service Manual (FSM). The Misapplication List allowed us to evaluate some of the past problems observed when fire retardants were unintentionally introduced in rivers between 2001 and 2005, and the adaptation of the program's (agency's) use of fire retardants on NFS lands in response to these actions that were authorized, funded or carried out by the USFS.

We supplemented this information using electronic searches of literature published in English or with English abstracts using research platforms in the *Online Computer Library Center's First Search, CSA Illumina,* and *ISI Web of Science.* These platforms allow us to cross-search multiple databases for journals, open access resources, books, proceedings, Web sites, doctoral dissertations and master's theses for literature on the biological, ecological, and medical sciences. Particular databases we searched for this consultation included *BasicBiosis, Dissertations, ArticleFirst, Proceedings, Aquatic Sciences and Fisheries Abstracts.* Some of the databases provide access to documents published from the 1960s through present, although references for many scientific journals contained in these databases only date back to the 1970s or later. Through these databases we accessed the major journals dealing with the biology, ecology, distribution, status, and trends of the threatened and endangered species considered in this Opinion, and the impacts of fire retardants on freshwater ecosystems.

For our literature searches, we used paired combinations of the keywords: fire retardant, fire fighting, Chinook salmon, and many others. We acquired references that, based on a reading of their titles and abstracts, appeared to comply with our keywords. If a reference's title did not allow us to eliminate it as irrelevant to this inquiry, we acquired and reviewed the reference. We supplemented our electronic searches by searching the literature cited sections and bibliographies of references we retrieved electronically to identify additional papers that had not been captured in our electronic searches.

Collectively, this information provided the basis for our determination as to whether and to what degree listed resources under our jurisdiction are likely to be exposed to the USFS' use and application of fire retardants, and whether and to what degree the USFS can ensure that their use of fire retardants are not likely to, individually or cumulatively, jeopardize the continued existence of endangered or threatened species or are not likely to result in the destruction or adverse modification of designated critical habitat.

Application of this Approach in this Consultation

In this consultation, we evaluated USFS' 2000 Guidelines, which aerially apply eight long-term fire retardants in fire management activities, and whether the USFS can ensure that any action authorized, funded, or carried out under this fire retardant program is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of critical habitat. We began our analysis of the fire retardant program by exploring where, why, and how the USFS would use the eight fire retardants under consideration. Specifically, we asked whether there are geographic or other differences among the retardants or other substantive decision criteria that would influence the USFS' decision to use one retardant over another when fighting a fire. We asked whether there are substantive decision criteria they follow as to when it is appropriate to aerially apply a retardant versus other means of fire control and suppression (e.g., fire line construction, ground crews, ground retardant application, *etc.*) prior to engaging and while engaged in fire fighting activities. In addition, we asked: how the USFS decides where to drop retardants; how often does the USFS invoke the exceptions to the 2000 Guidelines; how confident is the USFS in their ability to detect whether waterways were accidentally exposed to aerially applied fire retardants containing threatened and endangered species; are pilots accompanied by personnel observing and recording the drop location; how soon after a retardant was directly dropped on a river containing listed species would USFS personnel examine the waterway for effects to listed aquatic species; what indicators are they examining to evaluate the potential effects on a waterway and listed aquatic species, and what is the probability of detecting an effect when one exists; how likely is it that a subwatershed, watershed, and evolutionarily significant unit (ESU) or distinct population segment (DPS) would be exposed to fire retardants more than once during a fire season; and does the USFS engage in regular monitoring of water quality in burned and burning areas?

Through the course of this consultation we learned that the decision where and when to use a particular fire retardant formulation is largely left to the discretion of the Incidental Commander, Forest Supervisor, and other USFS field personnel (FSM 5100). The decision is informed by policy and guidance set by the USFS' Washington Office and various statutes (see below), and the risk analyses conducted by the WFCS, a part of the Missoula Technology and Development Center, for determining what chemicals should be approved for use in fire suppression activities.

Legal and Policy Framework for Fire Retardant Use by the USFS

Various authorities define the fire management responsibilities of the USFS. The following acts authorize and guide fire management activities for the protection of NFS 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 United State 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 Forest Service.

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 to engage in suppression actions on state, local and private lands. Pursuant to Title 41, United States 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 agencies 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 of the 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 emergency situations. 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 three influences: 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 after action 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 1995/2001 *Federal Wildland Fire Management Policy and Program Review* (FSM 5101.4, 5109.19 chapter 50), the *Wildland and Prescribed Fire Management Policy and Implementation Procedures Reference Guide* (FSM 5140.32) and others. 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. Among the many legal and regulatory statutes, the USFS must also ensure that any action authorized, funded, or carried out under their fire management program or using the long-term fire retardants on the QPL is not likely to jeopardize the continued existence of any endangered species or threatened species, or result in the destruction or adverse modification of critical habitat. This is done under section 7 consultation with the Services.

USFS Decision Structure -Use of Fire Retardants

The USFS asked NMFS to initially consult on the use of the 2000 Guidelines, but after some discussion the Services and USFS agreed that the consultation should include an analysis of aerially applied fire retardants, which could be but are not required to be used on NFS lands. Through the course of this review, however, we learned that the use of the fire retardants by the USFS personnel is a multifaceted action (a complex program of actions that may require consultation). Under the fire program, one of the early and arguably most important actions taken by the USFS is the review and approval of fire retardants, as well as foams and water enhancers (fire fighting chemicals) for use on NFS lands and elsewhere. Once a fire fighting chemical is approved for the QPL, the USFS purchases, warehouses, and distributes the chemical to individual bases across the nation. Since all agencies, state and Federal, obtain their fire fighting chemicals from the same bases, a particular chemical will continue to be used until it is exhausted, even when the chemical is no longer approved for use under the QPL. At the same time, if the USFS is no longer purchasing a product and its stockpile has been used up, no other agencies, state or Federal, will be able to use that chemical either.

Figure 1 depicts a simplified model of the USFS fire management program, as NMFS understands it. The use of the eight long-term fire retardants and the accompanying 2000 Guidelines, while an action that merits consultation, represents only a small part of the overall program and decision making process in fighting fires. During this consultation, we evaluated the currently approved retardants and the USFS' decision-making process for where and when to use those retardants. We reviewed the data and other information that the USFS gathers, analyzes, and considers when applying those retardants and the information the USFS gathers to reach conclusions as to whether listed species were affected during the application of fire retardants (i.e., conduct emergency consultation). We also reviewed the information that the USFS gathers to evaluate the validity of its conclusions (e.g., that threatened and endangered species are likely to be adversely affected when retardant or foam is applied within 300 feet of waterway). We evaluated this information to determine whether and to what degree the USFS' decision-making process ensures that any activities it authorizes, funds, or carries out are not likely to, individually or cumulatively, jeopardize the continued existence of listed species or result in the destruction or adverse modification of critical habitat that has been designated for them.

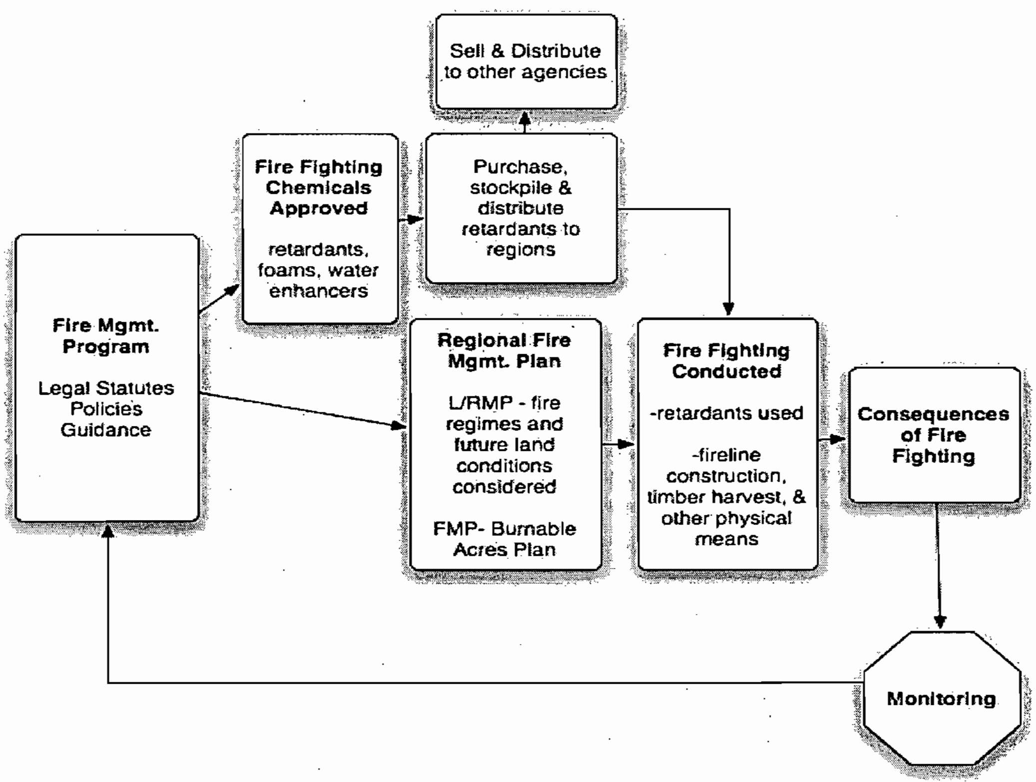


Figure 1. USFS' Fire Management Program Decision Making Process

We examined the USFS use of fire retardants and the accompanying 2000 Guidelines to see if it contains features that would necessarily prevent the exposure of endangered or threatened species, or their designated critical habitat (listed resources). We then broadly characterized the use of fire retardants and fire recurrence intervals to describe the risk of listed resources being exposed to fire retardants used on NFS lands. If, based on this information, we expected that listed resources are not likely to be exposed to fire retardants used by the USFS, then we concluded that the action would have "no effect" on those listed resources. If, based on this information, we determined that listed individuals may be exposed to activities authorized by the research program, but (a) the probability of exposure to those stressors is so small that it would not be reasonable to expect exposure to occur, (b) there is no possibility or only a very small possibility that the individual would respond when exposed to the stressor, (c) there is no possibility or only a small probability of a negative response even if an individual does exhibit a respond to their exposure, or (d) there is no possibility or only a small probability that the individual would experience a reduction in individual performance (or fitness), then we concluded that the USFS' action is "not likely to adversely affect" those listed resources.

If listed resources are harmed or killed by actions the USFS authorizes, funds, or otherwise carries out, NMFS examines if the program includes sufficient safeguards to ensure that the incidental take of individuals does not occur in a manner that reduces the viability of the populations those individuals represent (typically measured using changes in the populations' abundance, reproduction, spatial structure and connectivity, growth rates, or variance in these measures to make inferences about the population's extinction risks). Given their status and the environment in which the species exist, are those species likely to be adversely affected by the activities conducted under the proposed action likely to suffer changes in population viability that would be sufficient to reduce the viability of the species those populations comprise?

Action Area

The section 7 implementing regulations define the "Action Area" of a Federal action as all areas to be affected, directly or indirectly, and not merely the immediate area involved in the action (50 CFR 402.02). This Opinion assesses the consequences of the USFS' continued use of eight fire retardants for potential use on any NFS lands and immediately adjacent lands across the United States and its territories. According to the USFS, the NFS consists of 192 million acres of National Forests and National Grasslands across 42 states and 1 territory. In all, this amounts to 155 National Forests, 22 National Grasslands, 6 National Monuments, 20 National Recreational Areas, 9 National Scenic Areas, and 1 National Preserve, of which 403 are designated wilderness units and river reaches that are designated as Wild and Scenic Rivers.

At a minimum the extent of the action area is defined by NFS lands. Based on our assessment we have determined that the direct and indirect effects of the USFS' use of the fire retardants may extend beyond these lands for reasons that are interrelated and interdependent actions, or indirect effects of fire retardant application. We expect that the USFS would typically conduct fire suppression activities primarily on USFS lands, which are scattered across the United States. We are aware that in some instances the USFS may fight fires along the interface between Federal lands and other landholders where the application and effect of fire retardants extend beyond USFS jurisdiction (eg., the indirect effects of fire suppression activities extend to downstream areas or areas downslope of the NFS lands), and in certain instances the USFS may provide assistance to other Federal, state and local entities (fight fires and drop retardants on areas outside of the NFS [private lands or other Federal lands] see the section *Legal and Policy Framework for Fire Retardant Use by the USFS* in this Opinion). Because there may be times and areas where the application and the effects of fire retardants extend beyond the geographical boundaries of NFS lands and because the nearly 200 distinct areas designated as part of the NFS are widely distributed across the United States, we have defined the action area for this consultation broadly to encompass lands and waters of the United States with particular emphasis on USFS lands and adjacent properties.

Status of Listed Resources

Over 60 ESA-listed species are under NMFS jurisdiction, but not all of these species will be affected by fire retardants. The downstream effects of fire retardants are brief but intense. As a result, species living on or downstream of NFS lands could be affected by this action. Because no fires would be fought in estuaries or the ocean NMFS would not expect the effects of fire retardants to reach ocean waters, blue whale (*Balaenoptera musculus*), bowhead whale (*Balaena mysticetus*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), southern resident killer whale (*Orcinus orca*), Northern right whale (*Eubalaena glacialis*), sei whale (*Balaenoptera borealis*), Southern right whale (*Eubalaena australis*), sperm whale (*Physeter macrocephalus*), Caribbean monk seal (*Monachus tropicalis*), Hawaiian monk seal (*Monachus schauinslandi),* Steller sea lion (*Eumetopias jubatus*), green sea turtle (*Chelonia mydas*), hawksbill sea turtle (*Eretmochelys imbricata*), Kemp's ridley sea turtle (*Lepidochelys kempii*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), and olive ridley sea turtle (*Lepidochelys olivacea*), smalltooth sawfish (*Pristis pectinata*), white abalone (*Haliotis sorenseni*), elkhorn coral (*Acropora palmata*), staghorn coral (*Acropora cervicornis*), and Johnson's seagrass (*Halophila johnsonii*) will not be affected by fire retardants and therefore are not considered in this consultation.

There are no USFS lands in areas occupied by listed Atlantic salmon (*Salmo salar*), Ozette Lake sockeye (*Oncorhynchus nerka*), central California coast coho salmon (*O. kisutch*), or central California coast steelhead (*O. mykiss*). While the USFS is allowed to drop fire retardants adjacent to its land, it is unlikely that it would venture so far from NFS lands as to drop retardant near any watersheds containing these listed species. These species are also not in areas with frequent fire return intervals so NMFS believes it is extremely unlikely that the USFS' use of fire retardants would overlap with the distribution of these species. Consequently, we expect the USFS continued use of fire retardants would have no effect on these species and have not considered them further in this consultation. In the event USFS would authorize or carry out fire retardant drops or other fire suppression activities that may affect resources in a manner or to an extent not considered in this Opinion, USFS must reinitiate consultation to compensate for information that was not available for consideration during this consultation.

NMFS has determined that the following species and critical habitat designations may be affected by the USFS use of fire retardants on NFS lands:

Table 1. Species and critical habitat designations considered in this consultation

Common Name	*Scientific Name*	*Listed As*
Chinook salmon (California coastal) with critical habitat	*O. tshawytscha*	Threatened
Chinook salmon (Central Valley spring-run) with critical habitat		Threatened
Chinook salmon (Lower Columbia River) with critical habitat		Threatened
Chinook salmon (Puget Sound) with critical habitat		Threatened
Chinook salmon (Sacramento River winter-run) with critical habitat		Endangered
Chinook salmon (Snake River fall-run) with critical habitat		Threatened
Chinook salmon (Snake River spring/summer-run) with critical habitat		Threatened
Chinook salmon (UCR spring-run) with critical habitat		Endangered
Chinook salmon (Upper Willamette River) with critical habitat		Threatened
Chum salmon (Columbia River) with critical habitat	*O. keta*	Threatened

Table 1. Species and critical habitat designations considered in this consultation

Common Name	*Scientific Name*	*Listed As*
Chum salmon (Hood Canal summer run) with critical habitat		Threatened
Coho salmon (Lower Columbia River)	*O. kisutch*	Threatened
Coho salmon (Southern Oregon Northern Coastal California) with critical habitat		Threatened
Coho salmon (Oregon Coast)		Threatened
Sockeye salmon (Snake River) with critical habitat	*O. nerka*	Endangered
Steelhead (California Central Valley) with critical habitat	*O. mykiss*	Threatened
Steelhead (Lower Columbia River) with critical habitat		Threatened
Steelhead (Middle Columbia River) with critical habitat		Threatened
Steelhead (Northern California) with critical habitat		Threatened
Steelhead (Snake River Basin) with critical habitat		Threatened
Steelhead (South Central California coast) with critical habitat		Threatened
Steelhead (Southern California) with critical habitat		Endangered
Steelhead (UCR) with critical habitat		Endangered
Steelhead (Upper Willamette River) with critical habitat		Threatened
Steelhead (Puget Sound)		Threatened
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Green sturgeon	*A. medirostris*	Threatened

By regulation, NMFS must consider the status of these threatened species, endangered species, and designated critical habitat when making its 'jeopardy' or 'destruction or adverse modification' determinations (50 CFR 402.02). We determine a species' status by estimating its probability of extinction in particular time intervals (or its probability of persistence in a time interval, which is 1 – probability of extinction in the time interval). We use this estimate to determine whether the effects of an action are likely to reduce a species' likelihood of both surviving and recovering in the wild.

The species' narratives that follow this introduction focus on the status of the threatened and endangered species and designated critical habitat that are likely to occur in the action area and may be adversely affected by the misapplication of fire retardants. The information presented in this section summarizes a larger body of information and is intended to establish the status of the listed species and critical habitat designations that we consider in this Opinion. These summaries are the foundation for the analyses we present in the *Effects of the Action* section of this Opinion. Because this is a programmatic consultation that does not consider site-specific data or other information, we only summarize information on the geographic distribution of the species, their ecological relationship with waters of the United States, status, and principal threats to their survival and recovery.

More detailed information on the status and trends of these listed resources, their biology and ecology can be found in a number of published documents including assessments of the status and trends of Pacific salmon (Good *et al.* 2005); recovery plan for shortnose sturgeon (NMFS 1998); and listing regulations and critical habitat designations that have been published in the *Federal Register*.

Chinook Salmon

Figure 2 is a depiction of the distribution of the eight threatened and endangered Chinook salmon ESUs relative to Forest Service boundaries.

Chinook salmon are the largest of the Pacific salmon and historically ranged from the Ventura River in California to Point Hope, Alaska in North America, and in northeastern Asia from Hokkaido, Japan to the Anadyr River in Russia (Healey 1991). In addition, Chinook salmon have been reported in the Canadian Beaufort Sea (McPhail and Lindsey 1970). We discuss the distribution, status, and critical habitat of the nine species[1] of endangered and threatened Chinook salmon separately, and summarize their common dependence on waters of the United States.

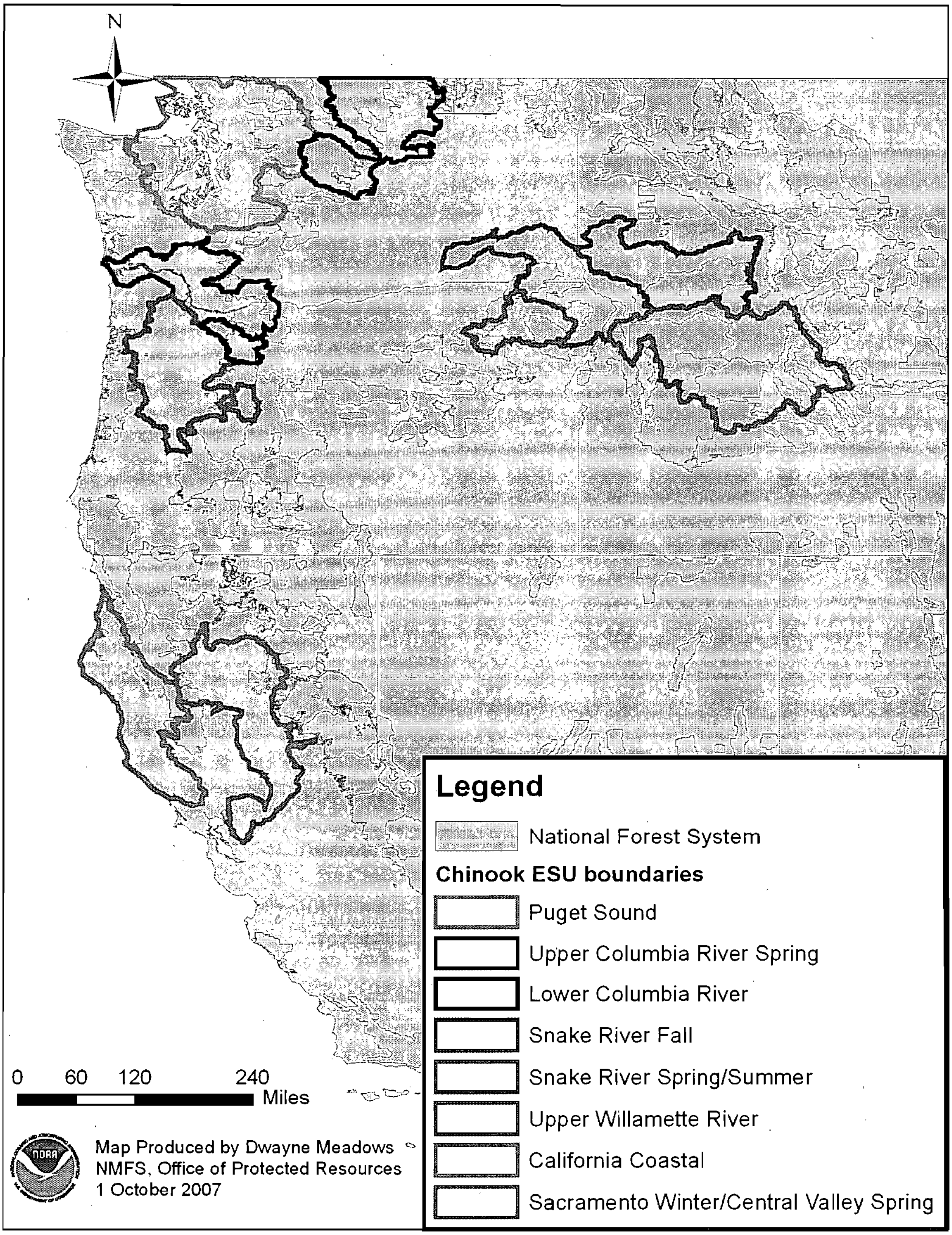
Of the Pacific salmon species, Chinook salmon exhibit arguably one the most diverse and complex life history strategies. Chinook salmon are generally described as one of two races, within which there is substantial variation. One form, the "stream-type" resides in freshwater for a year or more following emergence, and the "ocean-type" migrates to the ocean within their first year. The ocean-type typifies populations north of 56°N (Healy 1991). Within each race, there is often variation in age at seaward migration, age of maturity, timing of spawning migrations, male precocity, and female fecundity.

Over the past few decades, the size and distribution of Chinook salmon populations have declined because of natural phenomena and human activity, including the operation of hydropower systems, over-harvest, hatcheries, and habitat degradation. Natural variations in freshwater and marine environments have substantial effects on the abundance of salmon populations. Of the various natural phenomena that affect most populations of Pacific salmon, changes in ocean productivity are generally considered most important.

Chinook salmon are exposed to high rates of natural predation, during freshwater rearing and migration stages, as well as during ocean migration. In general, Chinook salmon are prey for pelagic fishes, birds, and marine mammals, including harbor seals, sea lions, and killer whales. There have been recent concerns that the increasing size of tern, seal, and sea lion populations in the Pacific Northwest may have reduced the survival of some salmon DPSs.

1 In this section of the Opinion, we use the word "species" as it has been defined in section 3 of the Endangered Species Act of 1973, which include "species, subspecies, and any distinction population segment of any species of vertebrate fish or wildlife which interbreeds when mature" (16 U.S.C. 1533). Pacific salmon that have been listed as endangered or threatened were listed as "evolutionarily significant units" which NMFS uses to identify distinct population segments of Pacific salmon. Nevertheless, any ESU or DPS is a "species" for the purposes of the ESA.

Figure 2. US Forest Service Boundaries and Listed Chinook Salmon Distributions



Dependence on Waters of the United States
Chinook salmon survive only in aquatic ecosystems and, therefore, depend on the quantity and quality of those aquatic systems. Chinook salmon, like the other salmon NMFS has listed, have declined under the combined effects of overharvests in fisheries; competition from fish raised in hatcheries and native and non-native exotic species; dams that block their migrations and alter river hydrology; gravel mining that impedes their migration and alters the dynamics (hydrogeomorphology) of the rivers and streams that support juveniles; water diversions that deplete water levels in rivers and streams; destruction or degradation of riparian habitat that increase water temperatures in rivers and streams sufficient to reduce the survival of juvenile Chinook salmon; and land use practices (logging, agriculture, urbanization) that destroy wetland and riparian ecosystems while introducing sediment, nutrients, biocides, metals, and other pollutants into surface and ground water and degrade water quality in the freshwater, estuarine, and coastal ecosystems throughout the Pacific Northwest.

Puget Sound Chinook salmon
Distribution. The boundaries of the Puget Sound ESU correspond generally with the boundaries of the Puget Lowland Ecoregion, and include all runs of Chinook salmon in the Puget Sound region from the North Fork Nooksack River to the Elwha River on the Olympic Peninsula. The Puget Sound ESU is comprised of 31 historically populations, of which 22 are believed to be extant. Chinook salmon in this area generally have an "ocean-type" life history. Thirty-six hatchery populations were included as part of the ESU and five were considered essential for recovery and listed including spring Chinook salmon from Kendall Creek, the North Fork Stillaguamish River, White River, and Dungeness River, and fall run fish from the Elwha River.

Status. *Puget Sound Chinook salmon were listed as threatened in 1999; that status was re-affirmed on June 28, 2005.* Long term trends in abundance and median population growth rates for naturally spawning populations of PS Chinook salmon indicate that approximately half of the populations are declining and the other half are increasing in abundance over the length of available time series. Eight of 22 populations are declining over the short-term, compared to 11 or 12 populations that have long-term declines (Good *et al.* 2005). Widespread declines and extirpations of spring- and summer-run Puget Sound Chinook populations represent a significant reduction in the life history diversity of this ESU (Myers *et al.* 1998).

The estimated total run size of Chinook salmon in Puget Sound in the early 1990s was 240,000 fish, representing a loss of nearly 450,000 fish from historic numbers. During a recent five-year period, the geometric mean of natural spawners in populations of Puget Sound Chinook salmon ranged from 222 to just over 9,489 fish. Most populations had natural spawners numbering in the hundreds (median recent natural escapement is 766), and of the six populations with greater than 1,000 natural spawners, only two have a low fraction of hatchery fish. Estimates of the historical equilibrium abundance, based on pre-European settlement habitat conditions, range from 1,700 to 51,000 potential Puget Sound Chinook salmon spawners per population. The historical estimates of spawner capacity are several orders of magnitude higher than spawner abundances currently observed throughout the ESU (Good *et al.* 2005).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 49 subbasins (5th field Hydrological Units) reviewed in NMFS' assessment of critical habitat for the Puget Sound ESUs, nine subbasins were rated as having a medium conservation value, 12 were rated as low, and the remaining subbasins (40), where the bulk of Federal lands occur in this ESU, were rated as having a high conservation value to Puget Sound Chinook salmon. Factors contributing to the downward trends in this ESU are hydromorphological changes (such as diking, revetments, loss of secondary channels in floodplains, widespread blockages of streams, and changes in peak flows), degraded freshwater and marine habitat affected by agricultural activities and urbanization, and upper river tributaries widely affected by poor forest practices, and lower tributaries. Changes in habitat quantity, availability, diversity, flow, temperature, sediment load, and channel stability are common limiting factors in areas of critical habitat.

Lower Columbia River Chinook salmon
Distribution. Lower Columbia River (LCR) Chinook salmon includes all naturally-spawned populations of Chinook salmon from the Columbia River and its tributaries from its mouth at the Pacific Ocean upstream to a transitional point between Washington and Oregon, east of the Hood River and the White Salmon River, and includes the Willamette River to Willamette Falls, Oregon, exclusive of spring-run Chinook salmon in the Clackamas River. The Cowlitz, Kalama, Lewis, White Salmon, and Klickitat Rivers are the major river systems on the Washington side, and the lower Willamette and Sandy Rivers are foremost on the Oregon side. The eastern boundary for this species occurs at Celilo Falls, which corresponds to the edge of the drier Columbia Basin Ecosystem and historically may have been a barrier to salmon migration at certain times of the year. The predominant life history type for this species is the fall-run, which consists of an early component that returns to the Columbia River in mid-August and spawns within a few weeks (Kostow 1995).

Status. LCR Chinook salmon were originally listed as threatened on March 24, 1999, and reaffirmed as threatened on June 28, 2005. Historical records of Chinook salmon abundance are sparse, but cannery records suggest a peak run of 4.6 million fish (43 million pounds [see Lichatowich 1999]) in 1883. Although fall-run Chinook salmon are still present throughout much of their historical range, they are still subject to large-scale hatchery production, relatively high harvest, and extensive habitat degradation. The Lewis River late fall Chinook salmon population is the healthiest and has a reasonable probability of being self-sustaining. Abundances largely declined during 1998 to 2000 and trend indicators for most populations are negative, especially if hatchery fish are assumed to have a reproductive success equivalent to that of natural-origin fish.

New data acquired for the Good *et al.* (2005) report includes spawner abundance estimates through 2001, new estimates of the fraction of hatchery spawners and harvest estimates. In addition, estimates of historical abundance have been provided by the Washington Department of Fish and Wildlife. The Willamette/Lower Columbia River Technical Review Team has estimated that 8-10 historic populations have been extirpated, most of them spring-run populations. Near loss of that important life history type remains an important concern. Although some natural production currently occurs in 20 or so populations, only one exceeds 1,000 spawners. High hatchery production continues to pose genetic and ecological risks to natural populations and to mask their performance. Most LCR Chinook salmon populations have not seen increases in recent years as pronounced as those that have occurred in many other geographic areas.

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 52 subbasins reviewed in NMFS' assessment of critical habitat for the LCR Chinook salmon ESU, 13 subbasins were rated as having a medium conservation value, 4 were rated as low, and the remaining subbasins (35), were rated as having a high conservation value to LCR Chinook salmon. Federal lands were generally rated as having high conservation value to the species.

Factors contributing to the downward trends in this ESU are hydromorphological changes resulting from hydropower development, loss of tidal marsh and swamp habitat, and degraded freshwater and marine habitat from industrial harbor and port development, and urban development. Limiting factors identified for this species include: (1) Reduced access to spawning/rearing habitat in tributaries, (2) hatchery impacts, (3) loss of habitat diversity and channel stability in tributaries, (4) excessive fine sediment in spawning gravels, (5) elevated water temperature in tributaries, and (6) harvest impacts.

Upper Columbia River spring-run Chinook salmon

Distribution. Endangered UCR spring-run Chinook salmon includes stream-type Chinook salmon that inhabit tributaries upstream from the Yakima River to Chief Joseph Dam. They currently spawn in only three river basins above Rock Island Dam: the Wenatchee, Entiat, and Methow Rivers. Several hatchery populations are also listed including those from the Chiwawa, Methow, Twisp, Chewuch, and White rivers, and Nason Creek.

Status. UCR spring-run Chinook salmon were listed as endangered on March 24, 1999, and reaffirmed as endangered on June 28, 2005, because they had been reduced to small populations in three watersheds. Based on redd count data series, spawning escapements for the Wenatchee, Entiat, and Methow rivers have declined an average of 5.6 percent, 4.8 percent, and 6.3 % per year, respectively, since 1958. In the most recent 5-year geometric mean (1997 to 2001), spawning escapements were 273 for the Wenatchee population, 65 for the Entiat population, and 282 for the Methow population, only 8% to 15% of the minimum abundance thresholds, although escapement increased substantially in 2000 and 2001 in all three river systems. Based on 1980-2004 returns, the average annual growth rate for this ESU is estimated as 0.93 (meaning the population is not replacing itself) (Fisher and Hinrichsen 2006). Assuming that population growth rates were to continue at 1980-2004 levels, UCR spring-run Chinook salmon populations are projected to have very high probabilities of decline within 50 years. Population viability analyses for this species (using the Dennis Model) suggest that these Chinook salmon face a significant risk of extinction: a 75 to 100% probability of extinction within 100 years (given return rates for 1980 to present).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. The UCR Spring-run Chinook salmon ESU has 31 watersheds within its range. Five watersheds received a medium rating and 26 received a high rating of conservation value to the ESU. The Columbia River rearing/migration corridor downstream of the spawning range was rated as a high conservation value. Factors contributing to the downward trends in this ESU include: (1) Mainstem Columbia River hydropower system mortality, (2) tributary riparian degradation and loss of in-river wood, (3) altered tributary floodplain and channel morphology, (4) reduced tributary stream flow and impaired passage, and (5) harvest impacts.

Upper Willamette River Chinook salmon
Distribution. Upper Willamette River Chinook salmon occupy the Willamette River and tributaries upstream of Willamette Falls. In the past, this ESU included sizable numbers of spawning salmon in the Santiam River, the middle fork of the Willamette River, and the McKenzie River, as well as smaller numbers in the Molalla River, Calapooia River, and Albiqua Creek. Historically, access above Willamette Falls was restricted to the spring when flows were high. In autumn, low flows prevented fish from ascending past the falls. The Upper Willamette spring-run Chinook salmon are one of the most genetically distinct Chinook salmon groups in the Columbia River Basin. Fall-run Chinook salmon spawn in the Upper Willamette but are not considered part of the species because they are not native. None of the hatchery populations in the Willamette River were listed although five spring-run hatchery stocks were included in the species' listing.

Status. Upper Willamette River Chinook salmon were listed as threatened on March 24, 1999, and reaffirmed as threatened on June 28, 2005. The total abundance of adult spring-run Chinook salmon (hatchery-origin + natural-origin fish) passing Willamette Falls has remained relatively steady over the past 50 years (ranging from approximately 20,000 to 70,000 fish), but it is an order of magnitude below the peak abundance levels observed in the 1920s (approximately 300,000 adults). Until recent years, interpretation of abundance levels has been confounded by a high but uncertain fraction of hatchery-produced fish.

Most natural spring Chinook salmon populations in likely extirpated or nearly so, with only one remaining naturally reproducing population identified in this ESU: the spring Chinook salmon in the McKenzie River. Unfortunately, recently short-term declines in abundance suggest that this population may not be self-sustaining (Myers *et al.* 1998, Good *et al.* 2005). Abundance in this population has been relatively low (low thousands) with a substantial number of these fish being of hatchery origin. The population increased substantially in 2000-2003, probably due to increased survival in the ocean. Future survival rates in the ocean are unpredictable, and the likelihood of long-term sustainability for this population has not been determined. Although the number of adult spring-run Chinook salmon crossing Willamette Falls is in the same range (about 20,000 to 70,000 adults) it has been for the last 50 years, a large fraction of these are hatchery produced. Of concern is that a majority of the spawning habitat and approximately 30 to 40% of total historical habitat are no longer accessible because of dams (Good *et al.* 2005).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning and rearing sites, freshwater migration corridors. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 65 subbasins reviewed in NMFS' assessment of critical habitat for the Upper Willamette River Chinook salmon ESU, 19 subbasins were rated as having a medium conservation value, 19 were rated as low, and the remaining subbasins (27), were rated as having a high conservation value to Upper Willamette River Chinook salmon. Federal lands were generally rated as having high conservation value to the species' spawning and rearing. Factors contributing to the downward trends in this ESU include: (1) Reduced access to spawning/rearing habitat in tributaries, (2) hatchery impacts, (3) altered water quality and temperature in tributaries, (4) altered stream flow in tributaries, and (5) lost/degraded floodplain connectivity and lowland stream habitat.

Snake River spring/summer-run Chinook salmon
Distribution. This species occupies the Snake River basin, which drains portions of southeastern Washington, northeastern Oregon, and north/central Idaho. Environmental conditions are generally drier and warmer in these areas than in areas occupied by other Chinook species. Snake River spring/summer-run Chinook salmon are primarily limited to the Salmon, Grande Ronde, Imnaha, and Tucannon Rivers in the Snake River basin. Snake River spring/summer-run Chinook salmon exhibit a stream-type life history. Juvenile fish mature in fresh water for one year before they migrate to the ocean in the spring of their second year.

Status. Snake River spring/summer-run Chinook salmon were originally listed as threatened on April 22, 1992, and were reaffirmed as threatened on June 28, 2005. Although direct estimates of historical annual Snake River spring/summer Chinook returns are not available, returns may have declined by as much as 97% between the late 1800s and 2000. According to Matthews and Waples (1991), total annual Snake River spring/summer Chinook production may have exceeded 1.5 million adult fish in the late 1800s. Total (natural plus hatchery origin) returns fell to roughly 100,000 spawners by the late 1960s (Fulton 1968) and were below 10,000 by 1980. Between 1981 and 2000, total returns fluctuated between extremes of 1,800 and 44,000 fish. The 2001 and 2002 total returns increased to over 185,000 and 97,184 adults, respectively. The 1997 to

2001 geometric mean total return for the summer run component at Lower Granite Dam was slightly more than 6,000 fish, compared to the geometric mean of 3,076 fish for the years 1987 to 1996. The 2002 to 2006 geometric mean of the combined Chinook salmon runs at Lower Granite Dam was over 18,000 fish. However, it is important to note that over 80% of the 2001 return and over 60% of the 2002 return originated in hatcheries (Good *et al.* 2005). Good *et al.* (2005) reported that risks to individual populations within the ESU may be greater than the extinction risk for the entire ESU due to low levels of annual abundance and the extensive production areas within the Snake River basin.

The Interior Columbia Basin Technical Recovery Team (ICBTRT) has identified 32 populations in 5 major population groups (Upper Salmon River, South Fork Salmon River, Middle Fork Salmon River, Grande Ronde/Imnaha, Lower Snake Mainstem Tributaries) for this species. Historic populations above Hells Canyon Dam are considered extinct (ICBTRT 2003). Thus, despite the recent increases in total spring/summer-run Chinook salmon returns to the basin, natural origin abundance and productivity are still below their targets. Snake River spring/summer Chinook salmon remains likely to become endangered (Good *et al.* 2005).

Critical habitat. Critical habitat for these salmon was designated on October 25, 1999. This 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 listed Snake River salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Adjacent riparian zones are defined as those areas within a horizontal distance of 300 feet from the normal line of high water of a stream channel or from the shoreline of a standing body of water. Designated critical habitat includes the Columbia River from a straight line connecting the west end of the Clatsop jetty (Oregon side) and the west end of the Peacock jetty (Washington side) and including all river reaches from the estuary upstream to the confluence of the Snake River, and all Snake River reaches upstream to Hells Canyon Dam; the Palouse River from its confluence with the Snake River upstream to Palouse Falls, the Clearwater River from its confluence with the Snake River upstream to its confluence with Lolo Creek; the North Fork Clearwater River from its confluence with the Clearwater river upstream to Dworshak Dam. Critical habitat also includes several river reaches presently or historically accessible to Snake River spring/summer Chinook salmon. Limiting factors identified for this species include: (1) Hydrosystem mortality, (2) reduced stream flow, (3) altered channel morphology and floodplain, (4) excessive fine sediment, (5) degraded water quality (NMFS 2006).

Snake River fall-run Chinook salmon

Distribution. The present range of spawning and rearing habitat for naturally-spawned Snake River fall Chinook salmon is primarily limited to the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater River. Snake River fall-run Chinook salmon spawn above Lower Granite Dam in the mainstem Snake River and in the lower reaches of the larger tributaries. Adult Snake River fall-run Chinook salmon enter the Columbia River in July and August. Spawning occurs from October through November. Juveniles emerge from the gravels in March and April of the following year, moving downstream from natal spawning and early rearing areas from June through early fall.

Status. Snake River fall-run Chinook salmon were originally listed as endangered in 1992 but were reclassified as threatened on June 28, 2005. Estimated annual returns for the period 1938 to 1949 was 72,000 fish, and by the 1950s, numbers had declined to an annual average of 29,000 fish (Bjornn and Horner 1980). Numbers of Snake River fall-run Chinook salmon continued to decline during the 1960s and 1970s as approximately 80% of their historic habitat was eliminated or severely degraded by the construction of the Hells Canyon complex (1958 to 1967) and the lower Snake River dams (1961 to 1975). Counts of natural-origin adult Snake River fall-run Chinook salmon at Lower Granite Dam were 1000 fish in 1975, and ranged from 78 to 905 fish (with an average of 489 fish) over the ensuing 25-year period (Good *et al.* 2005). Numbers of natural-origin Snake River fall-run Chinook salmon have increased over the last few years, with estimates at Lower Granite Dam of 2,652 fish in 2001, 2,095 fish in 2002, and 3,895 fish in 2003.

Snake River fall-run Chinook salmon have exhibited an upward trend in returns over Lower Granite Dam since the mid 1990s. Returns classified as natural-origin exceeded 2,600 fish in 2001, compared to a 1997-2001 geometric mean natural-origin count of 871. Both the long and short-term trends in natural returns are positive. Harvest impacts on Snake River fall Chinook salmon declined after listing and have remained relatively constant in recent years. There have been major reductions in fisheries impacting this stock. Mainstem conditions for subyearling Chinook migrants from the Snake River have generally improved since the early 1990s. The hatchery component, derived from outside the basin, has decreased as a percentage of the run at Lower Granite Dam from the 1998/99 status reviews (five year average of 26.2%) to 2001 (8%). This reflects an increase in the Lyons Ferry component, systematic removal of marked hatchery fish at the Lower Granite trap, and modifications to the Umatilla supplementation program to increase homing of fall Chinook release groups.

The ICBTRT has defined only one extant population for the Snake River fall-run Chinook salmon, the lower Snake River mainstem population. This population occupies the Snake River from its confluence with the Columbia River to Hells Canyon Dam, and the lower reaches of the Clearwater, Imnaha, Grande Ronde, Salmon, and Tucannon Rivers (ICBTRT 2003).

Critical habitat. Critical habitat for these salmon was designated on December 28, 1993. This 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 listed Snake River salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Adjacent riparian zones are defined as those areas within a horizontal distance of 300 feet from the normal line of high water of a stream channel or from the shoreline of a standing body of water. Designated critical habitat includes the Columbia River from a straight line connecting the west end of the Clatsop jetty (Oregon side) and the west end of the Peacock jetty (Washington side) and including all river reaches from the estuary upstream to the confluence of the Snake River, and all Snake River reaches upstream to Hells Canyon Dam. Critical habitat also includes several river reaches presently or historically accessible to Snake River fall-run Chinook salmon. Limiting factors identified for Snake River fall-run Chinook salmon include: (1) Mainstem lower Snake and Columbia hydrosystem mortality, (2) degraded water quality, (3) reduced spawning and rearing habitat due to mainstem lower Snake River hydropower system, and (4) harvest impacts.

Sacramento River winter-run Chinook salmon
Distribution. Sacramento River winter-run Chinook salmon consists of a single spawning population that enters the Sacramento River and its tributaries in California from November to June and spawns from late April to mid-August, with a peak from May to June. Sacramento River winter Chinook historically occupied cold, headwater streams, such as the upper reaches of the Little Sacramento, McCloud, and lower Pit Rivers.

Status. Sacramento River winter-run Chinook salmon were listed as endangered on January 4, 1994, and were reaffirmed as endangered on June 28, 2005, because dams restrict access to a small fraction of their historic spawning habitat and the habitat remaining to them is degraded. Sacramento River winter-run Chinook salmon consist of a single self-sustaining population which is entirely dependent upon the provision of suitably cool water from Shasta Reservoir during periods of spawning, incubation and rearing.

Construction of Shasta Dams in the 1940s eliminated access to historic spawning habitat for winter-run Chinook salmon in the basin. Winter-run Chinook salmon were not expected to survive this habitat alteration (Moffett 1949). However, cold water releases from Shasta Dam have created conditions suitable for winter Chinook for roughly 60 miles downstream from the dam. As a result the ESU has been reduced to a single spawning population confined to the mainstem Sacramento River below Keswick Dam; although some adult winter-run Chinook salmon were recently observed in Battle Creek, a tributary to the upper Sacramento River.

Quantitative estimates of run-size are not available for the period before 1996, the completion of Red Bluff Diversion Dam. The California Department of Fish and Game estimated spawning escapement of Sacramento River winter-run Chinook salmon at 61,300 (60,000 mainstem, 1,000 Battle Creek, and 300 in Mill Creek) in the early 1960s. During the first three years of operation of the county facility at the Red Bluff Diversion Dam 91967 to 1969), the spawning run of winter-run Chinook salmon averaged 86,500 fish. From 1967 through the mid-1990s, the population declined at an average rate of 18% per year, or roughly 50% per generation. The population reached critically low levels during the drought of 1987 to 1992; the three-year average run size for the period of 1989 to 1991 was 388 fish. Based on the Red Bluff Diversion Dam counts, the population has been growing rapidly since the 1990s. Most recent estimates indicate that the short term trend is 0.26, while the population growth rate is still less than 1. The draft recovery goal for the ESU is an average of 10,000 female spawners per year and a population growth rate ≥ 1.0, calculated over 13 years of data (Good *et al.* 2005).

Critical habitat. Critical Habitat was designated for this species on June 16, 1993 (58 FR 33212). The following areas consisting of the water, waterway bottom, and adjacent riparian zones: 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. Factors contributing to the downward trends in this ESU include: (1) Reduced access to spawning/rearing habitat, (2) possible loss of genetic integrity through population bottlenecks, (3) inadequately screened diversions, (4) predation at artificial structures and by nonnative species, (5) pollution from Iron Mountain Mine and other sources, (6) adverse flow conditions, (7) high summer water temperatures, (8) unsustainable harvest rates, (9) passage problems at various structures, and (10) vulnerability to drought (Good *et al.* 2005).

Central Valley spring-run Chinook salmon

Distribution. The Central Valley Spring-run Chinook salmon includes all naturally spawned populations of spring-run Chinook salmon in the Sacramento River and its tributaries in California. This species includes Chinook salmon entering the Sacramento River from March to July and spawning from late August through early October, with a peak in September. Spring-run fish in the Sacramento River exhibit an ocean-type life history, emigrating as fry, sub-yearlings, and yearlings.

Status. Central Valley spring-run Chinook salmon were listed as threatened on September 16, 1999, a classification this species retained when the original listing was reviewed on June 28, 2005. This ESU consists of spring-run Chinook salmon occurring in the Sacramento River basin. This species was listed because dams isolate them from most of their historic spawning habitat and the habitat remaining to them is degraded. Historically, spring-run Chinook salmon were predominant throughout the Central Valley occupying the upper and middle reaches (1,000 to 6,000 feet) of the San Joaquin, American, Yuba, Feather, Sacramento, McCloud and Pit Rivers, with smaller populations in most tributaries with sufficient habitat for over-summering adults (Stone 1874, Rutter 1904, Clark 1929). The Central Valley drainage as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and the 1940s (DFG 1998). Before construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River alone (Fry 1961). Following the completion of Friant Dam, the native population from the San Joaquin River and its tributaries (*i.e.*, the Stanislaus and Mokelumne Rivers) was extirpated. Spring-run Chinook salmon no longer exist in the American River due to the operation of Folsom Dam. Naturally spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (DFG 1998). Since 1969, the Central Valley spring-run Chinook salmon ESU (excluding Feather River fish) has displayed broad fluctuations in abundance ranging from 25,890 in 1982 to 1,403 in 1993 (DFG unpublished data).

The average abundance for the ESU was 12,499 for the period of 1969 to 1979, 12,981 for the period of 1980 to 1990, and 6,542 for the period of 1991 to 2001. In 2003 and 2004, total run size for the ESU was 8,775 and 9,872 adults respectively, well above the 1991 to 2001 average. Evaluating the ESU as a whole, however, masks significant changes that are occurring among populations that comprise the ESU (metapopulation). For example, the mainstem Sacramento River population has undergone a significant decline while the abundance of many tributary populations increased. Average abundance of Sacramento River mainstem spring-run Chinook salmon recently declined from a high of 12,107 for the period 1980 to 1990, to a low of 609 for the period 1991 to 2001, while the average abundance of Sacramento River tributary populations increased from a low of 1,227 to a high of 5,925 over the same periods.

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Factors contributing to the downward trends in this ESU include: reduced access to spawning/rearing habitat behind impassable dams, climatic variation, water management activities, hybridization with fall-run Chinook salmon, predation, and harvest have all impacted spring-run Chinook salmon critical habitat and population numbers (DFG 1998). Several actions have been taken to improve and increase the PCEs of critical habitat for spring-run Chinook salmon, including improved management of Central Valley water (*e.g.*, through use of CALFED EWA and CVPIA (b)(2) water accounts), implementing new and improved screen and ladder designs at major water diversions along the mainstem Sacramento River and tributaries, removal of several small dams on important spring-run Chinook salmon spawning streams, and changes in ocean and inland fishing regulations to minimize harvest. Although protective measures and critical habitat restoration likely have contributed to recent increases in spring-run Chinook salmon abundance, the ESU is still below levels observed from the 1960s through 1990. Threats from hatchery production (*i.e.*, competition for food between naturally spawned and hatchery fish, and run hybridization and homogenization), climatic variation, reduced stream flows, high water temperatures, predation, and large scale water diversions persist.

California Coastal Chinook salmon

Distribution. California Coastal Chinook salmon includes all naturally-spawned coastal Chinook salmon spawning from Redwood Creek south through the Russian River, inclusive. California Coastal Chinook salmon are a fall-run, ocean-type fish. A spring-run (river-type) component existed historically, but is now considered extinct (Bjorkstedt *et al.* 2005).

Status. California Coastal Chinook salmon were listed as threatened on September 16, 1999, and retained that listing upon review on June 28, 2005, because of the combined effect of dams that prevent them from reaching spawning habitat, logging, agricultural activities, urbanization, and water withdrawals in the river drainages that support them. Historical estimates of escapement, based on professional opinion and evaluation of habitat conditions, suggest abundance was roughly 73,000 in the early 1960s with the majority of fish spawning in the Eel River (see California Fish and Game 1965 *in* Good *et al.* 2005). The species exists as small populations with highly variable cohort sizes. The Russian River probably contains some natural production, but the origin of those fish is not clear because of a number of introductions of hatchery fish over the last century. The Eel River contains a substantial fraction of the remaining Chinook salmon spawning habitat for this species. Since its original listing and status review, little new data are available or suitable for analyzing trends or estimating changes in this population's growth rate (Good *et al.* 2005).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more Chinook salmon life stages. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, nearshore marine habitat and estuarine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. 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 limited instream cover that does exist is provided mainly by large cobble and overhanging vegetation. Instream large woody debris, needed for foraging sites, cover, and velocity refuges is especially lacking in most of the streams throughout the basin. NMFS has determined that these degraded habitat conditions are, in part, the result of many human-induced factors affecting critical habitat including: dam construction, agricultural and mining activities, urbanization, stream channelization, water diversion and logging among others.

Chum Salmon

Figure 3 is a depiction of the distribution of the two threatened chum salmon ESUs relative to Forest Service boundaries.

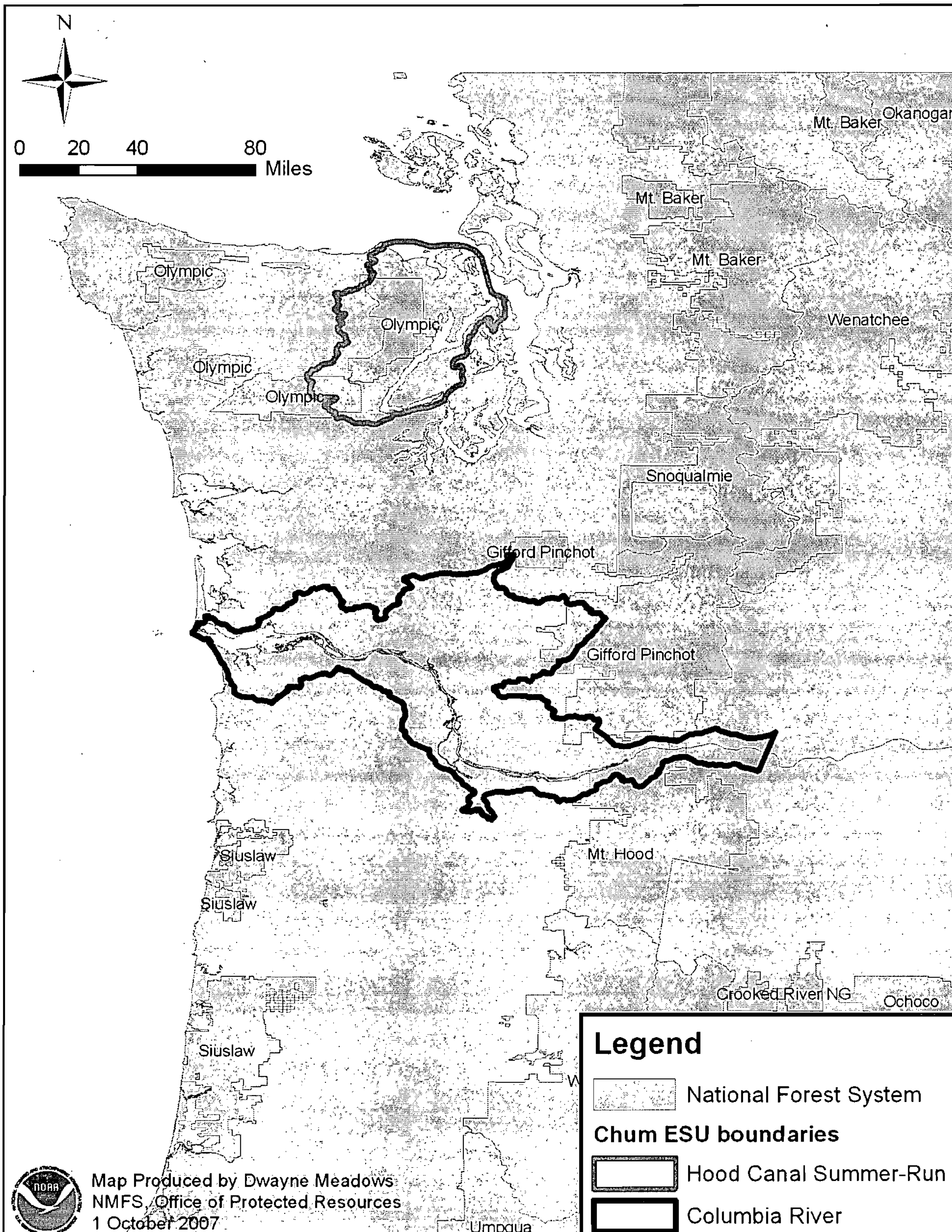
Historically, chum salmon were distributed throughout the coastal regions of western Canada and the United States, as far south as Monterey Bay, California. Presently, major spawning populations are found only as far south as Tillamook Bay on the northern Oregon coast. Chum salmon are semelparous, spawn primarily in freshwater and, apparently, exhibit obligatory anadromy (there are no recorded landlocked or naturalized freshwater populations).

Chum salmon spend two to five years in feeding areas in the northeast Pacific Ocean, which is a greater proportion of their life history than other Pacific salmonids. Chum salmon distribute throughout the North Pacific Ocean and Bering Sea, although North American chum salmon (as opposed to chum salmon originating in Asia), rarely occur west of 175°E longitude.

North American chum salmon migrate north along the coast in a narrow coastal band that broadens in southeastern Alaska, although some data suggest that Puget Sound chum, including Hood Canal summer run chum, may not make extended migrations into northern British Columbian and Alaskan waters, but instead may travel directly offshore into the north Pacific Ocean.

Chum salmon, like pink salmon, usually spawn in the lower reaches of rivers, with redds usually dug in the mainstem or in side channels of rivers from just above tidal influence to nearly 100 kilometers from the sea. Juveniles outmigrate to seawater almost immediately after emerging from the gravel that covers their redds (Salo 1991). This ocean-type migratory behavior contrasts with the stream-type behavior of some other species in the genus *Oncorhynchus* (e.g., coastal cutthroat trout, steelhead, coho salmon, and most types of Chinook and sockeye salmon), which usually migrate to sea at a larger size, after months or years of freshwater rearing. This means that survival and growth in juvenile chum salmon depend less on freshwater conditions (unlike stream-type salmonids which depend heavily on freshwater habitats) than on favorable estuarine conditions. Another behavioral difference between chum salmon and species that rear extensively in freshwater is that chum salmon form schools, presumably to reduce predation (Pitcher 1986), especially if their movements are synchronized to swamp predators (Miller and Brannon 1982).

Figure 3. US Forest Service Boundaries and Listed Chum Salmon Distributions



Chum salmon have been threatened by over harvests in commercial and recreational fisheries, adult and juvenile mortalities associated with hydropower systems, habitat degradation from forestry and urban expansion, and shifts in climatic conditions that changed patterns and intensity of precipitation.

Dependence on Waters of the United States
Chum salmon survive only in aquatic ecosystems and depend on the quantity and quality of those aquatic systems. Chum salmon, like the other salmon NMFS has listed, have declined under the combined effects of overharvests in fisheries; competition from fish raised in hatcheries and native and non-native exotic species; dams that block their migrations and alter river hydrology; gravel mining that impedes their migration and alters the dynamics (hydrogeomorphology) of the rivers and streams that support juveniles; water diversions that deplete water levels in rivers and streams, destruction or degradation of riparian habitat that increase water temperatures in rivers and streams sufficient to reduce the survival of juvenile chum salmon; and land use practices (logging, agriculture, urbanization) that destroy wetland and riparian ecosystems while introducing sediment, nutrients, biocides, metals, and other pollutants into surface and ground water and degrade water quality in the freshwater, estuarine, and coastal ecosystems throughout the Pacific Northwest.

Columbia River chum salmon
Distribution. Columbia River chum salmon includes all natural-origin chum salmon in the Columbia River and its tributaries in Washington and Oregon. The species consists of three populations: Grays River, Hardy, and Hamilton Creek in Washington State.

Status. Columbia River chum salmon were listed as threatened on March 25, 1999, and their threatened status was reaffirmed on June 28, 2005. Chum salmon in the Columbia River once numbered in the hundreds of thousands of adults and were reported in almost every river in the Lower Columbia River basin, but by the 1950s most runs disappeared (Rich 1942, Marr 1943, Fulton 1970). The total number of chum salmon returning to the Columbia River in the last 50 years has averaged a few thousand per year, with returns limited to a very restricted portion of the historical range. Significant spawning occurs in only two of the 16 historical populations, meaning that 88% of the historical populations are extirpated, or nearly so. The two remaining populations are the Grays River and the Lower Gorge (Good *et al.* 2005). Chum salmon appear to be extirpated from the Oregon portion of this ESU. In 2000, ODFW conducted surveys to determine the abundance and distribution of chum salmon in the Columbia River, and out of 30 sites surveyed only one chum salmon was observed.

Historically, the Columbia River chum salmon supported a large commercial fishery in the first half of this century which landed more than 500,000 fish per year as recently as 1942. Commercial catches declined beginning in the mid-1950s, and in later years rarely exceeded 2,000 per year. During the 1980s and 1990s, the combined abundance of natural spawners for the Lower Gorge, Washougal, and Grays River populations was below 4,000 adults. In 2002, however, the abundance of natural spawners exhibited a substantial increase at several locations (estimate of natural spawners is approximately 20,000 adults). The cause of this dramatic increase in abundance is unknown. However, long- and short-term productivity trends for populations are at or below replacement. The loss of off-channel habitat and the extirpation of approximately 17 historical populations increase this species' vulnerability to environmental variability and catastrophic events. Overall, the populations that remain have low abundance, limited distribution, and poor connectivity (Good *et al.* 2005).

Critical habitat. Critical habitat was originally designated for this on February 16, 2000 (65 FR 7764) and was re-designated on September 2, 2005 (70 FR 52630). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more chum salmon life stages. Columbia River chum salmon have PCEs of 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 21 subbasins reviewed in NMFS' assessment of critical habitat for the Columbia River chum salmon ESU, three subbasins were rated as having a medium conservation value, no subbasins were rated as low, and the majority of subbasins (18), were rated as having a high conservation value to Columbia River chum salmon. Washington's Federal lands were rated as having high conservation value to the species. The major factors limiting recovery for Columbia River chum salmon are altered channel form and stability in tributaries, excessive sediment in tributary spawning gravels, altered stream flow in tributaries and the mainstem Columbia River, loss of some tributary habitat types, and harassment of spawners in the tributaries and mainstem.

Hood Canal summer-run Chum salmon
Distribution. This ESU includes all naturally spawned populations of summer-run chum salmon in Hood Canal and its tributaries as well as populations in Olympic Peninsula rivers between Hood Canal and Dungeness Bay, Washington (March 25, 1999, 64 FR 14508). Eight artificial propagation programs are considered to be part of the ESU: the Quilcene NFH, Hamma Hamma Fish Hatchery, Lilliwaup Creek Fish Hatchery, Union River/Tahuya, Big Beef Creek Fish Hatchery, Salmon Creek Fish Hatchery, Chimacum Creek Fish Hatchery, and the Jimmycomelately Creek Fish Hatchery summer-run chum hatchery programs. NMFS determined that these artificially propagated stocks are no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the species.

Status. Hood Canal summer-run chum salmon were listed as threatened on March 25, 1999, and reaffirmed as threatened on June 28, 2005. Adult returns for some populations in the Hood Canal summer-run chum species showed modest improvements in 2000, with upward trends continuing in 2001 and 2002. The recent five-year mean abundance is variable among populations in the species, ranging from one fish to nearly 4,500 fish. Hood Canal summer-run chum are the focus of an extensive rebuilding program developed and implemented since 1992 by the state and tribal co-managers. Two populations (the combined Quilcene and Union River populations) are above the conservation thresholds established by the rebuilding plan. However, most populations remain depressed. Estimates of the fraction of naturally spawning hatchery fish exceed 60% for some populations, indicating that reintroduction programs are supplementing the numbers of total fish spawning naturally in streams. Long-term trends in productivity are above replacement for only the Quilcene and Union River populations. Buoyed by recent increases, seven populations are exhibiting short-term productivity trends above replacement.

Of an estimated 16 historical populations in the ESU, seven populations are believed to have been extirpated or nearly extirpated. Most of these extirpations have occurred in populations on the eastern side of Hood Canal, generating additional concern for ESU spatial structure. The widespread loss of estuary and lower floodplain habitat was noted by the BRT as a continuing threat to ESU spatial structure and connectivity. There is some concern that the Quilcene hatchery stock is exhibiting high rates of straying, and may represent a risk to historical population structure and diversity. However, with the extirpation of many local populations, much of this historical structure has been lost, and the use of Quilcene hatchery fish may represent one of a few remaining options for Hood Canal summer-run chum conservation.

Of the eight programs releasing summer chum salmon that are considered to be part of the Hood Canal summer chum ESU, six of the programs are supplementation programs implemented to preserve and increase the abundance of native populations in their natal watersheds. NMFS' assessment of the effects of artificial propagation on ESU extinction risk concluded that these hatchery programs collectively do not substantially reduce the extinction risk of the ESU. The hatchery programs are reducing risks to ESU abundance by increasing total ESU abundance as well as the number of naturally spawning summer-run chum salmon. Several of the programs have likely prevented further population extirpations in the ESU. The contribution of ESU hatchery programs to the productivity of the ESU in-total is uncertain. The hatchery programs are benefiting ESU spatial structure by increasing the spawning area utilized in several watersheds and by increasing the geographic range of the ESU through reintroductions. These programs also provide benefits to ESU diversity. By bolstering total population sizes, the hatchery programs have likely stemmed adverse genetic effects for populations at critically low levels. Additionally, measures have been implemented to maintain current genetic diversity, including the use of native broodstock and the termination of the programs after 12 years of operation to guard against long-term domestication effects. Collectively, artificial propagation programs in the ESU presently provide a slight beneficial effect to ESU abundance, spatial structure, and diversity, but uncertain effects to ESU productivity.

Critical habitat. Critical habitat for this species was designated on September 2, 2005. Hood Canal summer-run chum salmon have PCEs of 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 17 subbasins reviewed in NMFS' assessment of critical habitat for the Hood Canal chum salmon ESU, 14 subbasins were rated as having a high conservation value, while only three were rated as having a medium value to the conservation. Limiting factors identified for this species include: (1) Degraded floodplain and mainstem river channel structure, (2) Degraded estuarine conditions and loss of estuarine habitat, (3) Riparian area degradation and loss of in-river wood in mainstem, (4) Excessive sediment in spawning gravels, (5) reduced stream flow in migration areas.

Coho Salmon

Figure 4 is a depiction of the distribution of the three threatened and endangered coho salmon

ESUs relative to Forest Service boundaries.

Coho salmon occur naturally in most major river basins around the North Pacific Ocean from central California to northern Japan (Laufle *et al.* 1986). After entering the ocean, immature coho salmon initially remain in near-shore waters close to the parent stream. Most coho salmon adults are 3-year-olds, having spent approximately 18 months rearing in freshwater and 18 months in salt water. Most coho salmon enter rivers between September and February, but entry is influenced by discharge and other factors. In many systems, coho salmon and other Pacific salmon are unable to enter the rivers until sufficiently strong flows open passages and provide sufficient depth. Wild female coho return to spawn almost exclusively at age three. Coho salmon spawn from November to January, and occasionally into February and March. Spawning occurs in a few third-order streams must spawning activity occurs in fourth- and fifth-order streams. Spawning generally occurs in tributaries with gradients of 3% or less.

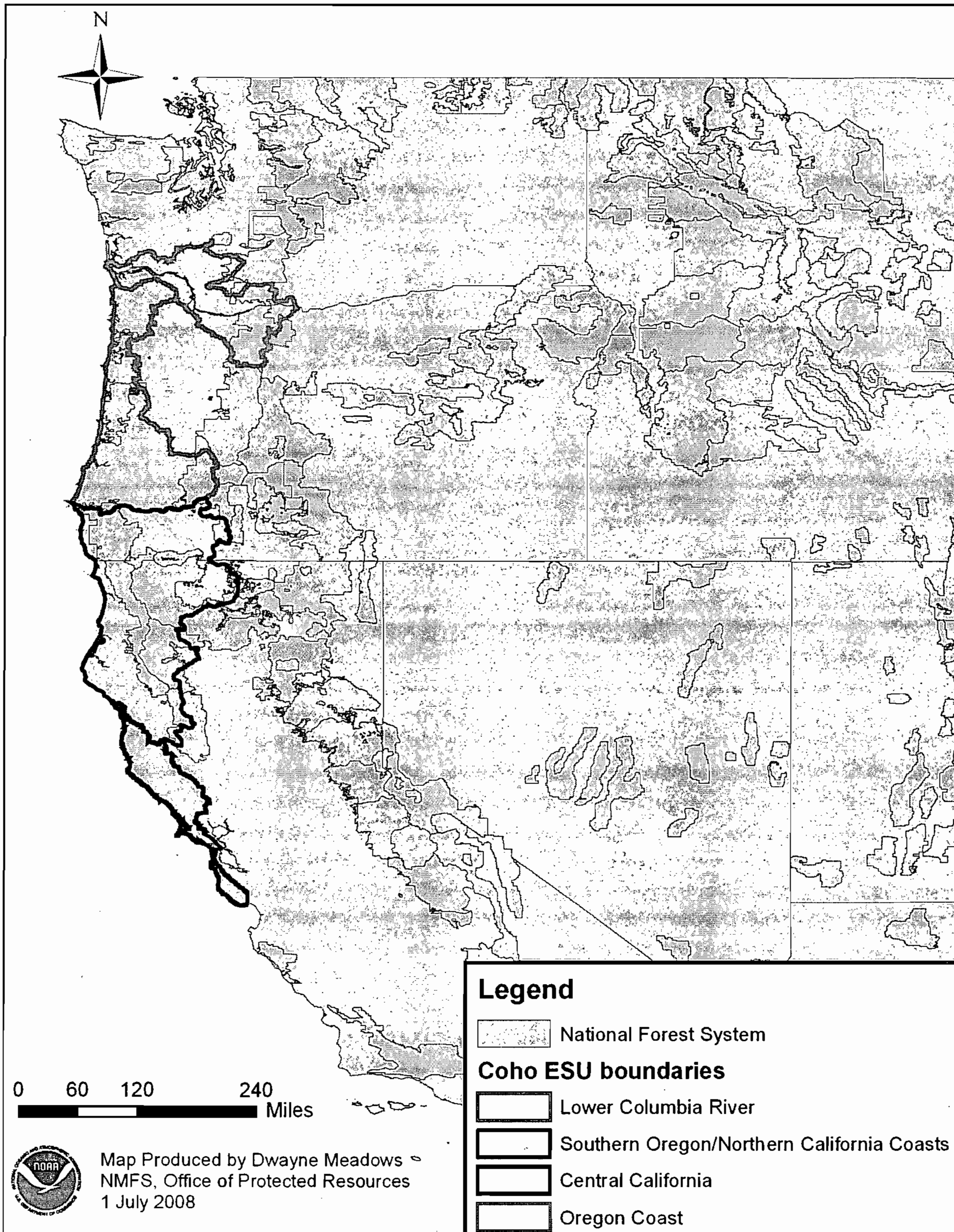
Eggs incubate for about 35 to 50 days, and start emerging from the gravel two to three weeks after hatching. Following emergence, fry move to shallow areas near the stream banks. As fry grow, they disperse upstream and downstream to establish and defend territories. Juvenile rearing usually occurs in tributaries with gradients of three percent or less, although they may move to streams with gradients of four to five percent. Juvenile coho salmon are often found in small streams less than five feet wide, and may migrate considerable distances to rear in lakes and off-channel ponds. During the summer, fry prefer pools featuring adequate cover such as large woody debris, undercut banks, and overhanging vegetation. Overwintering thends to occur in larger pools and backwater areas.

North American coho salmon will migrate north along the coast in a narrow coastal band that broadens in southeastern Alaska. During this migration, juvenile coho salmon tend to occur in both coastal and offshore waters. During spring and summer, coho salmon will forage in waters between 46° N, the Gulf of Alaska, and along Alaska's Aleutian Islands.

Dependence on Waters of the United States

Coho salmon survive only in aquatic ecosystems and depend on the quantity and quality of those aquatic systems. Coho salmon, like the other salmon NMFS has listed, have declined under the combined effects of overharvests in fisheries; competition from fish raised in hatcheries and native and non-native exotic species; dams that block their migrations and alter river hydrology; gravel mining that impedes their migration and alters the dynamics (hydrogeomorphology) of the rivers and streams that support juveniles; water diversions that deplete water levels in rivers and streams, destruction or degradation of riparian habitat that increase water temperatures in rivers and streams sufficient to reduce the survival of juvenile chum salmon; and land use practices (logging, agriculture, urbanization) that destroy wetland and riparian ecosystems while introducing sediment, nutrients, biocides, metals, and other pollutants into surface and ground water and degrade water quality in the freshwater, estuarine, and coastal ecosystems throughout the Pacific Northwest.

Figure 4. US Forest Service Boundaries and Listed Coho Salmon Distributions



Lower Columbia River Coho Salmon

Distribution. LCR coho salmon include all naturally spawned populations of coho salmon in the Columbia River and its tributaries in Washington and Oregon, from the mouth of the Columbia up to and including the Big White Salmon and Hood Rivers, and includes the Willamette River to Willamette Falls, Oregon, as well as twenty-five artificial propagation programs: the Grays River, Sea Resources Hatchery, Peterson Coho Project, Big Creek Hatchery, Astoria High School Coho Program, Warrenton High School Coho Program, Elochoman Type-S Coho Program, Elochoman Type-N Coho Program, Cathlamet High School FFA Type-N Coho Program, Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers, Cowlitz Game and Anglers Coho Program, Friends of the Cowlitz Coho Program, North Fork Toutle River Hatchery, Kalama River Type-N Coho Program, Kalama River Type-S Coho Program, Washougal Hatchery Type-N Coho Program, Lewis River Type-N Coho Program, Lewis River Type-S Coho Program, Fish First Wild Coho Program, Fish First Type-N Coho Program, Syverson Project Type-N Coho Program, Eagle Creek National Fish Hatchery, Sandy Hatchery, and the Bonneville/Cascade/Oxbow complex coho hatchery programs.

Status. LCR coho salmon were listed as endangered on June 28, 2005 (70 FR 37160). The vast majority (over 90%) of the historic population in the LCR coho salmon ESU appear to be either extirpated or nearly so. The two populations with any significant natural production (sandy and Clackamas) are at appreciable risk because of low abundance, declining trends and failure to respond after a dramatic reduction in harvest. Most of the other populations are believed to have very little, if any, natural production.

The Sandy population had a recent mean abundance of 342 spawners and a very low fraction of hatchery-origin spawners. Trends in the Sandy are similar to the Clackamas. The long-term trends and growth rate estimates over the period 1977 to 2001 have been slightly positive and the short-term trends have been slightly negative. Other populations in this ESU are dominated by hatchery production. There is very little, if any, natural production in Oregon outside of the Clackamas and Sandy rivers. The Washington side of the ESU is also dominated by hatchery production and there are no populations with appreciable natural production. The most serious threat facing this ESU is the scarcity of naturally-produced spawners, with attendant risks associated with small population, loss of diversity, and fragmentation and isolation of the remaining naturally-produced fish. In the only two populations with significant natural production (Sandy and Clackamas), short and long-term trends are negative and productivity (as gauged by pre-harvest recruits) is down sharply from recent (1980s) levels.

Critical habitat. Critical habitat has not been designated for this species.

Southern Oregon/Northern California Coast Coho Salmon

Distribution. Southern Oregon/Northern California coast coho salmon consists of all naturally spawning populations of coho salmon that reside below long-term, naturally impassible barriers in streams between Punta Gorda, California and Cape Blanco, Oregon as well as three artificial propogation programs: the Cole Rivers Hatchery (ODFW stock #52), Trinity River Hatchery, and Iron Gate Hatchery coho hatchery programs. The three major river systems supporting Southern Oregon – Northern Coastal California coast coho are the Rogue, Klamath (including the Trinity), and Eel rivers.

Status. Southern Oregon/Northern California coast coho salmon were listed as threatened on May 7, 1997; they retained that classification when their status was reviewed on June 28, 2005 (70 FR 37160). Southern Oregon/Northern California Coast coho salmon extend from Cape Blanco in southern Oregon to Punta Gorda in northern California (Weitkamp *et al.* 1995). The status of coho salmon coastwide, including the Southern Oregon/Northern California Coast coho salmon ESU, was formally assessed in 1995 (Weitkamp *et al.* 1995). Two subsequent status review updates have been published by NMFS, one addressing all West Coast coho salmon ESUs (NMFS 1996) and a second specifically addressing the Oregon Coast and Southern Oregon/Northern California Coast coho salmon ESUs (NMFS 1997). In the 1997 status update, estimates of natural population abundance were based on very limited information. New data on presence/absence in northern California streams that historically supported coho salmon were even more disturbing than earlier results, indicating that a smaller percentage of streams contained coho salmon compared to the percentage presence in an earlier study. However, it was unclear whether these new data represented actual trends in local extinctions, or were biased by sampling effort.

Data on population abundance and trends are limited for the California portion of this ESU. No regular estimates of natural spawner escapement are available. Historical point estimates of coho salmon abundance for thhe early 1960s and mid-1980s suggest that statewide coho spawning escapement in the 1940s ranged between 200,000 and 500,000 fish. Numbers declined to about 100,000 fish by the mid-1960s with about 43% originating from this ESU. Brown *et al.* (1994) estimated that the California portion of this ESU was represented by about 7,000 wild and naturalized coho salmon (see Good *et al.* 2005). In the Klamath River, the estimated escapement has dropped from approximately 15,400 in the mid-1960s to about 3,000 in the mid 1980s, and more recently to about 2,000 (see Good *et al.* 2005). The second largest producing river in this ESU, the Eel River, dropped from 14,000, to 4,000 to about 2,000 during the same period. Historical estimates are considered "best guesses" made using a combination of limited catch statistics, hatchery records, and the personal observations of biologists and managers.

Most recently, Williams *et al.* (2006) described the structure of historic populations of Southern Oregon/Northern California Coast coho salmon. They described three categories of populations; functionally independent populations, potentially independent populations and dependent populations. Functionally independent populations are populations capable of existing in isolation with a minimal risk of extinction. Potentially independent populations are similar but rely on some interchange with adjacent populations to maintain a low probability of extinction. Dependent populations have a high risk of extinction in isolation over a 100-year timeframe and rely on exchange of individuals from adjacent populations to maintain themselves.

Critical habitat. Critical habitat was designated for this species on November 25, 1997 and re-designated on May 5, 1999. Critical habitat for this species encompasses all accessible river reaches between Cape Blanco, Oregon, and Punta Gorda, California. Critical habitat consists of the water, substrate, and river reaches (including off-channel habitats) in specified areas. Accessible reaches are those within the historical range of the ESU that can still be occupied by any life stage of coho salmon. Of 155 historical streams for which data are available, 63% likely still support coho salmon. Limiting factors identified for this species include: (1) Loss of channel complexity, connectivity and sinuosity, (2) loss of floodplain and estuarine habitats, (3) loss of riparian habitats and large in-river wood, (4) reduced streamflow, (5) poor water quality, temperature and excessive sedimentation, and (6) unscreened diversions and fish passage structures.

Oregon Coast coho salmon
Distribution. The Oregon Coast coho ESU includes all naturally spawned populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco (63 FR 42587; August 10, 1998). One hatchery stock, the Cow Creek (ODFW stock # 37) hatchery coho, is considered part of the ESU.

Status. The Oregon coast coho salmon ESU was listed as a threatened species on February 11, 2008 (73 FR 7816). The abundance and productivity of Oregon Coast coho since the previous status review (NMFS 1997) represent some of the best and worst years on record. Yearly adult returns for the Oregon Coast coho ESU were in excess of 160,000 natural spawners in 2001 and 2002, far exceeding the abundance observed for the past several decades. These encouraging increases in spawner abundance in 2000–2002 were preceded by three consecutive brood years (the 1994–1996 brood years returning in 1997–1999, respectively) with fewer recruits than had returned in the previous year class. The encouraging 2000–2002 increases in natural spawner abundance occurred in many populations in the northern portion of the ESU, which were the most depressed at the time of the last review (NMFS 1997). Although encouraged by the increase in spawner abundance in 2000–2002, the BRT noted that the long-term trends in ESU productivity were still negative due to the low abundances observed during the 1990s (73 FR 7816).

Since 2002, the total abundance of natural spawners in the Oregon Coast coho ESU has declined each year. The abundance of total natural spawners in 2006 (111,025 spawners) was approximately 43% of the recent peak abundance in 2002 (255,372 spawners). In 2003, ESU-level productivity (evaluated in terms of the number of spawning recruits resulting from spawners three years earlier) was above replacement, and in 2004, productivity was approximately at replacement level. However, productivity was below replacement in 2005 and 2006, and dropped to the lowest level since 1991 in 2006. Preliminary spawner survey data for 2007 suggest that the 2007-2008 return of Oregon Coast coho is either: (1) much reduced from abundance levels in 2006, or (2) exhibiting delayed run timing from previous years.

The recent 5-year geometric mean abundance (2002-2006) of approximately 152, 960 total natural spawners remains well above that of a decade ago (approximately 52,845 from 1992-1996). However, the decline in productivity from 2003 to 2006, despite generally favorable marine survival conditions and low harvest rates, is of concern. (73 FR 7816). The long-term trends in productivity in this ESU remain strongly negative.

Critical habitat. Critical habitat was proposed for Oregon Coast coho on December 14, 2004 (69 FR 74578). The final designation of critical habitat is included in the final rule published on February 11, 2008 (73 FR 7816). Approximately 6,568 stream miles (10,570 km) and 15 square miles (38.8 sq km) of lake habitat are designated critical habitat.

Sockeye Salmon

Figure 5 is a depiction of the distribution of the two threatened and endangered sockeye salmon ESUs relative to Forest Service boundaries.

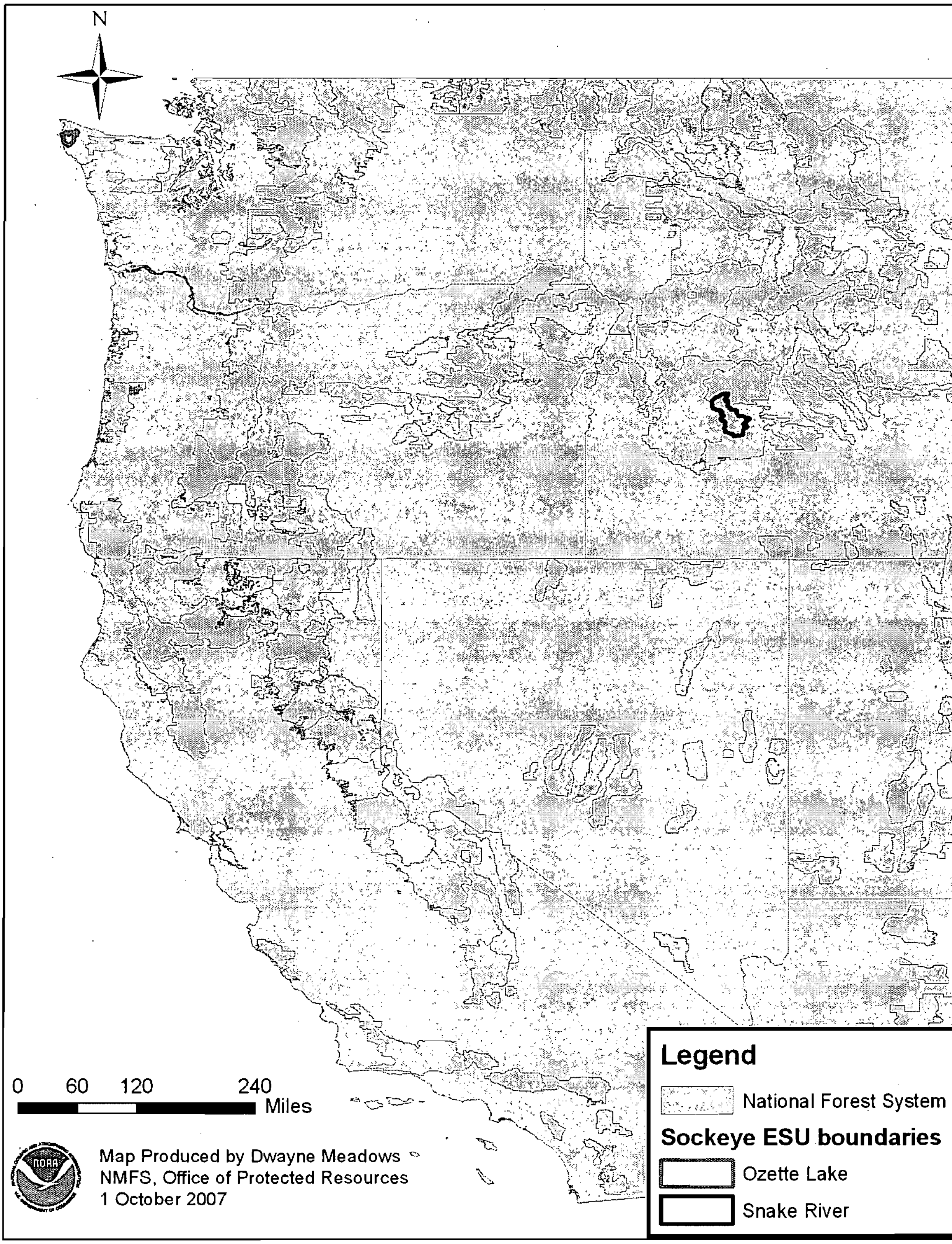
Sockeye salmon occur in the North Pacific and Arctic oceans and associated freshwater systems. This species ranges south as far as the Klamath River in California and northern Hokkaido in Japan, to as far north as far as Bathurst Inlet in the Canadian Arctic and the Anadyr River in Siberia.

The species exhibits riverine and lake life history strategies, the latter of which may be either freshwater resident forms or anadromous forms. The vast majority of sockeye salmon spawn in outlet streams of lakes or in the lakes themselves. These "lake-type" sockeye use the lake environment for rearing for up to 3 years and then migrate to sea, returning to their natal lake to spawn after 1-4 years at sea. Some sockeye spawn in rivers, however, without lake habitat for juvenile rearing. Offspring of these riverine spawners tend to use the lower velocity sections of rivers as the juvenile rearing environment for 1 to 2 years, or may migrate to sea in their first year.

Certain populations *O.nerka* become resident in the lake environment over long periods of time and are called kokanee or little redfish (Burgner 1991). Kokanee and sockeye often co-occur in many interior lakes, where access to the sea is possible but energetically costly. On the other hand, coastal lakes where the migration to sea is relatively short and energetic costs are minimal, rarely support kokanee populations.

Spawning generally occurs in late summer and autumn, but the precise time can vary greatly among populations. Males often arrive earlier than females on the spawning grounds, and will persist longer during the spawning period. Average fecundity ranges from about 2,000 to 2,400 eggs per female to 5,000 eggs, depending upon the population and average age of the female. Fecundity in kokanee is much lower and may range from about 300 to less than 2,000 eggs.

Figure 5. US Forest Service Boundaries and Listed Sockeye Salmon Distributions



Incubation is a function of water temperatures, but generally lasts between 100 and roughly 200 days (Burgner 1991). After emergence, fry move rapidly downstream or upstream along the banks to the lake rearing area. Fry emerging from lakeshore or island spawning grouns may simply move along the shoreline of the lake (Burgner 1991).

Dependence on Waters of the United States
Sockeye salmon survive only in aquatic ecosystems and depend on the quantity and quality of those aquatic systems. Sockeye salmon, like the other salmon NMFS has listed, have declined under the combined effects of overharvests in fisheries; competition from fish raised in hatcheries and native and non-native exotic species; dams that block their migrations and alter river hydrology; gravel mining that impedes their migration and alters the dynamics (hydrogeomorphology) of the rivers and streams that support juveniles; water diversions that deplete water levels in rivers and streams, destruction or degradation of riparian habitat that increase water temperatures in rivers and streams sufficient to reduce the survival of juvenile chum salmon; and land use practices (logging, agriculture, urbanization) that destroy wetland and riparian ecosystems while introducing sediment, nutrients, biocides, metals, and other pollutants into surface and ground water and degrade water quality in the freshwater, estuarine, and coastal ecosystems throughout the Pacific Northwest.

Snake River Sockeye Salmon
Distribution. Snake River sockeye salmon are unique compared to other sockeye salmon populations. Sockeye salmon returning to Redfish Lake in Idaho's Stanley Basin travel a greater distance from the sea (approximately 900 miles) to a higher elevation (6,500 feet) than any other sockeye salmon population and are the southern-most population of sockeye salmon in the world (Bjornn *et al.* 1968; Foerster 1968). Stanley Basin sockeye salmon are separated by 700 or more river miles from two other extant upper Columbia River populations in the Wenatchee River and Okanogan River drainages. These latter populations return to lakes at substantially lower elevations (Wenatchee at 1870 feet, Okanagon at 912 feet) and occupy different ecoregions.

Status. Snake River sockeye salmon were originally listed as endangered in 1991 and retained that classification when their status was reviewed on June 28, 2005. The only extant sockeye salmon population in the Snake River basin at the time of listing was that in Redfish Lake, in the Stanley Basin (upper Salmon River drainage) of Idaho. Other lakes in the Snake River basin historically supported sockeye salmon populations, including Wallowa Lake (Grande Ronde River drainage, Oregon), Payette Lake (Payette River drainage, Idaho) and Warm Lake (South Fork Salmon River drainage, Idaho) (Waples *et al.* 1997). These populations are now considered extinct. Although kokanee, a resident form of *O. nerka*, occur in numerous lakes in the Snake River basin, other lakes in the Stanley Basin and sympatrically with sockeye in Redfish Lake, resident *O.nerka* were not considered part of the species at the time of listing (1991). Subsequent to the 1991 listing, a residual form of sockeye residing in Redfish Lake was identified. The residuals are non-anadromous, completing their entire life cycle in freshwater, but spawn at the same time and in the same location as anadromous sockeye salmon. In 1993, NMFS determined that residual sockeye salmon in Redfish Lake were part of the Snake River sockeye salmon. Also, artificially propagated sockeye salmon from the Redfish Lake Captive Propagation program are considered part of this species (70 FR 37160; June 28, 2005).

NMFS has determined that this artificially propagated stock is genetically no more than moderately divergent from the natural population (NMFS 2005). Five lakes in the Stanley Basin historically contained sockeye salmon: Alturas, Pettit, Redfish, Stanley and Yellowbelly (Bjornn *et al.* 1968). It is generally believed that adults were prevented from returning to the Sawtooth Valley from 1910 to 1934 by Sunbeam Dam. Sunbeam Dam was constructed on the Salmon River approximately 20 miles downstream of Redfish Lake. Whether or not Sunbeam Dam was a complete barrier to adult migration remains unknown. It has been hypothesized that some passage occurred while the dam was in place, allowing the Stanley Basin population or populations to persist (see Bjornn *et al.* 1968, Waples *et al.* 1991).

Adult returns to Redfish Lake during the period 1954 through 1966 ranged from 11 to 4,361 fish (Bjornn *et al.* 1968). Sockeye salmon in Alturas Lake were extirpated in the early 1900s as a result of irrigation diversions, although residual sockeye may still exist in the lake (Chapman and Witty 1993). From 1955 to 1965, the Idaho Department of Fish and Game eradicated sockeye salmon from Pettit, Stanley, and Yellowbelly lakes, and built permanent structures on each of the lake outlets that prevented re-entry of anadromous sockeye salmon (Chapman and Witty 1993). In 1985, 1986, and 1987, 11, 29, and 16 sockeye, respectively, were counted at the Redfish Lake weir (Good *et al.* 2005). Only 18 natural origin sockeye salmon have returned to the Stanley Basin since 1987. The first adult returns from the captive brood stock program returned to the Stanley Basin in 1999. From 1999 through 2005, a total of 345 captive brood program adults that had migrated to the ocean returned to the Stanley Basin.

Recent annual abundances of natural origin sockeye salmon in the Stanley Basin have been extremely low. No natural origin anadromous adults have returned since 1998 and the abundance of residual sockeye salmon in Redfish Lake is unknown. This species is entirely supported by adults produced through the captive propagation program at the present time. Current smolt-to-adult survival of sockeye originating from the Stanley Basin lakes is rarely greater than 0.3% (Hebdon *et al.* 2004).

Critical habitat. Critical habitat for these salmon was designated on December 28, 1993, and 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 listed Snake River salmon (except reaches above impassable natural falls, and Dworshak and Hells Canyon Dams). Adjacent riparian zones are defined as those areas within a horizontal distance of 300 feet from the normal line of high water of a stream channel or from the shoreline of a standing body of water. Designated critical habitat includes the Columbia River from a straight line connecting the west end of the Clatsop jetty (Oregon side) and the west end of the Peacock jetty (Washington side) and including all river reaches from the estuary upstream to the confluence of the Snake River, and all Snake River reaches upstream to the confluence of the Salmon River; all Salmon River reaches to Alturas Lake Creek; Stanley, Redfish, yellow Belly, Pettit, and Alturas Lakes (including their inlet and outlet creeks); Alturas Lake Creek and that portion of Valley Creek between Stanley Lake Creek and the Salmon River. Critical habitat also includes all river lakes and reaches presently or historically accessible to Snake River sockeye salmon. Limiting factors identified for Snake River sockeye include: (1) Reduced tributary stream flow, (2) impaired tributary passage and blocks to migration, and (3) mainstem Columbia River hydropower system mortality (NMFS 2005a).

Steelhead

Figure 6 is a depiction of the distribution of the 11 threatened and endangered steelhead DPSs relative to Forest Service boundaries.

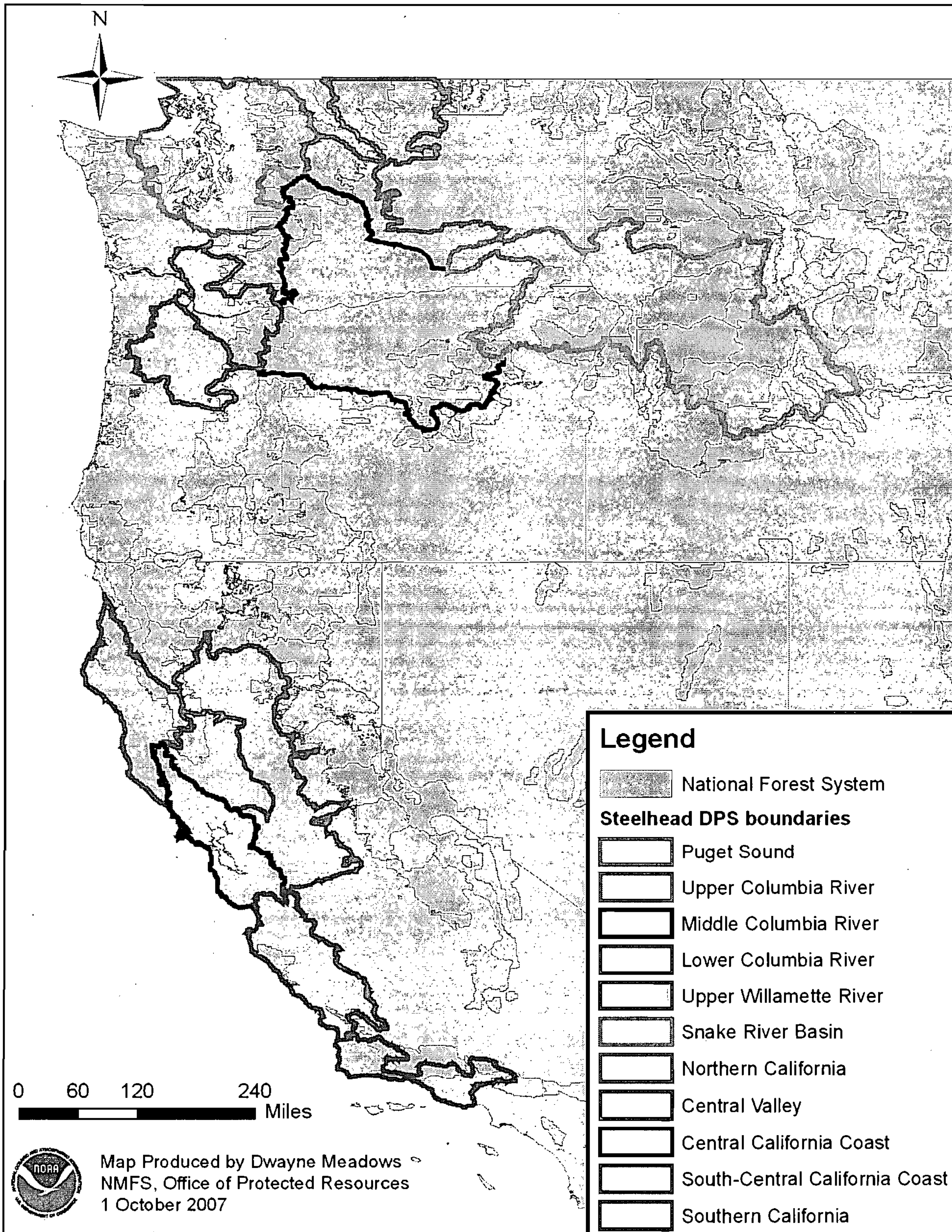
Steelhead are native to Pacific Coast streams extending from Alaska south to northwestern Mexico (Moyle 1976, NMFS 1997, Good *et al.* 2005). They can be divided into two basic run-types: the stream-maturing type, or summer steelhead, enters fresh water in a sexually immature condition and requires several months in freshwater to mature and spawn and the ocean-maturing type, or winter steelhead, enters fresh water with well-developed gonads and spawns shortly after river entry. Variations in migration timing exist between populations. Some river basins have both summer and winter steelhead, while others only have one run-type.

Summer steelhead enter fresh water between May and October in the Pacific Northwest (Busby *et al.* 1996, Nickelson *et al.* 1992). They require cool, deep holding pools during summer and fall, prior to spawning (Nickelson *et al.* 1992). They migrate inland toward spawning areas, overwinter in the larger rivers, resume migration in early spring to natal streams, and then spawn (Meehan and Bjornn 1991, Nickelson *et al.* 1992) in January and February (Barnhart 1986). Winter steelhead enter fresh water between November and April in the Pacific Northwest (Busby *et al.* 1996, Nickelson *et al.* 1992), migrate to spawning areas, and then spawn, generally in April and May (Barnhart 1986). Some adults, however, do not enter some coastal streams until spring, just before spawning (Meehan and Bjornn 1991).

There is a high degree of overlap in spawn timing between populations regardless of run type (Busby *et al.* 1996). Difficult field conditions at that time of year and the remoteness of spawning grounds contribute to the relative lack of specific information on steelhead spawning. Unlike Pacific salmon, steelhead are iteroparous, or capable of spawning more than once before death (Busby *et al.* 1996), although steelhead rarely spawn more than twice before dying; most that do so are females (Nickelson *et al.* 1992). Iteroparity is more common among southern steelhead populations than northern populations (Busby *et al.* 1996).

After 2 to 3 weeks, in late spring, and following yolk sac absorption, alevins emerge from the gravel and begin actively feeding. After emerging from the gravel, fry usually inhabit shallow water along banks of perennial streams. Fry occupy stream margins (Nickelson *et al.* 1992). Summer rearing takes place primarily in the faster parts of pools, although young-of-the-year are abundant in glides and riffles. Winter rearing occurs more uniformly at lower densities across a wide range of fast and slow habitat types. Some older juveniles move downstream to rear in larger tributaries and mainstem rivers (Nickelson *et al.* 1992).

Figure 6. US Forest Service Boundaries and Listed Steelhead Salmon Distributions



Juvenile steelhead migrate little during their first summer and occupy a range of habitats featuring moderate to high water velocity and variable depths (Bisson *et al.* 1988). Juvenile steelhead feed on a wide variety of aquatic and terrestrial insects (Chapman and Bjornn 1969), and older juveniles sometimes prey on emerging fry. Steelhead hold territories close to the substratum where flows are lower and sometimes counter to the main stream; from these, they can make forays up into surface currents to take drifting food. Juveniles rear in freshwater from 1 to 4 years, then smolt and migrate to the ocean in March and April (Barnhart 1986). Winter steelhead juveniles generally smolt after 2 years in fresh water (Busby *et al.* 1996). Juvenile steelhead tend to migrate directly offshore during their first summer from whatever point they enter the ocean rather than migrating along the coastal belt as salmon do. During the fall and winter, juveniles move southward and eastward (Hartt and Dell 1986 *op. cit.* Nickelson *et al.* 1992). Steelhead typically reside in marine waters for 2 or 3 years prior to returning to their natal stream to spawn as 4- or 5-year olds.

General life history information
Summer steelhead enter freshwater between May and October in the Pacific Northwest (Busby *et al.* 1996). Winter steelhead enter freshwater between November and April in the Pacific Northwest (Busby *et al.* 1996). Steelhead spawn in cool, clear streams featuring suitable gravel size, depth, and current velocity. Intermittent streams may also be used for spawning (Barnhart 1986, Everest 1973). Depending on water temperature, steelhead eggs may incubate for 1.5 to 4 months (61 FR 41542) before hatching. Juveniles rear in fresh water from one to four years, then migrate to the ocean as smolts (61 FR 41542). Winter steelhead populations generally smolt after two years in fresh water (Busby *et al.* 1996).

Dependence on Waters of the United States
Steelhead, like the other salmon discussed previously, survive only in aquatic ecosystems and, therefore, depend on the quantity and quality of those aquatic systems. Steelhead, like the other salmon NMFS has listed, have declined under the combined effects of overharvests in fisheries; competition from fish raised in hatcheries and native and non-native exotic species; dams that block their migrations and alter river hydrology; gravel mining that impedes their migration and alters the dynamics (hydrogeomorphology) of the rivers and streams that support juveniles; water diversions that deplete water levels in rivers and streams, destruction or degradation of riparian habitat that increase water temperatures in rivers and streams sufficient to reduce the survival of juvenile chum salmon; and land use practices (logging, agriculture, urbanization) that destroy wetland and riparian ecosystems while introducing sediment, nutrients, biocides, metals, and other pollutants into surface and ground water and degrade water quality in the freshwater, estuarine, and coastal ecosystems throughout the Pacific Northwest.

Puget Sound Steelhead
Distribution. Puget Sound steelhead occupy river basins of the Strait of Juan de Fuca, Puget Sound, and Hood Canal, Washington. Included are river basins as far west as the Elwha River and as far north as the Nooksack River. Puget Sound's fjord-like structure may affect steelhead migration patterns; for example, some populations of coho and Chinook salmon, at least historically, remained within Puget Sound and did not migrate to the Pacific Ocean itself. Even when Puget Sound steelhead migrate to the high seas, they may spend considerable time as juveniles or adults in the protected marine environment of Puget Sound, a feature not readily

accessible to steelhead from other areas of the Pacific Northwest. This species is primarily composed of winter steelhead but includes several stocks of summer steelhead, usually in subbasins of large river systems and above seasonal hydrologic barriers.

Status. Listed as a threatened species on May 11, 2007 (72 FR 26722). Run size for this DPS, was calculated in the early 1980s at about 100,000 winter-run fish and 20,000 summer-run fish. Its not clear what portion were hatchery fish, but a combined estimate with coastal steelhead suggested that roughly 70% of steelhead in ocean runs were of hatchery origin. The percentage in escapement to spawning grounds would be substantially lower due to differential harvest and hatchery rack returns. By the 1990s, total run size for four major stocks exceeded 45,000, roughly half of which was natural escapement.

Nehlsen *et al.* (1991) identified nine Puget Sound steelhead stocks at some degree of risk or concern, while the Washington Department of Fish and Wildlife *et al.* (1993) estimated that 31 of 53 stocks were of native origin and predominantly natural production. Their assessment of the status of these 31 stocks was 11 healthy, 3 depressed, 1 critical, and 16 of unknown status. Their assessment of the status of the remaining (not native/natural) stocks was 3 healthy, 11 depressed, and 8 of unknown status.

Of the 21 populations in the Puget Sound ESU reviewed by Busby *et al.* (1996), 17 had declining and four increasing trends, with a range from 18% annual decline (Lake Washington winter-run steelhead) to 7% annual increase (Skykomish River winter-run steelhead). Eleven of these trends (9 negative, 2 positive) were significantly different from zero. These trends were for the late-run naturally produced component of winter-run steelhead populations; no adult trend data were available for summer-run steelhead. Most of these trends were based on relatively short data series. The Skagit and Snohomish River winter-run populations have been approximately three to five times larger than the other populations in the DPS, with average annual spawning of approximately 5,000 and 3,000 total adult spawners respectively. These two basins exhibited modest overall upward trends at the time of the Busby *et al.* (1996) report. Busby *et al.* (1996) estimated 5-year average natural escapements for streams with adequate data range from less than 100 to 7,200, with corresponding total run sizes of 550 to 19,800.

Critical habitat. Critical habitat is under development.

Upper Columbia River Steelhead
Distribution. UCR steelhead occupy the Columbia River Basin upstream from the Yakima River, Washington, to the border between the United States and Canada. This area includes the Wenatchee, Entiat, and Okanogan Rivers. All UCR steelhead are summer steelhead. Steelhead primarily use streams of this region that drain the northern Cascade Mountains of Washington State. This species includes hatchery populations of summer steelhead from the Wells Hatchery because it probably retains the genetic resources of steelhead populations that once occurred above the Grand Coulee Dam. This species does not include the Skamania Hatchery stock because of its non-native genetic heritage.

Abundance estimates of returning naturally produced UCR steelhead have been based on extrapolations from mainstem dam counts and associated sampling information (e.g., hatchery/wild fraction, age composition). The natural component of the annual steelhead run over Priest Rapids Dam increased from an average of 1,040 (1992-1996), representing about 10% of the total adult count, to 2,200 (1997-2001), representing about 17% of the adult count during this period of time (ICBTRT 2003).

Status. UCR steelhead were originally listed as endangered in 1997, after their status was reviewed, they were reclassified to threatened on January 5, 2006 and then reinstated to endangered status per U.S. District Court decision in June 2007. This DPS includes all naturally spawned anadromous steelhead populations below natural and manmade impassable barriers in streams in the Columbia River Basin upstream from the Yakima River, Washington, to the U.S.-Canada border, as well six artificial propagation programs: the Wenatchee River, Wells Hatchery (in the Methow and Okanogan Rivers), Winthrop NFH, Omak Creek, and the Ringold steelhead hatchery programs. The ICBTRT has identified five populations within this DPS: the Wenatchee River, Entiat River, Methow River, Okanogan Basin, and Crab Creek.

Returns of both hatchery and naturally produced steelhead to the upper Columbia River have increased in recent years. The average 1997 to 2001 return counted through the Priest Rapids fish ladder was approximately 12,900 fish. The average for the previous five years (1992 to 1996) was 7,800 fish. Abundance estimates of returning naturally produced UCR steelhead have been based on extrapolations from mainstem dam counts and associated sampling information (e.g., hatchery/wild fraction, age composition). The natural component of the annual steelhead run over Priest Rapids Dam increased from an average of 1,040 (1992-1996), representing about 10% of the total adult count, to 2,200 (1997-2001), representing about 17% of the adult count during this period of time (ICBTRT 2003).

In terms of natural production, recent population abundances for both the Wenatchee and Entiat aggregate population and the Methow population remain well below the minimum abundance thresholds developed for these populations (ICBTRT 2005). A 5-year geometric mean (1997 to 2001) of approximately 900 naturally produced steelhead returned to the Wenatchee and Entiat rivers (combined). Although this is well below the minimum abundance thresholds, it represents an improvement over the past (an increasing trend of 3.4% per year). However, the average percentage of natural fish for the recent 5-year period dropped from 35% to 29%, compared to the previous status review. For the Methow population, the 5-year geometric mean of natural returns over Wells Dam was 358. Although this is well below the minimum abundance thresholds, it is an improvement over the recent past (an increasing trend of 5.9% per year). In addition, the 2001 return (1,380 naturally produced spawners) was the highest single annual return in the 25-year data series. However, the average percentage of wild origin spawners dropped from 19% for the period prior to the 1998 status review to nine percent for the 1997 to 2001 returns. This DPS is failing to meet viability criteria in all four categories; productivity, abundance, spatial structure, and genetic diversity.

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. Specific sites include freshwater spawning and rearing sites, freshwater migration corridors, estuarine areas free of obstruction, and offshore marine areas. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, and adequate passage conditions. The UCR steelhead DPS has 42 watersheds within its range. Three watersheds received a low rating, eight received a medium rating, and 31 rated a high conservation value to the DPS. In addition, the Columbia River rearing/migration corridor downstream of the spawning range was rated as a high conservation value. Limiting factors identified for the UCR steelhead include: (1) Mainstem Columbia River hydropower system mortality, (2) reduced tributary streamflow, (3) tributary riparian degradation and loss of in-river wood, (4) altered tributary floodplain and channel morphology, and (5) excessive fine sediment and degraded tributary water quality.

Middle Columbia River Steelhead

Distribution. Middle Columbia River (MCR) steelhead occupy the Columbia River Basin from Mosier Creek, Oregon, upstream to the Yakima River, Washington, inclusive (61 FR 41541). Steelhead from the Snake River Basin (described elsewhere) are excluded. This species includes the only populations of inland winter steelhead in the United States, in the Klickitat River and Fifteenmile Creek (Busby *et al.* 1996). Two hatchery populations are considered part of this species, the Deschutes River stock and the Umatilla River stock; listing for neither of these stocks was considered warranted. MCR steelhead occupy the intermontane region which includes some of the driest areas of the Pacific Northwest, generally receiving less than 15.7 inches of rainfall annually. Vegetation is of the shrub-steppe province, reflecting the dry climate and harsh temperature extremes. Because of this habitat, occupied by the species, factors contributing to the decline include agricultural practices, especially grazing, and water diversions and withdrawals. In addition, hydropower development has impacted the species by preventing these steelhead from migrating to habitat above dams, and by killing them in large numbers when they try to migrate through the Columbia River hydroelectric system.

Status. MCR steelhead were listed as threatened in 1999, and their status was reaffirmed on January 5, 2006 (71 FR 834). The ICBTRT (2003) identified 15 populations in four major population groups (Cascades Eastern Slopes Tributaries, John Day River, the Walla Walla and Umatilla Rivers, and the Yakima River) and one unaffiliated independent population (Rock Creek) in this species. There are two extinct populations in the Cascades Eastern Slope major population group, the White Salmon River and Deschutes Crooked River above the Pelton/Round Butte Dam complex.

Seven hatchery steelhead programs are considered part of the MCR steelhead species. These programs propagate steelhead in three of 16 populations and improve kelt survival in one population. No artificial programs produce the winter-run life history in the Klickitat River and Fifteenmile Creek populations. All of the MCR steelhead hatchery programs are designed to produce fish for harvest, although two are also implemented to augment the naturally spawning populations in the basins where the fish are released. The NMFS' assessment of the effects of artificial propagation on MCR steelhead extinction risk concluded that these hatchery programs collectively do not substantially reduce the extinction risk. Artificial propagation increases total species abundance, principally in the Umatilla and Deschutes Rivers. The kelt reconditioning efforts in the Yakima River do not augment natural abundance but do benefit the survival of the natural populations. The Touchet River Hatchery program has only recently been established, and its contribution to species viability is uncertain. The hatchery programs affect a small proportion of the species. Collectively, artificial propagation programs provide a slight beneficial effect to species abundance but have neutral or uncertain effects on species productivity, spatial structure, and diversity.

The precise pre-1960 abundance of this species is unknown, but historic run estimates for the Yakima River imply that annual species abundance may have exceeded 300,000 returning adults (Busby *et al.* 1996). MCR steelhead run estimates between 1982 and 2004 were calculated by subtracting adult counts for Lower Granite and Priest Rapids Dams from those at Bonneville Dam. The 5-year average (geometric mean) return of natural MCR steelhead for 1997 to 2001 was up from previous years' basin estimates. Returns to the Yakima River, the Deschutes River and sections of the John Day River system were substantially higher compared to 1992 to 1997 (Good *et al.* 2005). Yakima River returns are still substantially below interim target levels of 8,900 (the current 5 year average is 1,747 fish) and estimated historical return levels, with the majority of spawning occurring in one tributary, Satus Creek (Berg 2001). The recent 5-year geometric mean return of the natural-origin component of the Deschutes River run exceeded interim target levels (Good *et al.* 2005). Recent 5-year geometric mean annual returns to the John Day River basin are generally below the corresponding mean returns reported in previous status reviews. However, each major production area in the John Day system has shown upward trends since the 1999 return year (Good *et al.* 2005). The Touchet, and Umatilla are all below their interim abundance targets of 900 and 2,300, respectively. The 5 year average for these basins is 298, and 1,492 fish, respectively (Good *et al.* 2005).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. MCR steelhead have PCEs of 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, and adequate passage conditions. Although pristine habitat conditions are still present in some wilderness, roadless, and undeveloped areas, habitat complexity has been greatly reduced in many areas of designated critical habitat for MCR steelhead. Limiting factors identified for MCR steelhead include: (1) Hydropower system mortality; (2) reduced stream flow; (3) impaired passage; (4) excessive sediment; (5) degraded water quality; and (6) altered channel morphology and floodplain.

Lower Columbia River Steelhead

Distribution. LCR steelhead include naturally-produced steelhead returning to Columbia River tributaries on the Washington side between the Cowlitz and Wind rivers in Washington and on the Oregon side between the Willamette and Hood rivers, inclusive. In the Willamette River, the upstream boundary of this species is at Willamette Falls. This species includes both winter and summer steelhead. Two hatchery populations are included in this species, the Cowlitz Trout Hatchery winter-run stock and the Clackamas River stock but neither was listed as threatened.

Status. LCR steelhead were listed as threatened on March 19, 1998, and reaffirmed as threatened on January 5, 2006 (71 FR 834). The 1998 status review noted that this ESU is characterized by populations at low abundance relative to historical levels, significant population declines since the mid-1980s, and widespread occurrence of hatchery fish in naturally-spawning steelhead populations. During this review NMFS was unable to identify any natural populations that would be considered at low risk.

All 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 while in the 1990s fish abundance dropped to 1,000 to 2,000. Recent abundance estimates of natural-origin spawners range from completely extirpated for some populations above impassable barriers to over 700 for the Kalama and Sandy winter-run populations. A number of the populations have a substantial fraction of hatchery-origin spawners in spawning areas, and are hypothesized to be sustained largely by hatchery production. Exceptions are the Kalama, the Toutle, and East Fork Lewis winter-run populations. These populations have relatively low recent mean abundance estimates with the largest being the Kalama (geometric mean of 728 spawners).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more steelhead life stages. Specific sites include: 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 47 subbasins reviewed in NMFS' assessment of critical habitat for the LCR steelhead, 34 subbasins were rated as having a high conservation value, while 11 were rated as having a medium value and two were rated as having a low value to the conservation of the DPS.

Upper Willamette River steelhead

Distribution. Upper Willamette River steelhead occupy the Willamette River and its tributaries upstream of Willamette Falls. This is a late-migrating winter group that enters fresh water in March and April (Howell *et al.* 1985). Only the late run was included is the listing of this species, which is the largest remaining population in the Santiam River system.

Status. Upper Willamette River steelhead were listed as threatened in 1999, when their status was reviewed on January 5, 2006 they retained that classification (71 FR 834). A major threat to Willamette River steelhead results from artificial production practices. Fishways built at Willamette Falls in 1885 have allowed Skamania-stock summer steelhead and early-migrating winter steelhead of Big Creek stock to enter the range of Upper Willamette River steelhead. The population of summer steelhead is almost entirely maintained by hatchery salmon, although natural-origin, Big Creek-stock winter steelhead occur in the basin (Howell *et al.* 1985). In recent years, releases of winter steelhead are primarily of native stock from the Santiam River system.

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more steelhead life stages. Specific sites include 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, forage, adequate passage conditions, and floodplain connectivity. Of 43 subbasins reviewed in NMFS' assessment of critical habitat for the Upper Willamette River steelhead, 20 subbasins were rated as having a high conservation value, while 6 were rated as having a medium value and 17 were rated as having a low value to the conservation of the DPS.

Snake River Steelhead
Distribution. Snake River basin steelhead are an inland species that occupy the Snake River basin of southeast Washington, northeast Oregon, and Idaho. The Snake River Basin steelhead species includes all naturally spawned populations of steelhead (and their progeny) in streams in the Snake River basin of southeast Washington, northeast Oregon, and Idaho. Snake River Basin steelhead do not include resident forms of *O. mykiss* (rainbow trout) co-occurring with these steelhead. The historic spawning range of this species included the Salmon, Pahsimeroi, Lemhi, Selway, Clearwater, Wallowa, Grande Ronde, Imnaha, and Tucannon Rivers.

Status. Snake River steelhead were listed as threatened in 1997, when their status was reviewed on January 5, 2006 they retained that classification (71 FR 834). The ICBTRT (2003) identified 23 populations in the following six major population groups in this species: Clearwater River, Grande Ronde River, Hells Canyon, Imnaha River, Lower Snake River, and Salmon River. Snake River Basin steelhead remain spatially well distributed in each of the six major geographic areas in the Snake River basin (Good *et al.* 2005). Environmental conditions are generally drier and warmer in these areas than in areas occupied by other steelhead species in the Pacific Northwest. Snake River Basin steelhead were blocked from portions of the upper Snake River beginning in the late 1800s and culminating with the construction of Hells Canyon Dam in the 1960s. The Snake River Basin steelhead "B run" population levels remain particularly depressed. The ICBTRT has not completed a viability assessment for Snake River Basin steelhead.

The paucity of information on adult spawning escapement for specific tributary production areas for Snake River Basin steelhead made a quantitative assessment of viability difficult. Annual return estimates are limited to counts of the aggregate return over Lower Granite Dam, and spawner estimates for the Tucannon, Grande Ronde, and Imnaha Rivers. The 2001 return over Lower Granite Dam was substantially higher relative to the low levels seen in the 1990s; the recent 5-year mean abundance (14,768 natural returns) was approximately 28% of the interim recovery target level. The 10-year average for natural-origin steelhead passing Lower Granite Dam between 1996 and 2005 is 28,303 adults. Parr densities in natural production areas, which are another indicator of population status, have been substantially below estimated capacity for several decades. The Snake River supports approximately 63% of the total natural-origin production of steelhead in the Columbia River Basin.

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more life stages of steelhead. The critical habitat designation for this ESU identifies PCEs that include sites necessary to support one or more steelhead life stages. Specific sites include 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. Of the 291 fifth order streams reviewed in this DPS, 220 were rated as high, 44 were rated as medium, and 27 were rated as low conservation value. The physical or biological features that characterize these sites include water quality and quantity, natural cover, and adequate forage. Limiting factors identified for Snake River Basin steelhead include: (1) Hydrosystem mortality, (2) reduced stream flow, (3) altered channel morphology and floodplain, (4) excessive sediment, (5) degraded water quality, (6) harvest impacts, and (7) hatchery impacts (NMFS 2006).

Northern California Steelhead

Distribution. Northern California steelhead includes steelhead in California coastal river basins from Redwood Creek south to the Gualala River, inclusive.

Status. Northern California steelhead were listed as threatened on June 7, 2000, and when their status was reviewed on January 5, 2006 they retained that classification (71 FR 834). Long-term data sets are limited for this Northern California steelhead. Before 1960, estimates of abundance specific to this DPS were available from dam counts in the upper Eel River (Cape Horn Dam–annual average of 4,400 adult steelhead in the 1930s), the South Fork Eel River (Benbow Dam–annual average of 19,000 adult steelhead in the 1940s), and the Mad River (Sweasey Dam–annual average of 3,800 adult steelhead in the 1940s). Estimates of steelhead spawning populations for many rivers in this DPS totaled 198,000 by the mid-1960s. At the time of the first status review on this population, adult escapement trends could be computed on seven populations. Five of the seven populations exhibited declines while two exhibited increases with a range of almost 6% annual decline to a 3.5% increase. At the time little information was available on the actual contribution of hatchery fish to natural spawning, and little information on present total run sizes for the DPS (Busby *et al.* 1996).

More recent time serious data come from snorkel counts conducted on summer-run steelhead int eh Middle Fore Eel River. An estimate of lambda over the interval 1966 to 2002 was made and a random-walk with drift model fitted using Bayesian assumptions. 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).

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more steelhead life stages. Specific sites include 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, and adequate forage.

South-Central California Coast Steelhead

Distribution. The South-Central California steelhead DPS includes all naturally spawned populations of steelhead (and their progeny) in streams from the Pajaro River (inclusive) to, but not including the Santa Maria River, California.

Status. South-Central California Coast steelhead were listed as threatened in 1997, when their status was reviewed on January 5, 2006 they retained that classification (71 FR 834). Historical data on the South-Central California Coast steelhead DPS are limited. In the mid-1960s the California Department of Fish and Game estimated that the adult population at about 18,000. We know of no recent estimates of the total DPS. However, five river systems, the Pajaro, Salinas, Carmel, Little Sur, and Big Sur, indicate that runs are currently less than 500 adults. Past estimates for these basins were almost 5,000 fish. Carmel River time series data indicate that the population declined by about 22% per year between 1963 and 1993 (Good *et al.* 2005). From 1991 the population increased from one adult, to 775 adults at San Clemente Dam. Good *et al.* (2005) thought that this recent increase seemed to great to attribute simply to improved reproduction and survival of the local steelhead population. Other possibilities were considered including that the substantial immigration or transplantation occurred, or that resident trout production increased as a result of improved environmental conditions within the basin.

Critical habitat. Critical habitat was designated for this species on September 2, 2005 (70 FR 52488). 2005. The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more steelhead life stages. Specific sites include 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, and adequate forage.

Southern California Steelhead

Distribution. Southern California steelhead occupy rivers from the Santa Maria River to the U.S. –Mexico border.

Status. Southern California steelhead were listed as endangered in 1997, when their status was reviewed on January 5, 2006 they retained that classification (71 FR 834). In many watersheds throughout Southern California, dams isolate steelhead from historical spawning and rearing habitats and alter the hydrology of the basin (e.g., Twitchell Reservoir within the Santa Maria River watershed, Bradbury Dam within the Santa Ynez River watershed, Matilija and Casitas dams within the Ventura River watershed, Rindge Dam within the Malibu Creek watershed). 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. 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).

Critical habitat. Critical habitat was designated for this species on September 2, 2005. The designation identifies PCEs that include sites necessary to support one or more steelhead life stages and, in turn, these sites contain the physical or biological features essential for the species conservation. Specific sites include freshwater spawning sites, freshwater rearing sites, freshwater migration corridors, and estuarine areas. The physical or biological features that characterize these sites include water quantity, depth, and velocity, shelter, cover, living space and passage conditions.

California Central Valley Steelhead
Distribution. California central valley steelhead occupy the Sacramento and San Joaquin Rivers and their tributaries.

Status. California Central valley steelhead were listed as threatened in 1998, when their status was reviewed on January 5, 2006 they retained that classification. Central Valley steelhead were listed as threatened under the ESA on March 19, 1998. This DPS consists of steelhead populations in the Sacramento and San Joaquin River (inclusive of and downstream of the Merced River) basins in California's Central Valley. Steelhead historically were well distributed throughout the Sacramento and San Joaquin Rivers (Busby *et al.* 1996). Steelhead were found from the upper Sacramento and Pit River systems (now inaccessible due to Shasta and Keswick Dams), south to the Kings and possibly the Kern River systems (now inaccessible due to extensive alteration from water diversion projects), and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). The present distribution has been greatly reduced (McEwan and Jackson 1996). Steelhead habitat in the basin has been hypothesized to have been reduced from 6,000 miles historically to 300 miles today. Historically, steelhead probably ascended Clear Creek past the French Gulch area, but access to the upper basin was blocked by Whiskeytown Dam in 1964 (Yoshiyama *et al.* 1996). Steelhead also occurred in the upper drainages of the Feather, American, Yuba, and Stanislaus Rivers which are now inaccessible (McEwan and Jackson 1996, Yoshiyama *et al.* 1996).

Historic Central Valley steelhead run size is difficult to estimate given the paucity of data, but 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 counts at Red Bluff Diversion 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, with an estimated total annual run size for the entire Sacramento-San Joaquin system, based on Red Bluff Diversion Dam counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at Red Bluff Diversion Dam ended in 1993 due to changes in dam operations.

The only consistent data available on steelhead numbers in the San Joaquin River basin come from DFG mid-water trawling samples collected on the lower San Joaquin River at Mossdale. These data indicate a decline in steelhead numbers in the early 1990s, which have remained low through 2002 (DFG 2003). In 2004, a total of 12 steelhead smolts were collected at Mossdale (DFG, unpublished data).

Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Populations may exist in Big Chico and Butte Creeks and a few wild steelhead are produced in the American and Feather Rivers (McEwan and Jackson 1996).

Recent snorkel surveys (1999 to 2002) indicate that steelhead are present in Clear Creek (J. Newton, FWS, pers. comm. 2002, as reported in Good *et al.* 2005). Because of the large resident *O. mykiss* population in Clear Creek, steelhead spawner abundance has not been estimated.

Until recently, steelhead were thought to be extirpated from the San Joaquin River system. Recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be void of steelhead (McEwan 2001). On the Stanislaus River, steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995. It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring programs.

Critical habitat. *Critical habitat was designated for this species on September 2, 2005 (70 FR 52488).* The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more life stages of steelhead. The critical habitat designation for this DPS identifies PCEs that include sites necessary to support one or more steelhead life stages. Specific sites include 1) freshwater spawning, 2) freshwater rearing, 3) freshwater migration, 4) estuarine areas free of obstruction, 5) nearshore marine areas free of obstructions, and 6) offshore marine areas with good water quality. The physical or biological features that characterize these sites include water quality and quantity, natural cover, and adequate forage.

Shortnose sturgeon

Figures 7a and 7b are depictions of shortnose sturgeon habitat along the Ocala and Francis Marion National Forests. Shortnose sturgeon are present in the full length of each river within each National Forest.

Figure 7A. Ocala Forest Boundary and Shortnose Sturgeon Distribution

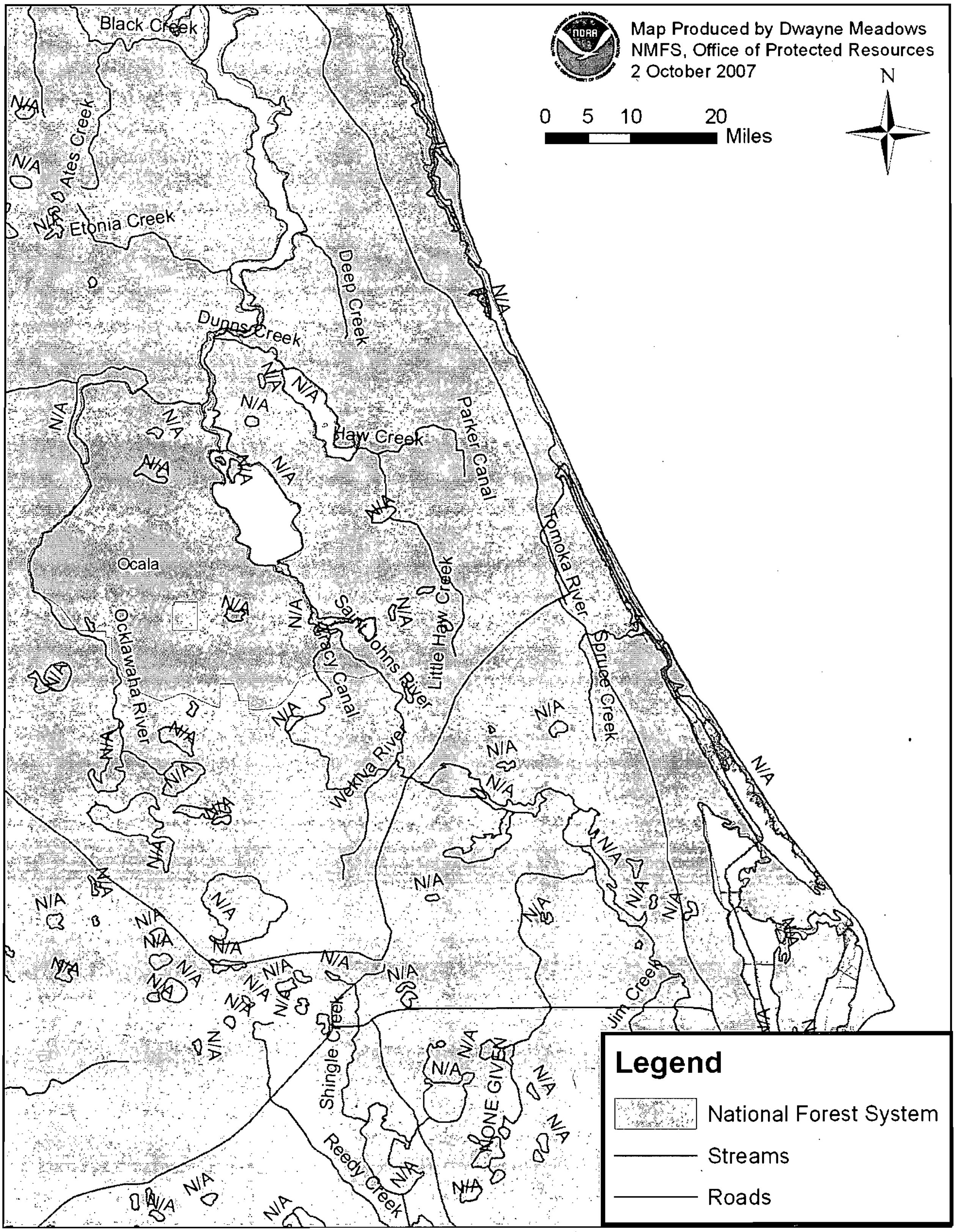
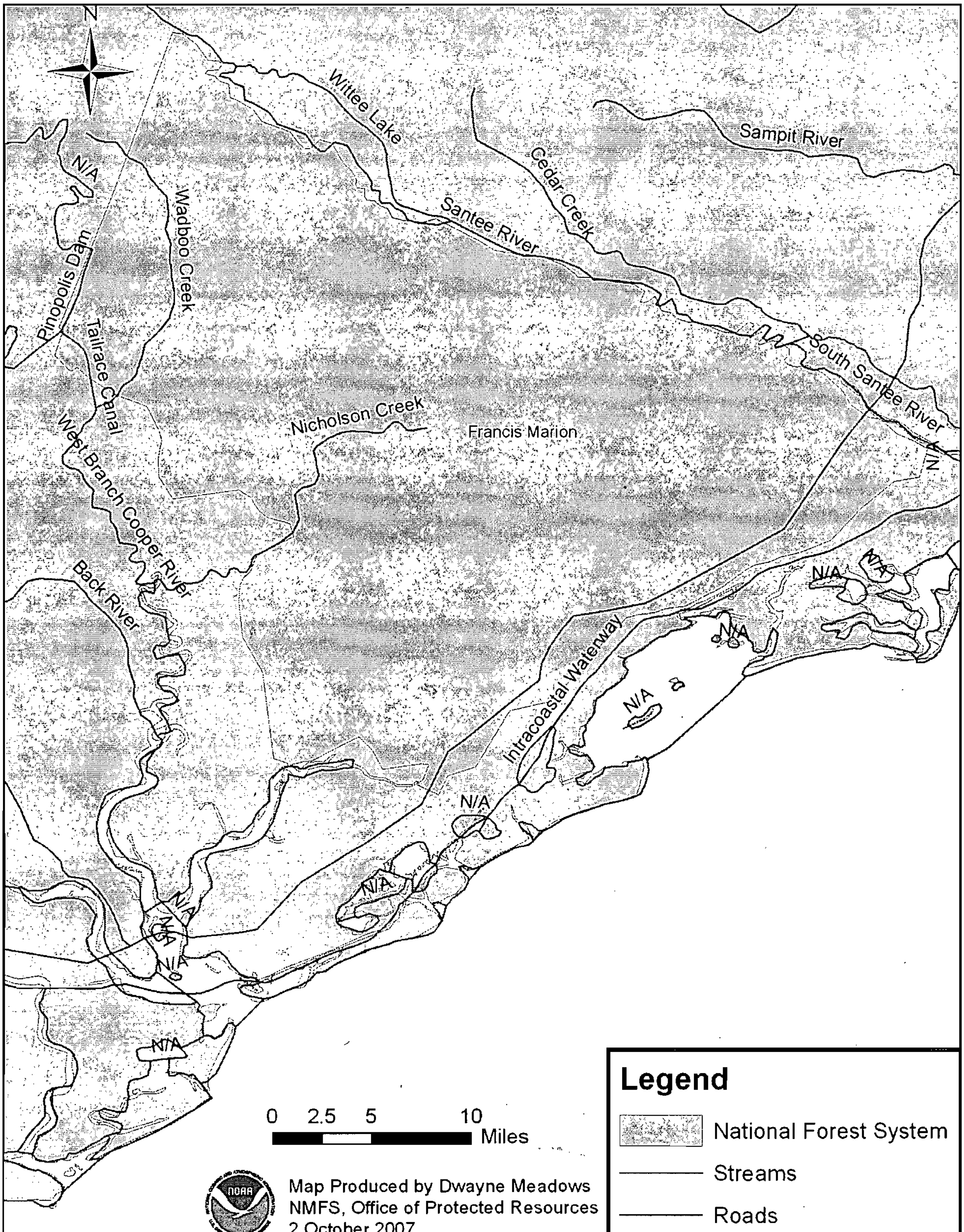


Figure 7B. Francis Marion Forest Boundary and Shortnose Sturgeon Distribution



Dependence on Waters of the United States
Shortnose sturgeon are anadromous fish that live primarily in slower-moving rivers or nearshore waters; they prefer nearshore marine, estuarine, and riverine habitats near large river systems. They are benthic omnivores that feed on crustaceans, insect larvae, worms and mollusks (NMFS 1998) but they have also been observed feeding off plant surfaces and on fish bait (Dadswell *et al.* 1984).

During the summer and winter, adult shortnose sturgeon occur in freshwater reaches of rivers or river reaches that are influenced by tides; as a result, they often occupy only a few short reaches of a river's entire length (Buckley and Kynard 1985). During the summer, at the southern end of their range, shortnose sturgeon congregate in cool, deep, areas of rivers where adult and juvenile sturgeon can take refuge from high temperatures (Flournoy *et al.* 1992, Rogers and Weber 1994, Rogers and Weber 1995, Weber 1996). Juvenile shortnose sturgeon generally move upstream for the spring and summer seasons and downstream for fall and winter; however, these movements usually occur above the salt- and freshwater interface of the rivers they inhabit (Dadswell *et al.* 1984, Hall *et al.* 1991). Adult shortnose sturgeon prefer deep, downstream areas with soft substrate and vegetated bottoms, if present. While shortnose sturgeon are occasionally collected near the mouths of coastal rivers, they are not known to engage in coastal migrations (Dadswell *et al.* 1984).

Distribution. Shortnose sturgeon occur along the Atlantic Coast of North America, from the St. John River in Canada to the St. John's River in Florida. Nineteen, geographically-distinct populations of shortnose sturgeon in the wild are distributed from New Brunswick, Canada; Maine; Massachusetts; Connecticut; New York; New Jersey and Delaware; Chesapeake Bay and Potomac River; North Carolina; South Carolina; Georgia; and Florida. Two additional, geographically distinct populations represent shortnose sturgeon that were isolated by dams occur in the Connecticut River (above the Holyoke Dam) and in Lake Marion on the Santee-Cooper River system in South Carolina (above the Wilson and Pinopolis Dams).

Status. Shortnose sturgeon were listed as endangered on March 11, 1967 (32 FR 4001) and remained on the endangered species list with enactment of the Endangered Species Act of 1973, as amended. These sturgeon were listed as endangered because of population declines resulting from the construction of dams in the large river systems of the northeastern United States during the late-1800s and early-1900s, dredging, the effects of water pollution, bridge construction, and incidental capture in commercial fisheries. More recently, alteration of freshwater flows into the estuaries of rivers had reduced the nursery habitat of juvenile shortnose sturgeon and larval and juvenile shortnose sturgeon have been killed after being impinged on the intake screens or entrained in the intake structures of power plants on the Delaware, Hudson, Connecticut, Savannah and Santee rivers.

Critical habitat. Critical habitat has not been designated for shortnose sturgeon.

Green Sturgeon (Southern Population)

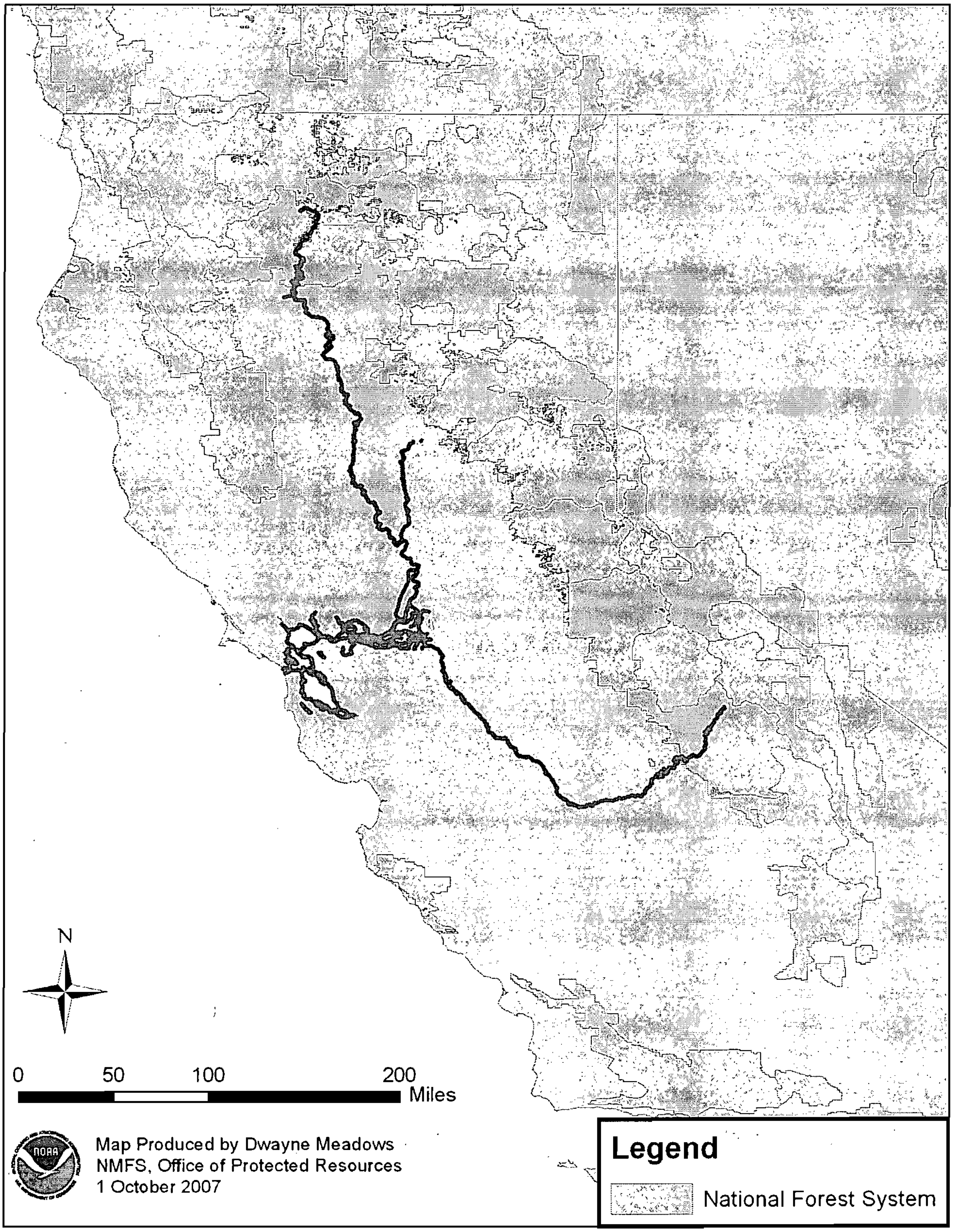
Distribution. The southern population of green sturgeon occurs in the freshwater and estuarine waters of the Sacramento and Feather Rivers in central California (Figure 8), though there is uncertainty surrounding the extent of their distribution.

Status. The southern population of Green sturgeon was listed as threatened on April 7, 2006, primarily because of population declines caused by dams the prevented them from reaching spawning areas located above the dams (USFWS 1995). Population abundance information concerning the Southern DPS of North American green sturgeon is limited, and comes largely from incidental captures during the white sturgeon (*Acipenser transmontanus*) monitoring program by the California Department of Fish and Game. The California Department of Fish and Game uses a multiple-census or Peterson mark-recapture method to estimate the legal population of white sturgeon captures in trammel nets. By comparing ratios of white sturgeon to green sturgeon captures, CDFG provides estimates of adult and sub-adult North American green sturgeon abundance. Estimated abundance between 1954 and 2001 ranged from 175 fish to more than 8,000 per year and averaged 1,509 fish per year. Unfortunately, there are many biases and errors associated with these data, and CDFG does not consider these estimates reliable.

Fish monitoring efforts at Red Bluff Diversion Dam and Glen Colusa Irrigation District on the upper Sacramento River have captured between 0 and 2,068 juvenile North American green sturgeon per year, mostly between June and July. The only existing information regarding changes in the abundance of the Southern DPS of North American green sturgeon includes changes in abundance at the John Skinner Fish Protection Facility between 1968 and 2001 (State facility). The estimated average annual number of North American green sturgeon taken at the State Facility prior to 1986 was 732; from 1986 on, the average annual number was 47 (70 FR 17386). For the Tracy Fish Collection Facility (Federal facility), the average annual number prior to 1986 was 889; from 1986 to 2001 it was 32. In light of the increased exports, particularly during the previous 10 years, it is clear that the abundance of the Southern DPS of North American green sturgeon is dropping. Catches of sub-adult and adult North American green sturgeon by the Interagency Ecological Program between 1996 and 2004 ranged from 1 to 212 green sturgeon per year (212 occurred in 2001), however, the portion of these catches that were made up of the Southern DPS of North American green sturgeon is unknown as these captures were primarily located in San Pablo Bay which is known to consist of a mixture of the Northern and Southern population segments. Additional analysis of North American green and white sturgeon taken at the State and Federal facilities indicates that take of both North American green and white sturgeon per acre-foot of water exported has decreased substantially since the 1960's.

Larval and post larval North American green sturgeon are caught each year in rotary screw traps at the Red Bluff Diversion Dam. A total of 2,608 juvenile sturgeon were captured from 1994-2000. All were assumed to be North American green sturgeon since 124 of these fish were grown by the University of California, Davis' researchers to an identifiable size and all were North American green sturgeon. Young sturgeon appear in catches from early May through August. Most range in size from 1 to 3 inches. Catch rates were greatest in 1995 and 1996 and were lowest in 1999 and 2000.

Figure 8. US Forest Service Boundaries and Listed Green Sturgeon Distributions



No North American green sturgeon have been detected during intensive salmonid monitoring efforts in Clear, Battle, Butte, Deer and Mill creeks, all of which are tributaries to the Sacramento River. Sampling on these tributaries includes monitoring adult passage at fish ladders (Battle Creek), snorkel surveys (Deer, Butte, Clear and Battle creeks), and rotary screw trapping (Deer, Mill, Clear, Battle and Butte creeks). Much of this monitoring has occurred during time periods when adult North American green sturgeon would be expected to be in the rivers spawning, and when juvenile North American green sturgeon would be expected to be hatching, rearing and migrating through the river systems.

Similar monitoring activities have likewise failed to detect North American green sturgeon in the American River. These sampling efforts included snorkeling, rotary screw trapping, and seining, and were conducted during periods when adult and juvenile North American green sturgeon would have been expected to be in the river.

Green and white sturgeon adults have been observed periodically in small numbers in the Feather River. There are at least two confirmed records of adult North American green sturgeon. There are no records of larval or juvenile sturgeon of either species, even prior to the 1960's when Oroville Dam was built. During high flow years, green sturgeon may reproduce in the Feather River.

Dependence on Waters of the United States. The status reviews, proposed and final regulations to list green sturgeon as threatened did not identify water quality as a problem. Further, the published literature on green sturgeon provides limited information on the ecological relationship between green sturgeon and water quality. However, studies from other sturgeon demonstrates that sturgeon populations are limited by low levels of dissolved oxygen levels and high temperatures in the rivers, streams, and estuaries they occupy; juvenile anadromous sturgeon also depend on the freshwater-brackish interface in the tidal portion of rivers for nursery areas.

Critical habitat. Critical habitat has not been designated for green sturgeon.

Environmental Baseline

By regulation, the environmental baseline for biological opinions include the past and present impacts of all state, Federal 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 (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. The baseline analysis "is not the proportional share of responsibility the Federal agency bears for the decline in the species, but what jeopardy might result from the agency's proposed actions in the present and future human and natural contexts." (Pacific Coast Federation, 426 F3d at 1093).

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 *Effects of the Action*, and *Cumulative Effects* sections of this biological opinion. When we "add" the effects of a new, continuing, or proposed action to the prior condition of endangered and threatened individuals and designated critical habitat, as our regulations require, our assessments are more likely to detect a proposed action's "true" consequences on endangered species, threatened species, and designated critical habitat.

Because this is a programmatic consultation, however, on what is essentially a continuing action with a broad geographic scope that encompasses many waters of the United States this environmental baseline serves a slightly different purpose. The environmental baseline for this consultation focuses on the status and trends of the aquatic ecosystems in the United States and the consequences of that status for listed resources that occur in a general region. Since 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 five broad geographic regions: the Northeast Atlantic Region, the Southeast Atlantic Region, the Gulf Coast Region, the Southwest Region, and the Pacific Northwest 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.

Baseline Conditions During a Fire

During this assessment, we evaluated several potential stressors associated with the proposed action including the general risk of fire and the frequency of fire retardant use, the regional distribution of species and the likelihood they would be exposed to retardants, the direct effects to exposed species, the indirect effects to exposed species, and the effects to their critical habitat. The narratives that follow describe the exposure, response, and risk to listed species, their forage resources, and their critical habitat in greater detail, based on the best scientific and commercial evidence available.

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 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 United States (Figure 9). Since 1960 total acreage burned has ranged from 1.14 million acres in 1984 to as many as 9.87 million acres in 2006. For three consecutive years, 2004 to 2006, total acreage burned by wildland fires set new record highs (NIFC 2007). According to the USFS, between 1950 and 1970 fire suppression activities resulted in relatively stable burned areas, whereas the 1980s marked an increase of wildfires, due in part to unprecedented success of fire suppression and its effects on forest conditions (USFS 2005). In 2006 USFS lands accounted for approximately 20.7% of the burned lands nationwide (2.04 million acres of 9.87 million acres). While the 2007 fire season is not yet over (it was nearing its end at the writing of this Opinion), to date, USFS lands account for 32% of the burned lands nationwide (2.6 million acres of 8.16 million acres; NIFC 2007).

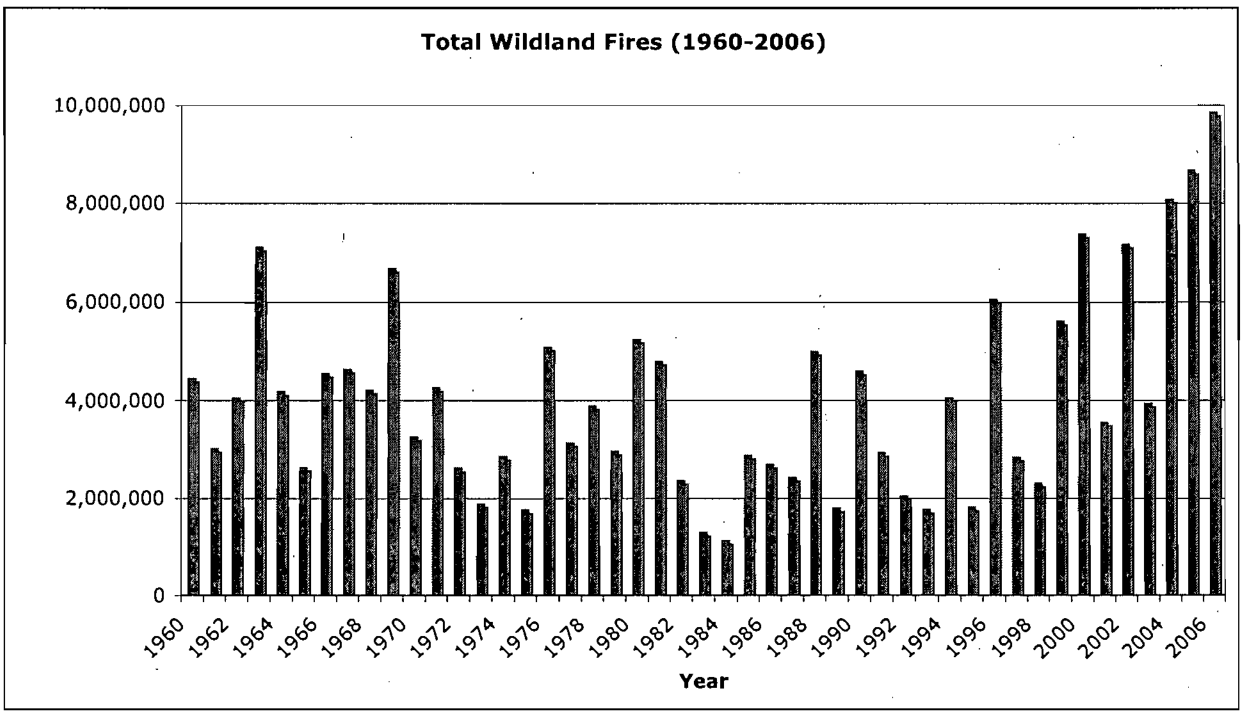


Figure 9. Total Wildland Fires in the United States between 1960 and 2006 (NFIC 2007. Note: Statistics were compiled by state and agency prior to 1983; 2004 data does not include fires in North Carolina).

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 degree of departure from natural fire regimes. As fire size increases, so do the chances of adverse effects, although, as mentioned above, most fires are small in size. 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); however, fire is also one of the dominant habitat-forming processes in mountain streams (Bisson *et al.* 2003). As a result, many large fires burning near streams can result in fish kills with the survivors actively moving downstream to avoid the poor water quality (Gresswell 1999, Rinne 2004). The patchy, mosaic pattern burned by fires provides a refuge for those 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 (USFS 2000). 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).

The presence of ash also has indirect 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 indirectly 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 furthermore have 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. As a result, we expect listed fish species will be exposed to an increasing number of fires and fire fighting techniques over time.

Northeast Atlantic Region

This region encompasses Maine, New Hampshire, Massachusetts, Connecticut, New York, New Jersey, Delaware, Pennsylvania, Maryland and Virginia. The region is ecologically diverse, encompassing several broad ecoregions—according to Bailey's (1995) *Description of the Ecoregions of the United States* this region encompasses the warm continental, the hot continental and the hot continental mountains divisions —these ecoregions can be further subdivided into provinces based on vegetation (Bailey 1995). This region encompasses the New England/Acadian mixed forests and the Northeastern Coastal Forests. The headwaters of the Connecticut River originate in New England/Acadian forests, and as the river descends, it transitions from boreal forest to temperate deciduous forest. As the river flows through the low gradient coastal region, the ecoregion transitions to Northeastern Coastal Forest. The headwaters of the Hudson River flow through Eastern Forest/Boreal Transition ecoregions. As the river descends, it transitions to Eastern Great Lakes Lowland Forest and then Northeastern Coastal Forest. The headwaters of the Delaware River originate in the Allegheny Highland Forest ecoregion, and then as the river descends, it transitions to Appalachian/Blue Ridge Forest and then Northeastern Coastal Forest ecoregions.

In this section, we describe several basins and estuarine complexes to characterize the general ecology and natural history of the area, and past and current human activities and their impacts on the area. In certain instances we described some river basins in further detail to provide additional context for evaluating the influence of the environmental baseline on listed species under NMFS' jurisdiction and the health of the environment.

New England Drainages
Natural History

This region encompasses drainages entering the Gulf of Maine, and encompasses all of Maine, parts of New Hampshire, Massachusetts the Canadian provinces of New Brunswick and Nova Scotia. Characterized by a temperate climate and a rocky coastline, the greater Gulf of Maine encompasses the Bay of Fundy, Casco Bay, Massachusetts Bay, Merrymeeting Bay and Cape Cod Bay. Significant Rivers that drain into the Gulf of Maine include the St. John, St. Croix, Penobscot River Basin, Kennebec/Androscoggin River Basin and the Merrimack River Basin. Estuaries within the Gulf of Maine were formed by glaciers and as a result have characteristically rocky shorelines, shallow soils, and deeply carved channels. The Gulf of Maine is semi-enclosed—bounded to the south by Georges Banks and to the north by Brown's Bank. The area is more strongly influenced by the Labrador Current, which makes the waters significantly colder and more nutrient rich than waters to the south that are more strongly influenced by the Gulf Stream.

The cold waters of the Gulf make it one of the most productive marine ecosystems in the world. The Gulf is characterized by salt marshes, kelp and seagrass beds, tidal mudflats, and underwater rocky outcrops form the foundation of a complex ecosystem and provide habitat for Atlantic herring (*Clupea harengus*), American lobster (*Homarus americanus*), Atlantic salmon, several whale species including endangered Northern right whales—where they are regularly observed in the spring and summer at regular nursery and feeding areas.

Penobscot River Basin

The Penobscot River flows 275 miles to the ocean, with the largest watershed in Maine of 8,592 square miles (mi^2) (Jackson *et al.* 2005). The river flows from the mountains of western Maine, including Maine's highest peak, Mt. Katahdin to the ocean near the town of Bucksport, Maine. The Penobscot basin was formed by glaciation during the last ice age and the river's bed is composed of glacial deposits and granitic bedrock. The average precipitation is approximately 42 inches per year. At the mouth, the average discharge is 10.1 billion gallons each day, or 14,000 cubic feet per second, but the discharge fluctuates seasonally and with dam releases, with naturally higher flows in the spring (Hasbrouck 1995, MaineRivers 2007a). The river and estuary are also important for many fish species, with 45 freshwater and 39 salt water species having been recorded in the river or estuary. Despite being home to so many fish, there are only three nonnative species (Baum 1983, Jackson *et al.* 2005). The Penobscot estuary extends from Bangor downstream to Penobscot Bay in the Gulf of Maine, approximately 31 miles, making it the largest estuary in Maine and one of the largest on the East Coast (PEARL 2007). Downstream of Bangor, the river is a tidally influenced, salt-wedge estuary. The majority of the estuary is bedrock-based, and sediment deposits are limited to isolated coves and near marshes.

Merrymeeting Bay Drainages

Merrymeeting Bay is the largest, freshwater tidal estuary, approximately 18.6 miles upstream of the mouth of the estuary that enters the Gulf of Maine (Kistner and Pettigrew 2001, Jackson *et al.* 2005). The Kennebec and Androscoggin Rivers, along with four smaller tributaries, converge to form the bay, although the two large rivers account for 98% of the inflow. Merrymeeting Bay typically has the largest freshwater outflow to the Gulf of Maine, usually exceeding 15,000 cubic feet per second. These high flows thoroughly flush the bay and have prevented eutrophication. The bay substrate is mud, sand, and exposed bedrock.

In Merrymeeting Bay, sampling only sandy substrate, which doesn't hold as much contaminant as muddy substrates due to less surface area, some toxic substances were identified. Sediments associated with the Androscoggin River had higher levels of PAHs and mercury, while sediments from the Kennebec River had higher levels of chromium, arsenic, and selenium (Hayden 1998). The bay has more moderate levels of these toxins than the rivers themselves. Chilcote and Waterfield (1995) found that levels of arsenic are higher than levels identified by EPA as likely to have adverse effects. At one station, PAHs from the Androscoggin also exceeded EPA identified levels of minimal effects. In this region of the Gulf of Maine, metal deposition is linked more to the Androscoggin and Kennebec than the Sheepscot River. Based on benthic samples taken in 1980 and again in 1991, it appears that all metals are declining in Merrymeeting bay except for copper, which showed an increase (Hayden 1998). Commercially important fish also have elevated metal concentrations in their livers, which is thought to be from their time spent in Merrymeeting Bay (Kirtner and Pettigrew 2001).

The Kennebec River flows 230 miles from the headwaters to the ocean, with a watershed of 5,384 mi^2 (Jackson *et al.* 2005, MaineRivers 2007b). The Kennebec River basin is primarily medium to coarse sand with some glacial till overlaying bedrock. Average precipitation is 42.5 inches of rain per year (Jackson *et al.* 2005). The average discharge at the mouth of the Kennebec River is 5,893 million gallons per day, with natural and controlled discharges similar to those seen on other Maine rivers (MaineRivers 2007b). There are 48 species of freshwater fish that use the Kennebec, including 10 nonnative species.

The Androscoggin River travels 164 miles, with a watershed of 3,263 mi^2 (Jackson *et al.* 2005, MaineRivers 2007c). The river flows from northwest Maine, into New Hampshire, and then back into Maine, where it meets the Kennebec River in Merrymeeting Bay. The Androscoggin has been Maine's principle industrial river (MaineRivers 2007c). The average precipitation in the watershed is 43.7 inches per year, resulting in an average discharge at the mouth of the Androscoggin, entering Merrymeeting Bay, of approximately 4,190 million gallons each day. The river is home to 33 freshwater fish and 7 estuarine fish, including 8 nonnative species (Jackson *et al.* 2005).

Merrimack River Basin

The Merrimack River is 180 miles long, with 16 sub-basins in a watershed of 5,014 mi^2 (Jackson *et al.* 2005, MRWCI 2007a). Seventy five percent of the watershed is in New Hampshire, with the rest in northeast Massachusetts. The precipitation is approximately 36 inches per year, with an average discharge of 5,364 million gallons per day, or 8,299 cubic feet per second. The geology of the Merrimack is dominated by granitic bedrock. The river is home to 50 species of fish, including 5 nonnative species (Jackson *et al.* 2005). For the lowest nine miles of the

Merrimack River, extending north into New Hampshire and south to Cape Ann, Massachusetts, there are 25,000 acres of estuarine habitat and 15,000 acres of salt marsh habitat, which is referred to as the Great Marsh (USGS 2003).

Human Activities and Their Impacts
Land Use

Most of the watersheds within this region are heavily forested with relatively small areas of highly urbanized lands. Land use in the Penobscot watershed is 5% agriculture and 95% forest and wetland (90% forest and forested wetlands). There are approximately 21 people per square mile living in the Penobscot watershed, and the largest town is Bangor, consisting of 33,000 people (Jackson *et al.* 2005). While there is not much urban development in the watershed, Doggett and Sowles (1989) report tanneries, metal finishing, pulp and paper mills, textile plants, chemical products, and municipal sewage contribute chromium, mercury, zinc, copper, lead, arsenic, hydrocarbons, dioxins, PAHs, pesticides, and other contaminants to the river.

The Kennebec River watershed usage is 82% forest, 10% water, 6% agriculture, 2% developed (Jackson *et al.* 2005). The only major town in the watershed is Augusta, Maine, but there are approximately 39 people per square mile throughout the watershed (Jackson *et al.* 2005). Currently, the primary pollution source on the river is from two pulp and paper mills, but there were multiple historical polluters along the river. The river exceeds recommended levels of dioxins, arsenic, cadmium chromium, copper, lead, mercury, nickel, silver, zinc, and PAHs in the sediments and surface water (MDEP 1999, Harding Lawson Associates 1999, Harding Lawson Associates 2000). Since 1990, the levels of dioxins in other rivers in Maine have been decreasing, but the levels in the Kennebec have remained constant (Kahl 2001).

The Androscoggin River watershed usage is 5% agriculture, 86% forested, 7% water, and 2% developed (Jackson *et al.* 2005). Major towns in the Androscoggin watershed are Auburn, Lewiston, and Brunswick. The human population in the watershed is approximately 65 people per square mile (Jackson *et al.* 2005). Throughout the 20^{th} century, textile mills, paper and pulp mills, and municipalities contributed large quantities of pollutants to the river. At one time it was considered one of the 10 most polluted rivers in the country and was one of the reasons for the implementation of the Clean Water Act. The river has become much cleaner since the CWA was passed, but pesticides, mercury, lead, sedimentation, total suspended solids, PCBs, and dioxins are still considered too high (Chamberland *et al.* 2002).

The Merrimack River watershed is composed of 75% forest, 13% urban, 6% agriculture, 5% surface water, and 1% other (Jackson *et al.* 2005). The Merrimack River flows through industrial centers Manchester and Concord, New Hampshire, and Lowell and Lawrence, Massachusetts. There are approximately 404 people per square mile in the Merrimack watershed (Jackson *et al.* 2005). The biggest sources of pollution facing the river are combined sewage overflows, industrial discharge, urbanization and its associated run-off (USACE 2003). The upper mainstem of the river has problems with bacteria, E. coli, and acidity, while the lower mainstem has problems with bacteria, metals, nutrients, dioxins, turbidity and suspended solids, and un-ionized ammonia. In all, over 125 miles of mostly lower watershed areas do not support their designated uses (USACE 2003).

Hydromodification Projects

There are five major hydroelectric dams along the mainstem of the Penobscot River as well as 111 other licensed dams located along the river and its tributaries. Atlantic salmon historically migrated as far as 143 miles upstream of the mouth, but due to development along the river, in the 1960s, Atlantic salmon were extirpated (Jackson *et al.* 2005). The population has since been re-established and runs of 2,000 to 4,000 occur with natural spawning as far upstream as 62 miles. Unfortunately, 6,000 to 10,000 salmon are required for a sustainable population, so the Penobscot run depends on fish from a local hatchery (Moore and Platt 1996).
The Kennebec River has eight large hydroelectric dams on its mainstem, which restricts fish passage both up and downstream. In 1999, the Edwards Dam was removed, opening 17 additional miles of habitat for fish and macroinvertebrates in the river. Removal of Edwards dam restored full access to historical spawning habitat for species like Atlantic sturgeon, shortnose sturgeon, and rainbow smelt, but not for species like alewife, American shad, and Atlantic salmon that migrated much further up the river. Since the removal of Edwards Dam, DO levels and macroinvertebrate density have improved. Additionally, in 2007, the fish passage facilities on the lowest dam on the Kennebec River as well as the second and third lowest dams on the Sebasticook River became operational. The lowest dam on the Sebasticook River has been decommissioned and may be breached in as early as 2007 (MDMR 2007).

The Androscoggin River has 14 hydroelectric dams on the mainstem of the river and 18 in the watershed. Fish ladders have been installed on the lower dams allowing anadromous fish passage to Lewiston Falls (Brown *et al.* 2006). The dams play a considerable role in the poor water quality of the river, causing reduced DO throughout the summer. During the 60s, most of the river had oxygen levels of 0ppm, resulting in massive fish kills. There is still a 14 mile stretch of river that requires aerators to provide dissolved oxygen to the river.

The Merrimack River watershed has over 500 dams, including three in Massachusetts and three in New Hampshire, that essentially make the mainstem into a series of ponds (Dunn 2002, Jackson *et al.* 2005). Flow alteration is considered a problem on the upper mainstem of the river and has resulted in the river not meeting EPA's flow requirements (USACE 2003).

Mining

Mining in Northeast Atlantic watersheds first began prior to the Civil War. Since then, mining has been conducted for granite, peat, roofing slate, iron ore, sulfur, magnetite, manganese, copper, zinc, mica, and other materials. Currently, exploration for precious metals and basic metals is ongoing, but to a lesser extant than during the 1980s. Recent mining activities were conducted in this region by The Penobscot Nation, Champion Paper Company, Oquossoc Minerals, Boliden Resources, Inc., Black Hawk Mining, and BHP-Utah. There are several abandoned mines in the Northeast Atlantic coast watersheds that have become superfund sites due to excessive pollutants being leached into groundwater, such as Elizabeth Mine, Pike Hill Mine, Calhoun Mines, and others. Common pollutants leaked by mining operations in this area are lead, mercury, arsenic, and selenium (Ayuso *et al.* 2006, Piatak *et al.* 2006). All mines that are not in use are supposed to be decommissioned and cleaned up, but the impacts could persist for years before the rivers return to their pristine state.

Commercial and Recreational Fishing

The primary commercial fisheries along the Northeast Atlantic coast by harvest weight exist for herring (39%), lobster (26%), blue mussel (6%), hatchery-origin sea-run Atlantic salmon (4%), groundfish (4%), quahog (4%), soft clam (3%), sea cucumber (3%), seaweed (3%), crabs (2%), and various other species (6%). Directed harvest of shortnose sturgeon and wild Atlantic salmon is prohibited by the ESA; however, both are taken incidentally in other fisheries along the east coast and are probably targeted by poachers throughout their range (Dadswell 1979, Dovel *et al.* 1992, Collins *et al.* 1996). Since 2006, a 30 day recreational fishing season between mid September and mid October for hatchery-origin Atlantic salmon has been permitted on the Penobscot River, the only river with listed Atlantic salmon that allows salmon fishing. On the Penobscot, spring salmon fishing has not taken place since 1999, but may be permitted again in 2008. Poaching is likely another fishing threat, but its impacts to individual population segments is unknown. Entanglement of marine mammals in fishing gear is not uncommon and can lead to mortality or serious injury.

Long Island Sound and the Connecticut River
Natural History

The Long Island Sound watershed includes portions of Connecticut, New York, Massachusetts, New Hampshire, Rhode Island and Vermont. Long Island Sound was designated a national estuary in 1987, due to its significance as an area where freshwater from the Connecticut, Thames, and Housatonic Rivers (90% of the freshwater input) mixes with the Atlantic Ocean. The sound ranges in salinity from 23 parts per thousand (ppt) in the western end to 35ppt on the eastern side. The surface area of Long Island Sound is 1,320 mi^2, draining an area of over 16,000 mi^2. Long Island Sound connects to the Atlantic Ocean on both the eastern and western side, called "The Race" and the East River, respectively. The sound substrate is primarily mud, sand, silt, and clay, with very small areas of exposed bedrock. The sound is home to more 120 species of fish and at least 50 species use the sound as spawning grounds.

The Connecticut River drains a watershed of 11,259 mi^2 and flows approximately 410 miles to Long Island Sound. The river flows from the highlands of New Hampshire and Quebec, and is bordered by the Green and White Mountains. The Connecticut River's bed is composed of glacial deposits and granitic bedrock. The average precipitation is approximately 43 inches per year. At the mouth, the average discharge is 10.2 billion gallons each day, or 15,715 cubic feet per second, which accounts for approximately 70% of the freshwater inflow to Long Island Sound (Jackson *et al.* 2005). The final 56 miles of the river prior to Long Island Sound is a tidal estuary (Jackson *et al.* 2005). The river and estuary are also important for many fish species, with 64 freshwater and 44 estuarine species having been recorded in the river or estuary, but 20 of the fish are nonnative (Jackson *et al.* 2005).

Human Activities and Their Impacts
Land Use

More than eight million people live in the Long Island Sound watershed. With so many people in the watershed, both point and non-point source pollution is a major concern. Toxic substances often adsorb to the surface of sediments, which means sediments with high surface to volume ratios like sand, silt, and clay, can hold more pollutants than larger substrates. The sound has elevated levels of PCBs, PAHs, nitrogen, lead, mercury, cadmium, cesium, zinc, copper, and arsenic. Organic and metal contaminants in Long Island Sound are above national averages (Turgeon and O'Connor 1991). Lead, copper, and zinc are believed to be deposited via the atmosphere (Cochran *et al.* 1998). Cadmium, chlordane, and lead appear to be decreasing while copper is increasing (Turgeon and O'Connor 1991). Studies on winter flounder showed PAHs and PCBs leading to alteration of DNA in the livers of those fish (Gronlund *et al.* 1991). One of the biggest problems facing the sound is DO depletion (Parker and O'Reilly 1991), resulting in dead zones. The governors of Connecticut and New York have signed agreements to reduce the total nitrogen input to Long Island Sound by 58.5% before 2015 in an effort to get the DO of surface water above 5ppm, of deeper water above 3.5ppm, and no water ever below 2ppm.

Within the Connecticut River watershed the dominant land use is forest (80%), with 11% used for agriculture and the remaining 9% in mixed (other) uses (Jackson *et al.* 2005). Major towns in the Connecticut watershed are Holyoke and Springfield, Massachusetts and Hartford, Connecticut. The human population in the watershed is approximately 179 people per square mile (Jackson *et al.* 2005). Throughout the 20th century, power plants, defense contractors, municipalities, and corporations such as General Electric, Union Carbide, and Pfizer contributed large quantities of pollutants to the river. Still to this day, approximately one billion gallons of raw sewage enters the river as a result of combined sewer overflow from Hartford, Connecticut alone (CRWC 2006). The river has become much cleaner since the CWA was passed, but chromium, copper, nickel, lead, mercury, and zinc, chlordane, DDT, DDE, PCBs, and PAHs are found in quantities above the EPA recommended levels in sediments and fish tissue throughout the watershed (Jackson *et al.* 2005). Acid rain also affects rivers in the northeast, as it reduces the pH of rivers and causes metals to leach from bedrock at a faster rate (USFWS 2007).

Hydromodification Projects

The Connecticut River has 16 hydroelectric dams on the mainstem of the river and as many as 900 are estimated to have been built in the watershed. Fish ladders have been installed at Vernon, Turner Falls, and Holyoke Dams allowing fish passage to areas above Holyoke Dam in Massachusetts since 1981 (USGS 2004). For some species, the ladders are not efficient, so fish passage continues to be compromised. For instance, overall passage efficiency at Turner Falls fish ladder is 17%, and has historically been inefficient at passing shad. Shortnose sturgeon are not able to migrate to spawning habitat above Holyoke Dam, which was recently re-licensed through 2039, so the only spawning shortnose sturgeon in the river are the fish that reside above the dam. The dams also affect the river's water quality, causing reduced DO and elevated water temperatures throughout the summer.

Mining

Dating back thousands of years, there is evidence of native people mining and extracting natural resources from the headwaters of the Connecticut River. There are many mines along the Connecticut River, which currently degrade the river's water quality, including the country's first chartered copper mine. Towns such as Plymouth, Vermont were famous for mining gold, iron, talc, soapstone, marble, asbestos, and granite (Ewald 2003). Other towns through New Hampshire and Vermont also mined gold, silver, soapstone, talc, granite, slate, and copper (Ewald 2003). In many locations, far downstream of the mines, accumulated heavy metals are in concentrations high enough to threaten aquatic life. In other cases, the mines are abandoned or failing and need to be cleaned. Such is the case with Elizabeth Mine, an old copper mine perched above the Connecticut River that leaches heavy metals into the river. As a result, Elizabeth Mine has been declared a superfund site. There is little to no mining in Long Island Sound and the concept is generally frowned upon in the region, although there has been and continues to be discussions about mining for sand and gravel.

Commercial and Recreational Fishing

There are not many commercial fisheries in the Connecticut River. Shad is the primary commercial fishery here, although shellfish, bluefish, striped bass, and flounder can be caught in the tidal estuary near the mouth. There are many recreationally angled fish, such as shad, striped bass, bluefish, northern pike, largemouth and smallmouth bass, perch, catfish, and other fish.

Long Island Sound fisheries provide an estimated 5.5 million dollars to the Connecticut economy. The primary fisheries target oysters, lobsters, scallops, blue crabs, flounder, striped bass, and bluefish. Recently, due to DO deficiencies, the western portion of Long Island Sound has seen major declines in fish and shellfish populations. Despite these recent declines, the sound houses the largest oyster fishery in the US, which provides 95% of the nation's oysters. At this same time, lobsters have been suffering from an unknown disease and their population has been declining. Simultaneously, menhaden have made a dramatic recovery over the past 10 years, which has resulted in much better fishing for larger predatory fish such as striped bass.

Directed harvest of shortnose sturgeon is prohibited by the ESA. However, shortnose sturgeon are likely taken incidentally in fisheries in the Connecticut River and Long Island Sound. Moser and Ross (1993) found that captures of shortnose sturgeon in commercial shad nets disrupted spawning migrations in the Cape Fear River, North Carolina, and Weber (1996) reported that these incidental captures caused abandonment of spawning migrations in the Ogeechee River, Georgia. Entanglement of marine mammals in fishing gear is not uncommon and can lead to mortality or serious injury.

Hudson River Basin

Natural History

The Hudson River flows approximately 315 miles to the ocean, with a watershed of 13,365 mi^2. The river flows from the Adirondack Mountains, draining most of eastern New York State, to the ocean where the Hudson River canyon continues onto the continental shelf, marking where the original mouth of the Hudson was covered by rising sea levels after the last ice age. The Hudson River's bed is composed of metamorphosed plutonic rock in the Adirondack Mountains, then transitions to sedimentary rock, such as shale and limestone in the middle portion of the watershed, and the lower portion of the watershed is a mixture of sedimentary, metamorphic, and igneous rocks. The average precipitation is approximately 36 inches per year. At the mouth, the average discharge is 13.5 billion gallons each day, or 20,906 cubic feet per second (Jackson *et al.* 2005). The Hudson is a freshwater tidal estuary between Troy, NY at river mile 154 to Newburgh Bay at river mile 62, and then it is a tidal brackish estuary for the lower 62 miles to the Atlantic Ocean (Jackson *et al.* 2005). The river and estuary are home to over 200 fish species, with approximately 70 native freshwater fish species and 95 estuarine species having been recorded (Jackson *et al.* 2005).

Human Activities and Their Impacts

Land Use

The Hudson River watershed usage is 25% agriculture, 65% forested, 8% urban, and 5% other (Jackson *et al.* 2005). Major towns in the Hudson River watershed are New York City, Albany, Poughkeepsie, and Hudson, New York and Jersey City, New Jersey. The human population in the watershed is approximately 350 people per square mile, but there are no people living in the headwaters and the population density in Manhattan is over 25,907 people per square mile (Jackson *et al.* 2005).

Throughout the 20th century, power plants, municipalities, pulp and paper mills, and corporations such as IBM, General Motors, and General Electric in particular, who the EPA estimates dumped between 209,000 and 1.3 million pounds of PCBs into the river, contributed large quantities of pollutants to the Hudson. The PCB levels in the Hudson River are amongst the highest nationwide. The upper basin is mostly unaffected by humans, with clear, soft water with low nutrients. The middle Hudson is more polluted, with 30 to 50% of the land in this region being used for agriculture and several cities such as Corinth, Glens Falls, Hudson Falls, and Fort Edward contributing industrial waste to the river. The tidal freshwater portion of the Hudson is nutrient rich with exceptionally low gradient. High tide in this stretch causes the river to flow backwards due to the low gradient and this prevents stratification. The brackish tidal estuary portion of the Hudson is nutrient rich with hard water. Two hundred miles of the Hudson River, from Hudson Falls to New York City, were designated as a superfund site due to the amount of pollution. There are still elevated amounts of cadmium, copper, nickel, chromium, lead, mercury, and zinc, DDT, PCBs, and PAHs are found in quantities above the EPA recommended levels in sediments and fish tissue throughout the watershed (Wall *et al.* 1998).

Hydromodification Projects

The mainstem Hudson River has 14 dams and there are dams near the mouths of many tributaries, but the lower 154 miles of tidally influenced river is undammed. Several flood control dams on tributaries such as the Indian and Sacandaga Rivers have drastically altered the flow of the mainstem Hudson River. The Hudson is an important river for anadromous fishes because it is unobstructed for the lower 154 miles, resulting in the healthiest population of ESA-listed endangered shortnose sturgeon in the United States. Prior to the Clean Water Act, the middle stretch of the Hudson and much of the lower reaches had low dissolved oxygen as a result of reduced flow behind the dams, high nutrients, and the collection of waste with high biological oxygen demand.

Mining

The Hudson River has been periodically important as a source of metals and mined resources. The Adirondack Mountains, in the headwaters, have mined silver, iron, titanium, coal, talc, vanadium, graphite, garnet, and zinc at various times over the past 300 years. McIntyre Mine is an example of a mine that has produced different minerals during different generations. Initially bought as an iron mine, McIntyre sat dormant for 75 years before titanium was discovered there, at which point National Lead purchased it and mined there until 1982 when NL Industries abandoned the mine.

Commercial and Recreational Fishing

The Hudson River commercial fishery historically caught fish, blue crabs, and oysters. Now, the only fish that is caught commercially in the Hudson is American shad. Historically, Atlantic sturgeon, striped bass, American eel, and white perch were productive commercial fisheries. The striped bass fishery closed in 1976 due to PCBs in the river and fish tissue. Atlantic sturgeon were fished until the mid 1990s. Blue crabs are still fished in the estuary all the way to Troy, NY with recent catches over 88,185 pounds per year. There is no commercial fishery for oysters but they used to be taken commercially in the brackish tidal section of the Hudson.

Delaware River Basin

Natural History

The Delaware River flows approximately 329 miles to the ocean, with a watershed of 12,757 mi^2. The river originates in the Catskill Mountains with over half of the river flowing through Pennsylvania and the rest of the watershed occupying parts of New Jersey, New York, and Delaware. The Delaware River's geology is sandstone with shale conglomerate in the upper watershed transitioning to sandstone, shale, and limestone in the middle watershed and igneous and metamorphic rock in the lower watershed. The average precipitation is approximately 43 inches per year. At the mouth, the average discharge is 9.6 billion gallons each day, or 14,903 cubic feet per second, and although it is only the 42^{nd} largest river by discharge, Philadelphia is home to the largest freshwater port in the country (Jackson *et al.* 2005). The Delaware River estuary begins in Trenton, New Jersey and extends downstream for 144 miles (Jackson *et al.* 2005). The river and estuary are home to 105 species of fish, with approximately 8 nonnative fish (Jackson *et al.* 2005).

Human Activities and Their Impacts

Land Use

The Delaware River watershed usage is 24% agriculture, 60% forested, 9% urban, and 7% surface water or other (Jackson *et al.* 2005). Major towns in the Delaware River watershed are Easton, Allentown, Reading, and Philadelphia, Pennsylvania; Trenton and Camden, New Jersey;

and Wilmington, Delaware. The human population in the watershed is approximately 555 people per square mile (Jackson *et al.* 2005). The water quality was significantly degraded around Philadelphia by 1799. By the 1960s the average DO in the lower river was approximately 0.2ppm. A survey in the 1970s of organochlorine frequency in rivers ranked the Delaware at Trenton and the Schuylkill, the largest tributary to the Delaware, as the 8th and 1st worst, respectively in the nation (Jackson *et al.* 2005). While there aren't many point sources of pollution since the Clean Water Act was enacted, historically, power plants, municipalities, pulp and paper mills, and industries such as the Philadelphia Shipyard, Bethlehem Steel, New Jersey Zinc Company, contributed large quantities of pollutants to the Hudson. Approximately 95% of PCBs are introduced to the river through combined sewage overflows from treatment plants. Even 35 years after the Clean Water Act, there are still elevated amounts of copper, chromium, lead, mercury, and zinc, DDT, PCBs, and PAHs are found in quantities above the EPA recommended levels in sediments and fish tissue throughout the watershed. (Wall *et al.* 1998). The heaviest concentrations of chemicals in the river occur in a 14 mile stretch between the Philadelphia naval yard and the Tacony-Palmyra Bridge.

Hydromodification Projects

The Delaware River has 16 dams in the headwaters but the middle and lower river is the longest undammed stretch of river east of the Mississippi. This stretch of free-flowing river is beneficial to anadromous and catadromous species, such as American shad, striped bass, and American eels.

Mining

The Delaware River watershed, particularly the eastern section was home to the majority of the nation's anthracite coal. As a result, many mining towns were established in the watershed to exploit the abundant resources. By 1914, over 181,000 people were employed as miners in the region. Apart from the coal mining, other minerals such as sulfur, talc, mica, aluminum, titanium, and magnesium were mined. Mines were also established for sand and gravel. Eventually minerals from the watershed were used to produce steel.

Commercial and Recreational Fishing

In the Delaware River, commercial fisheries exist for American shad, weakfish, striped bass, Atlantic croaker, Atlantic silversides, bay anchovy, black drum, hogchoker, northern kingfish and American eel. Commercial fishermen use gillnets and trawls as the primary means of capturing fish. Bycatch is a concern for the recovery of endangered shortnose sturgeon, where the highest mortality rates are recorded in gillnet fisheries. Recreational fishermen target weakfish, striped bass, croaker, drum, kingfish, and eel. No data exists on shortnose sturgeon poaching.

Chesapeake Bay Drainages

Natural History

Chesapeake Bay, the largest estuary in the United States, was formed by glacial activity more than 18,000 years ago. The Bay stretches some 200 miles from Havre de Grace, Maryland to Norfolk, Virginia, with more than 11,000 miles of shoreline. At its widest point, Chesapeake

Bay is about 35 miles wide (near the Potomac River). Despite its massive size, the Bay is relatively shallow—average depth is only 21 feet—making it susceptible to significant fluctuations in temperature.

The Bay lies totally within the Atlantic Coastal Plain but the watershed includes parts of the Piedmont Province and the Appalachian Province. The tributaries provide a mixture of waters with a broad geochemical range to the Bay with its own mixture of minerals, nutrients and sediments depending on the geology of the place where the waters originate. In turn, the nature of the Bay itself depends on the characteristics and relative volumes of these contributing waters. While more than 50 tributaries deliver freshwater to Chesapeake Bay, major rivers include the Susquehanna, Potomac, and the James River, which we describe in greater detail below.

Susquehanna River

Rated as the 18th largest river in the United States based on discharge, drainage area, or length, the Susquehanna River flows approximately 448 miles to the ocean, with a watershed of 27,580 mi^2 (Kammerer 1990; Jackson *et al.* 2005). The river flows north to south from New York, through Pennsylvania, and reaches the Chesapeake Bay in Havre de Grace, Maryland. The Susquehanna River's bed is rocky throughout, being described as a mile wide and a foot deep, with distinct pool/riffle formations even near the mouth. The average precipitation is approximately 39 inches per year. At the mouth, the average discharge is 26.3 billion gallons each day, or 40,718 cubic feet per second, and serves as the primary freshwater source of the Chesapeake Bay (Jackson *et al.* 2005). The Susquehanna isn't tidally influenced and doesn't have much estuary habitat (Jackson *et al.* 2005). The river is home to 103 fish species, but 27 of the fish are nonnative (Jackson *et al.* 2005).

Potomac River

The Potomac River is approximately 383 miles long and has a watershed of 14,670 mi^2. The river's headwaters begin in the Allegheny Mountains of West Virginia and the Potomac most famously flows through Washington, D.C., to the western side of the Chesapeake Bay. The substrate of the Potomac and its tributaries is mostly schist, phyllite, and metavolcanic rock. The average precipitation is approximately 39 inches. At the mouth, the average discharge is 7.3 billion gallons each day, or 11,301 cubic feet per second (Jackson *et al.* 2005). The Potomac River estuary begins two miles below the Washington, D.C. Maryland border, just below the Little Falls of the Potomac River. Ninety-five fish species live in the Potomac, but only 65 of those are native to the area (Jackson *et al.* 2005).

James River

The James River is approximately 340 miles long and drains a watershed of 10, 432 mi^2. The James River is one of the longest bodies of water in entirely in one state, beginning in the Allegheny Mountains of western Virginia and flowing across the state to the Chesapeake Bay. The upper James River's geology is primarily schist and siliclastic rock. The middle James River is primarily course grained conglomerates and sandstone. The lower section of the James is almost entirely sedimentary rock. The average precipitation is approximately 40 inches. At the mouth, the average discharge is 6.5 billion gallons each day, or 10,030 cubic feet per second (Blue 1998). The James River estuary begins at the fall-line in Richmond, Virginia. Ninety-five fish species live in the Potomac, but only 65 of those are native to the area (Jackson *et al.* 2005).

Human Activities and Their Impacts

Land Use

The Susquehanna River watershed usage is 20% agriculture, 63% forested, 9% urban, and 7% pasture (Jackson *et al.* 2005). Major towns in the Susquehanna River watershed are Scranton, State College, and Harrisburg, Pennsylvania and Havre de Grace, Maryland. The human population in the watershed is approximately 145 people per square mile (Jackson *et al.* 2005). The water quality has not been well documented because the river wasn't used as a primary source of drinking water for any major cities. The three main events that had the greatest effect on the river were logging, dam building, and mining. While most of these activities took place in the 1800s, the river is still responding to the disruption they caused (Jackson *et al.* 2005). Sediment transport in the early 1900s was nine times higher than it was 200 years earlier, due to logging and agriculture. Sediment transport and its associated nutrients remain a major concern for the Chesapeake Bay. Coal is abundant through the watershed, amounting to nearly 30 billion tons of coal mined. Coal waste and acid mine drainage damaged much of the river and its tributaries. There was so much coal silt in the Susquehanna at one point that a fleet of over 200 vessels began harvesting the silt from the river's bed. From 1920 to 1950, over 3 million tons of coal were harvested from behind one dam. Later, between 1951 and 1973, over 10 million tons were harvested from behind another dam. Coal is no longer a primary industry in the watershed, but the impacts of the acid mine drainage are still prominent. Another major problem is untreated sewage and industrial waste that is dumped directly into the river. In Binghampton, New York, there are 10 sewer outfalls, 70 in Scranton, Pennsylvania, 65 in Harrisburg, Pennsylvania, and the number of outfalls totals over 400 in the watershed, generally with the number of outfalls being proportional to the size of the city. As a result, the Susquehanna contributes 44% of the nitrogen and 21% of the phosphorous to the Chesapeake Bay. This has led to large algal blooms in the bay and a resulting "dead zone" between Annapolis, Maryland and Newport News, Virginia. In 2005, the Susquehanna was named America's most endangered river by American Rivers, who produce an annual list. Even 35 years after the Clean Water Act, there are still elevated amounts of copper, sulfur, selenium, arsenic, cobalt, chromium, lead, mercury, zinc, and pesticides (Beyer and Day 2004).

The Potomac River watershed usage is 32% agriculture, 58% forested, 5% developed, 4% water, 1% wetland, and 1% barren (Jackson *et al.* 2005). Major towns in the Potomac River watershed are Washington, D.C.; Arlington and Alexandria, Virginia; and Hagerstown, Maryland. The human population in the watershed is approximately 358 people per square mile (Jackson *et al.* 2005). The water quality has significantly improved over the past 50 years. Even 35 years after the Clean Water Act, there are still elevated amounts of cadmium, chromium, copper, lead, dioxin, PCBs, and chlordane, which may have resulted in recent highly publicized reports of male fish producing eggs.

The James River watershed usage is 23% agriculture, 71% forested, and 6% urban (VDCR 2006). Major towns in the James River watershed are Charlottesville, Richmond, Petersburg, and Hampton Roads, Virginia. The human population in the watershed is approximately 2.5 million people, or approximately 240 people per square mile (VDCR 2006). The James River has 21 municipal dischargers permitted and 28 permitted industrial dischargers. There are also 18 EPA Superfund sites along the river, mostly found in the major cities along its corridor. In some cases, industries such as Allied Chemical were fined and forced to clean up large areas of extreme toxicity. Even 35 years after the Clean Water Act, there are still elevated amounts of zinc, copper, cadmium, nickel, chromium, lead, arsenic, dioxin, PCBs, and pesticides.

Hydromodification Projects

There are many dams along the Potomac River and its tributaries, but only three impoundments are larger than 1.5 square miles. One of the major tributaries, the Anacostia River, is having over 60 dams removed or altered to improve water quality and fish passage.

The Susquehanna River has over 100 dams along the mainstem and the first major dam is located just 10 miles upstream of the mouth. In recent years modern fishways have been installed in some of these dams and migratory fish appear to be responding positively. For instance, between 1928 and 1972, no shad passed Conowingo Dam, 10 miles upstream of the mouth of the Susquehanna River, but since fish began coming back, their abundance has increased from approximately 100 to more than 100,000.

The James River has several large dams along its length. Many dams have been removed or improved to allow fish passage, and in 1999, a ladder was built over Boscher Dam, which had prevented upstream fish runs since 1823. That ladder provided access to 137 additional miles of the James and 168 miles of its tributaries.

Mining

In the Chesapeake Bay watershed, coal mining has likely had the most significant impact on water quality. Mining in this watershed was so extensive that while many mines have been reclaimed and others are currently being reclaimed, at the current level of funding, it will take decades or more to completely reclaim all of the old mines in the watershed. Abandoned coal mines leach sulfuric acid as a result of natural reactions with the chemicals found in coal mines. Many of these abandoned coal mines must be treated with doses of limestone to balance the pH of the water draining from the mines. Much of the Appalachian Mountain chain that was mined for coal is now leaching sulfuric acid into tributaries of the Chesapeake Bay and requires some sort of treatment to improve the water quality of the region.

Commercial and Recreational Fishing

The Chesapeake Bay supports fisheries for American eel, croaker, blue crab, black sea bass, bluefish, oyster, red drum, spot, striped bass, summer flounder, weakfish, menhaden, and white perch (CFEPTAP 2004). Stocks of striped bass got so low in the mid 1980s that a moratorium started in 1985, but they recovered so well that well-regulated harvests are now permitted. Since the mid 1990s, levels of blue crab and menhaden have dropped to the lowest levels in history. Species such as catfish and white perch are year round residents and managed by individual states around the bay. Species like Spanish mackerel, king mackerel, red drum, and summer flounder have ranges that extend beyond the bay and are managed under multiple regional management plans. Some species such as American shad are allowed to be fished by some states (Virginia and Maryland) within the Chesapeake Bay, but not by other states (Delaware and Pennsylvania).

The Risk of Fire in the Region

Peak fire season in the Northeast Atlantic Region occurs between March and June, August, October, and November. Based on a review of more than 80,000 wildfires, Malamud *et al.* (2005) calculated the wildfire recurrence interval for large fires (≥ 2,471 acres (10 km^2)) in the region as ranging between every 14 years to 300 years depending upon the specific ecoregion. Based on the work by Malamud *et al.* (2005) lowland areas surrounding the southern Gulf of Maine (coastal areas of New Hampshire and Massachusetts) exhibit more frequent large fires (on average one wildfire with a burned area ≥ 2,471 acres (10 km^2) would occur every 14 to 54 years). Whereas, Malamud *et al.* (2005) estimate that on average one wildfire with a burned area ≥ 2,471 acres (10 km^2) in the lowland area surrounding the northern portion of the Gulf of Maine would occur every 100 to 300 years. USFS lands in this region occur within the hot continental ecoregions division where, according to estimates by Malamud *et al.* (2005) on average one large wildfire would occur every 28 to 82 years.

Southeast Atlantic Region

This region covers all the drainages that ultimately drain to the Atlantic Ocean between the states of North Carolina and Florida. This region includes all of South Carolina and parts of Georgia, North Carolina, Florida, and Virginia. The region encompasses three ecoregions—the hot continental division, subtropical division, and savanna division (southern most tip of Florida's panhandle). The hot continental division is characterized by it's winter deciduous forest dominated by tall broadleaf trees, soils rich in humus and moderately leached (Inceptisols, Ultisols, and Alfisols), and rainfall totals that decrease with distance from the ocean (Bailey 1995).

Most of the Southeast Atlantic Coast Region is contained 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. The savanna ecoregion has a tropical wet-dry climate, controlled by moist warm topical air masses and supports flora and fauna that is adapted to fluctuating water levels (Bailey 1995).

In the sections that follow we describe several basins and estuaries to characterize the general ecology and natural history of the area, and past and current human activities and their impacts on the area. The region contains more than 22 river systems that generally flow in a southeasterly direction to the Atlantic Coast. The diverse geology and climate ensures variability in biological productivity and hydrology. Major basins include the Albemarle-Pamlico

Watershed and its tributaries, the Cape Fear River, Winyah Bay and the Santee-Cooper Systems, the Savannah, Ogeechee, and the St. Johns River, to name a few. The more northerly river, the Roanoke which is part of the Albemarle-Pamlico Watershed, is cooler and has a higher gradient and a streambed largely characterized by cobble, gravel and bedrock.

The southern rivers are characterized by larger 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 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). We described several river basins in detail to provide additional context for evaluating the influence of the environmental baseline on listed species under NMFS' jurisdiction and the health of the environment.

Albemarle-Pamlico Sound Complex

Natural History

The Albemarle-Pamlico Sound Estuarine Complex, the largest lagoonal estuarine system in the United States, 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 Albemarle-Pamlico watershed encompasses four physiographic regions—the Valley and Ridge, Blue Ridge, Piedmont and Costal 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 reaches 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. As a result, of the basin's geology, as a general matter more than half of the water flowing in streams discharging to the Albemarle-Pamilico Estuarine Complex comes from ground water.

Primary freshwater inputs to the Estuary Complex include the Pasquotank, Chowan and Roanoke Rivers that flow into Albemarle Sound, and the Tar-Pamlico and Neuse Rivers that flow into Pamlico Sound. The Roanoke River is approximately 410 miles long and drains a watershed of 9,580 mi^2. The Roanoke River begins in the mountains of western Virginia and flows across the North Carolina border before entering the Albemarle Sound. The upper Roanoke River's geology is primarily a high gradient boulder-rubble bedrock system. The middle Roanoke River is primarily course sand and gravel. The lower section of the Roanoke is almost entirely organic-rich mud. The average precipitation is approximately 43 inches. At the mouth, the average discharge is 5.3 billion gallons each day, or 8,193 cubic feet per second (Smock *et al.* 2005). The Roanoke River is home to 119 fish species, and only seven of those are not native to the area

(Smock *et al.* 2005). The Roanoke is also home to nine endangered fish species, two amphibians, and seven mussels, including several important anadromous fish species.

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 (Turekian *et al.* 1967). The average precipitation is approximately 48 inches. At the mouth, the average discharge is 3.4 billion gallons each day, or 5,297 cubic feet per second (USGS 2005).

Human Activities and Their Impacts

Land Use

Land use in the Roanoke River is dominated by forest (68%) and the basin contains some of the largest intact, least disturbed bottomland forest floodplains along the eastern coast. Only 3% of the basin qualifies as urban land uses, and 25% is used for agriculture (Smock *et al.* 2005). The only major town in the Roanoke watershed is Roanoke, Virginia. The population in the watershed is approximately 80 people per square mile (Smock *et al.* 2005). In contrast, the Neuse River watershed is described as 35% agriculture, 34% forested, 20% wetlands, and 5% urban, and 6% other, with a basin wide density of approximately 186 people per square mile (Smock *et al.* 2005). While the population increased in the Albemarle-Pamlico Complex more than 70% during the last 40 years, the rate of growth is relatively low for many coastal counties in the Southeast (EPA 2006). Much of the estuarine complex is protected by large amounts of state and federally protected lands, which may reduce development pressures.

Throughout the 20th century, mining, agriculture, paper and pulp mills, and municipalities contributed large quantities of pollutants to the Roanoke River and the Albemarle-Pamlico Estuarine Complex. Even so, today the Albemarle-Pamlico Estuarine Complex is rated in good to fair condition in the National Estuary Program Coastal Condition Report despite that over the past 40-year period data indicate some noticeable changes in the estuary, including increased dissolved oxygen levels, increased pH, decreased levels of suspended solids, and increased chlorophyll *a* levels (EPA 2006).

Coal is mined from the mountainous headwaters of the Roanoke River in southwestern Virginia. Mining through the piedmont and coastal areas of North Carolina was conducted for limestone, lead, zinc, titanium, apatite, phosphate, crushed stone, sand, and fossils. Many active mines in these watersheds are still in operation today. These mines are blamed for increased erosion, reduced pH, and leached heavy metals.

Agricultural activities are major source of nutrients to the estuary and a contributor to the harmful algal blooms (HABs) in summer, although according to McMahon and Woodside 1997 (cited in EPA 2006) nearly one-third of the total nitrogen inputs and one-fourth of the total phosphorus input to the estuary are from atmospheric sources. Primary agricultural activities within the watershed include corn, soybean, cotton, peanut, tobacco, grain, potato, and the production of chicken, hog, turkey, and cattle.

In general, the Roanoke River is much cleaner since the passage of the CWA, although mercury, arsenic, cadmium, chromium, copper, lead, nickel, zinc, and PCBs are still considered high (NCDENR 2000). Fish tissues sampled within the estuary also showed elevated concentrations of total PAHs and total PCBs—10% of the sampled stations exceeded risk-based EPA Advisory Guidance values (EPA 2006). Water quality studies in the mid-1990s showed the Neuse Basin contained the highest nitrogen and phosphorus yields, while the Chowan Basin had the lowest yields (Spruill *et al.* 1998).

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. The problem is persistent but the cause of the kills differs among events; in 2004 more than 700,000 estuarine fish died and more than 5,000 fresh fish died within the basin. Freshwater species most commonly identified during investigations 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 may often have different causative agents, and in many cases the precise cause is not clear, but 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).

Both the Roanoke River and the Neuse Rivers are 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 recently in an effort to improve environmental conditions and fish passage. Widespread stream modification and bank erosion were rated high within the greater watershed relative to other sites in the Nation (Spruill *et al.* 1998).

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 the same species as the Roanoke River.

Commercial and recreational fisheries exist for oyster, crab, clam, American shad, American eel, shrimp, and many other species. Shellfish can be collected by dredging, which has adverse effects to benthic organisms, including 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 could still accidentally capture a shortnose sturgeon.

Major Southeast Coastal Plains Basins

Natural History

More than five major river basins flow through the Coastal Plains of the Southeast and directly enter the Atlantic Ocean including the Cape Fear, Great Pee-Dee, Altamaha, and the St. Johns Rivers (see Table 2 for a description of several basins within this region). Rainfall is abundant in the region and temperatures are generally warm throughout the year. Northern rivers originate in the Blue Ridge Mountains or the Piedmont Plateau, but all the rivers described in this section have sizeable reaches of slack water as they flow through the flat Coastal Plain. Two rivers, The Satilla River in Georgia and the St. Johns River in Florida, are located entirely within the 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.

Smock *et al.* (2005) describe the mountains and plateau as areas of heavily dissected and primarily highly metamorphosed rock of Paleozoic age, with occasional areas of igneous and sedimentary rock. Underlying rock is varied with bands of limestone, dolomite, shale, sandstone, cherts, and marble, with a number of springs and caves scattered throughout the area. Where the Piedmont Plateau dips the sedimentary deposits of the coastal plain is termed the fall line. Here, steep changes in elevation result in rapids or falls before the rivers level off in their Coastal Plain reaches. In the Coastal Plain reaches of the areas rivers soils are acidic with a low cation exchange capacity and 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 Piemont Plateau) appearance. The Satilla River is a blackwater river that has a naturally low pH (between 4 and 6) and white sandbars--due to the low pH it also has naturally lower productivity than other rivers that originate within the mountains or the Plateau.

Table 2. Rivers of the Southeast United States (data from NCDENR 1999 and 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
Cape Fear River	320	9,324	PP, CP	47	7,663	95	8 fish, 1 mammal, 15 mussels
Great Pee Dee River	430	10,641	BR, PP, CP	44	13,102	>100	6 fish, 1 reptile
Santee-Cooper River	440	15,251	BR, PP, CP	50	15,327	>100	5 fish, 2 reptiles
Savannah River	300	10,585	BR, PP, CP	45	11,265	>100	7 fish, 4 amphibians, 2 reptiles, 8 mussels, 3 crayfish
Ogeechee River	250	5,212	PP, CP	44	4,061	>80	6 fish, 2 amphibians, 2 reptiles, 1 mussel
Altamaha River	140 (>400)	14,517	PP, CP	51	13,879	93	1 mammal, 12 fish, 2 amphibians, 2 reptiles, 7 mussels, 1 crayfish
Satilla River	200	3,530	CP	50	2,295	52	2 fish, 1 amphibian, 2 reptiles, 1 mussel
St. Johns River	311	8,702	CP	52	7,840	>150	1 mammal, 4 fish, 2 reptiles, 2 birds

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

Human Activities and Their Impacts
Land Use

Across this region, land use 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 square mile of catchment, most of whom are located near Jacksonville, Florida. In contrast, there are only 29 people per square mile in the Saltilla River watershed in Georgia (Smock *et al.* 2005). See Table 3 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 Miami and Jacksonville, Florida, and Savannah, Georgia. Major towns include Greensboro, Chapel Hill, Fayetteville, South Carolina, and Wilmington, North Carolina in the Cape Fear River watershed; Winston-Salem, North Carolina and Georgetown, Florence, and Sumter, South Carolina in the Great Pee-Dee River Watershed; Charlotte, Hickory, and Gastonia, North Carolina and Greenville and Columbia, South Carolina in the Santee-Cooper River watershed; Savannah and Augusta, Georgia, in the Savannah River watershed; Louisville, Statesboro, and Savannah, Georgia, in the Ogeechee River watershed; Athens, and Atlanta, Georgia, in the Altamaha River watershed; and Jacksonville, Florida in the St. Johns River watershed.

Several of the rivers in the region have elevated levels of metals 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).

Several watersheds exhibit high nitrogen loads including the Cape Fear River, Winyah Bay, Charleston Harbor, St. Helena Sound, Savannah River, Ossabaw Sound, Altamaha River, and St. Mary's River and Cumberland Sound (Bricker *et al.* 2007). Nitrate concentrations (as nitrogen) tend to be higher in stream draining basins with agricultural and mixed land uses (Berndt *et al.* 1998). Based on studies in Georgia, however, 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 3. Land Uses and Population Density in Several Southeast Atlantic Basins (data from Smock et al. 2005)

Watershed	Land Use Categories (Percent)				Density
	Agriculture	Forested	Urban	Other	(people/mi.^{2})
Cape Fear River	24	56	9	11	80
The Great Pee-Dee	28	58	8	6	127
Santee-Cooper River	26	64	6	4	168
Savannah River	22	65	4	9	91

Ogeechee River	18	54	1	17 (wetlands)	78
Altamaha River	--	64	3	7	73
Satilla River	26	72	1	1	29
St. Johns River	25	45	6	24 (wetlands & water)	202

Sediment is the most serious pollutant in the Yadkin (Pee-Dee) River and has historically been blamed on agricultural runoff. In the mid 1990s, farmers in the region began using soil conservation techniques that have reduced sediment inputs by 77%. Unfortunately, the reduction in sediment inputs from farms did not translate to a reduction in sediment in the river, as during this period there was a 25% reduction in agricultural land and a 38% increase in urban development.

Mining

Mining occurs throughout the region. South Carolina is ranked 25th in the states in terms of mineral value and 13th among the eastern 26 states, and produces 1% of the total nonfuel mineral production value in the United States. There are currently 13 minerals being extracted from 485 active mines in South Carolina alone. Portland and masonry cement and crushed stone were the State's leading nonfuel minerals in 2004 (NMA 2007). In contrast, Georgia accounts for 4%, Florida accounts for 5%, and North Carolina accounts for 1.76% of the total nonfuel mineral production value in the United States. North Carolina's leading nonfuel minerals in 2004 were crushed stone, phosphate rock, and construction sand and gravel. 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 United States and produces about six times more than any other state in the nation. Peat and zirconium concentrates are also produced in Florida.

The first gold mine discovered and operated in the United States is outside Charlotte, North Carolina in the Pee Dee watershed. Mines through Georgia are also major producers of barite and crude mica, iron oxide, and feldspar. There is a proposed titanium mine near the mouth of the Satilla River. Unfortunately, mines release some toxic materials and negatively impact fish, as fish living around dredge tailings have elevated levels of mercury and selenium.

Hydromodification Projects

Several of the rivers within the area have been modified by dams and impoundments. In contrast to rivers along the Pacific Coast, we found considerable less information on other types of hydromodification projects in this area, such as levees and channelization projects. There are three locks and dams along the mainstem Cape Fear River and a large impoundment on the Haw River. The lower river and its tributaries are relatively undisturbed. The lower reach is naturally a blackwater river with naturally low dissolved oxygen, which is compounded by the reduced flow and stratification caused by upstream reservoirs and dams. The Yadkin (Pee Dee) River is heavily utilized for hydroelectric power. 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. 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. Although the Altamaha River is undammed, hydropower dams are located in its tributaries the Oconee and Ocmulgee Rivers above the fall lines. There are no dams, however, along the entire mainstem Satilla River. There are no major dams on the mainstem St. Johns River either, 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.

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. 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 often interact with sea turtles. There are approximately 1.15 million recreational anglers in the state.

The Risk of Fire in the Region

Peak fire season in the Southeast Atlantic Region occurs between October and June, depending on various 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 ranging between every 19 years to 47. Of the total land area within this ecoregion (more than 4,000,000 mi^2 [which incidentally encompasses a sizeable portion of the Gulf Region—discussed next]) the USFS manages 16,571 mi^2 (less than 1%).

Gulf Coast Region

This region encompasses states of Alabama, Arkansas, Illinois, Iowa, Kansas, Kentucky, Louisiana, Mississippi, Missouri, Oklahoma, South Dakota, Tennessee, the western portion of Florida including the Florida Keys, and parts of, Georgia, Texas, Minnesota, Montana, North Dakota, Nebraska, Colorado, Indiana, Ohio, New Mexico, North Carolina, Pennsylvania, Virginia, West Virginia, Wisconsin, Wyoming, Mexico, and two Canadian provinces. Almost 2/3 of the continental United States drains to the Gulf of Mexico through the Mississippi River Basin. The Gulf is roughly 800 nautical miles wide, and is connected with the Atlantic Ocean through the Florida Straits and the Caribbean Sea through the Yucatan Channel between Cuba and Mexico.

While the Mississippi River is the most notable basin that drains to the Gulf of Mexico in terms of overall size (and the largest river in the United States) more than ten major river basins flow through to the Gulf including the Atchafalaya, Mobile, Red, Brazos, Colorado, and Rio Grande Rivers several (see Table 6 for a description of several basins within this region). In the following sections, we describe several basins and estuaries that enter the Gulf of Mexico to characterize the general ecology and natural history of the area, and past and current human activities and their impacts on the area.

Natural History

Due to the enormity of the drainages in this region, several ecoregions are encompassed in this region including the subtropical, the tropical/subtropical steppe, hot continental and mountain segments, temperate steppe, and the prairie ecoregions (Bailey 1995). Most of the region is within the subtropical ecoregion (division) 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 region 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.

The geology of the eastern Gulf Coast is primarily sedimentary rocks of both siliclastic (sand, silt, clay) and carbonate (limestone and dolomite) types. Karst is a major mineral in Florida. The piedmont region of Georgia is composed of metamorphosed sedimentary rock and overlaid by decomposed rock called saprolite. Saprolite is rich in aluminum, silicon, and iron oxide. The metamorphosed sedimentary rock is also rich in minerals that intruded during earthquakes millions of years before.

Soils in the eastern Gulf are rich in oxides of iron and aluminum, moister and strongly leached (Bailey 1995), whereas soils in the western Gulf Coast highly varied, and reflect climate and geological differences. Arid parts of the region exhibit calcarious and/or gypsum-rich soils, and tend to have a neutral pH, whereas prairie soils are commonly slightly acidic sandy to clay loams. There is a strong decline in total rainfall moving east to west, which strongly affects vegetation patterns, river discharge (see Table 4 – rivers are listed in their general east to west pattern).

Table 4. Select Rivers in the Gulf Coast Region (data from Kammerer 1990, Brown *et al.* 2005. Dahm *et al.* 2005, and Ward *et al.* 2005)

Watershed	Length (mi. [approx.)	Basin Size (mi^2)	Physiographic Provinces*	Mean Annual Precipitation (inches)	Mean Discharge (cfs).	No. Fish Species	No. Endangered Species
Suwanee River	245	9,640	CP	53	10,804	81	1 fish
Apalachicola River System	106 (>530)	19,571	BR, PP, CP	50	26,804	104	1 fish, 1 reptile
Choctawhatchee River	170	4,646	CP	57	7,487	80	1 fish
Escambia-Conecuh River	231	4,233	CP	65	6,922	102	0
Mobile River	774	43,000	CP, VR, AP, PP, BR	50	67,592	236	12 fish, 3 reptiles, 19 mussels, 7 snails
Pascagoula River	140 (>400)	9,498	CP	61	15,256	119	1 fish, 2 reptiles
Pearl River	409	8,494	CP	56	13,172	119	1 fish, 2 reptiles, 1 mussel
Mississippi River	2,320	1,151,000		39	450,000	375	
Sabine River	555	9,756	CP	50	8,405	>104	>4 fish, 2 crayfish
Neches River	416	10,011	CP	54	6,321	96	≥4 fish, 1 crayfish

Trinity River	550	17,969	CL, GP, CP	45	7,840	99	3 fish, 1 crayfish, 3 mussels
Brazos River	1,280	44,620	CL, GP, CP	32	8,793	93	>4 fish, 4 mussels
Colorado River	862	39,900	CL, GP, CP	32	2,649	98	>4 fish, 2 salamanders, 1 snake, 5 mussels
San Antonio/Guadalupe Rivers	408	10,128	GP, CP	32	2,790	88	≥ 7 fish, several amphibians, 3 spring/cave pool-associated aquatic insects, 1 plant
Nueces River	315	16,800	GP, CP	24	706	≥66	≥3 fish
Rio Grande	1,759	335,908	SR, CO, B/R, GP, CP, SC, SO	8	1,307	>160	≥16 fish, several mollusks, 6 birds

Physiographic Provinces: BR = Blue Ridge, PP = Piedmont Plateau, CP = Coastal Plain, VR=Valley Ridge, AP=Appalachian Plateau, SR=Southern Rock Mtns., CO=Colorado Plateau, B/R=Basin & Range, GP=Great Plains, SC=Sierra Madre Occidental, SO=Sierra Madre Oriental, CL=Central Lowlands

Human Activities and Their Impacts

Land Use

Land use is dominated by forest in the basins east of the Mississippi, whereas grass/shrub and rangeland uses dominate in basins west of the Mississippi. The Mississippi also appears to be a divide between the less developed eastern basins, and the increasingly urbanized western basins. According to data presented in Table 5, the most developed watersheds are the Trinity River, the San Antonio and Guadalupe Rivers, the Brazos River, the Colorado River, and the Mississippi River. Most of the population within the San Antonio River watershed is concentrated within the greater San Antonio area. Based on data from 2000, the population density of San Antonio is an estimated 1,122 people/mi^2, and in other areas of the basin density is as little as 16 people/mi^2 (Dahm *et al.* 2005). The Trinity River Basin encompasses several urban areas including one of the most highly populated areas in the region--the City of Dallas. In stark contrast, overall there are only 29 people per square mile in the Neches River watershed (Dahm *et al.* 2005).

Major threats to the southwestern basins also include wastewater effluent, water extraction, non-point source pollution, nonnative species, existing impoundments, and proposals for dams (Dahm *et al.* 2005), and new reservoirs are proposed for some basins (Lane-Miller and DeVries 2007). Municipal waste water discharge poses a serious problem in several rivers, including the Suwannee River basin, and the Chattahoochee and Flint Rivers. According to Dahm *et al.* (2005) the Rio Grande is one of the most impacted rivers due to water quality and quantity concerns. The basin suffers from elevated levels of salinity, nutrients, bacteria, metals, pesticides, herbicides, organic solvents, and the basin is heavily hydromodified by dams and water diversions for irrigation. About 100 miles downstream of Atlanta the Chatahoochee is very polluted, with excessive amounts of nutrients, pesticide, fecal coliform bacteria, PAHs, and oils. The lower Mississippi River is degraded by excess fecal coliform bacteria, PCBs, chlordane, turbidity, siltation, nutrients, reduced DO, pesticides, and eutrophication. Most of the riparian habitat has been lost to agriculture and urban development (Brown *et al.* 2005).

In many basins agricultural practices associated with row crops (corn, soybeans, hay and cotton) confined animal feeding operations (poultry and lifestock—hog, cattle, sheep, goats), and dairy production are significant source of nutrients, fecal coliform, and pesticides. Other basins are severely impacted by altered sediment regimes. The Choctawhatchee River watershed has highly erodable soils, heavy rains, and intermittent droughts that leads to excessive sediment loading. Erosion causes sediment and nutrient issues, while droughts cause low flow and low dissolved oxygen. In contrast, downcutting of reaches of the Brazos River are a problem resulting from numerous dams interrupting sediment transport within the basin.

Several rivers including the Pascagoula River and its tributaries, and the Sabine River are also impaired by sediment, pathogens, low DO, fecal coliform, nutrients, mercury, PCB, dioxin, ammonia, pesticides like atrazine, and BOD. Occasional fish kills occur within the Colorado River as a result of storm runoff and low DO. The upper Colorado River has salinity problems and many reservoirs have problems with toxic golden algae (Dahm *et al.* 2005). The upper Brazos River basin has naturally high salinity, the middle basin has elevated nutrients from nearby dairy farms, several reservoirs have toxic golden algae, and the lower basin has elevated atrazine, bacteria, phosphorous, and low DO (Dahm *et al.* 2005). Major polluters in the Mobile River include pulp and paper mills, textiles, chemical plants, hydroelectric, iron and steel manufacturing, and coal plants.

Pollution of this nature can reduce productivity and health of the fish populations within the basin, and at times can lead to fish kills. Since 1998, there have been at least 16 fish kills, at least one of which was the result of elevated ammonia levels, two were contributed to pesticides, 10 were from low DO, and 3 were from unknown causes (MSDEQ 2000). Large fish kills are the most severe and usually the most easily observed response of aquatic ecosystems to pollution, but often the degradation is more elusive occurring at sublethal levels.

Table 5. Land Uses and Population Density in Several Gulf of Mexico Basins (data from Brown et al. 2005, Dahm et al. 2005, and Ward et al. 2005).

Watershed	Land Use Categories (Percent)				Density (people/mi.^{2})
	Agriculture	Forested	Urban	Other	
Suwannee River	30	38	1	9	57
Apalachicola River System	25	55	2	18 (10% wetland)	133
Choctawhatchee River	25	57	1	17 (9% wetland)	46
Escambia-Conecuh River	15	72	<1	12 (7% wetland)	86
Mobile River	18	68	2	12 (7% wetlands)	114
Pascagoula River	17	66	1	16 (11% wetland)	75
Pearl River	24	58	2	15 (12% wetland)	109
Mississippi River	57	28	14	---	26
Sabine River	10	67	8	15 grassland	47
Neches River	15	65	5	15 grassland	29
Trinity River	15	35	30	20 grassland	254
Brazos River	24	3	16	15 grassland	52
Colorado River	30	--	15	55 range	91
San Antonio and Guadalupe Rivers	15	--	25	60 range	220
Nueces River	15	--	5	55 shrubland	42
Rio Grande River	5	14	7	74 shrub & grass	42

Mining

Mining occurs throughout the region. Mining along the eastern Gulf of Mexico coast is primarily for clay, sand, limestone, phosphate, and peat. There are also some sulfide mines upstream on the Apalachicola River and gravel mines in the Escambia River.

Hydromodification Projects

Several of the rivers within the area have been modified by dams, impoundments for navigation, levees, and drainage systems. Some rivers on both the eastern and western portion of the Gulf (including the Mississippi River) have been heavily hydromodified—fragmented by hydroelectric power plants and navigational dams, channels have been deepened, straightened, and contained within levees. For instance, there are 13 dams on the mainstem Chattahoochee and three on the Flint River, but there are no major dams on the Apalachicola River. There are 36 major dams in the Mobile River watershed, and the Trinity River watershed is also highly fragmented with 21 major dams throughout the watershed.

There are more than a 132 dams on the Brazos River—as a result of the dams there has been a reduction in sediment transport to reaches below the dams, consequently the river channel has deepened (downcut) resulting in the isolation of the mainstem from several of the oxbow lakes and off channel habitat once available to the native fishes and other animals. According to Dahm *et al.* (2005), although development is not prevalent in the lower river due to the frequency of flooding, the river is threatened by existing and proposed diversions to the neighboring cities of Houston and Fort Worth.

Commercial and Recreational Fishing

There is an extensive commercial fishery in the Gulf of Mexico. Fishermen fish with gillnets, trawls, paired trawls, and cast nets. Recreational fishermen are allowed to use hand lines, rod and reels, spears, and cast nets. This gear poses a risk to gulf sturgeon as a potential bycatch species. Gulf of Mexico fishing regulations require special gear to release turtles and smalltooth sawfish.

Ecoregions and Risk of Fire

The ecoregions in the Rio Grande watershed comprise Colorado Rockies Forests, Colorado Plateau Shrublands, Chihuahuan Desert, Tamaulipan Mezquital, Sierra Madre Occidental pine-oak Forests, and Sierra Madre Oriental oak-pine Forests, Tamaulipan Pastizal, and Tamaulipan Matorral. The San Antonio and Guadalupe Rivers span the Edwards Plateau Savannas, Texas Blackland Prairies, East Central Texas Forests, and Western Gulf Coastal Grasslands. The Colorado and Brazos River basins mostly flow through the Western Short Grasslands, Edwards plateau Savannas, Texas Blackland Prairies, East Central Texas Forests, Western Gulf Coastal Grasslands, and Central Forest/Grassland Transition Zone. The Sabine River watershed encompasses Texas Blackland Prairies, East Central Texas Forests, Piney Woods Forests, and Western Gulf Coast Grasslands. The other rivers in the region flow through multiple ecoregions, but share the ecoregions of the rivers listed above.

Peak fire season in the Gulf Region is similar to the Southeast Region. 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 as one every 19 to 47 years. The recurrence interval large fires in the two most arid regions, the tropical/subtropical steppe region and the prairie ecoregions (Texas portions of the Gulf Region) is much more frequent. One such large fire is expected in the prairie ecoregion every one to 17 years, and in the tropical/subtropical steppe region we would expect one large fire every 13 to 27 years (Malamud *et al.* 2005).

Southwest Coast Region

The basins described in this section are encompassed by the state of 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 the area. Essentially, this region encompasses all Pacific Coast Rivers south of Cape Blanco, California 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 on the basis of 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 see Table 6).

Natural History

The physiographic regions covered by the basins discussed herein, include: (a) the Cascade-Sierra Nevada Mountains province, which extends beyond this region as we have defined it and continue north into British Columbia, (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 influences by topograph 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 6. 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.

Human Activities and Their Impacts

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 7). Overall, the most developed watersheds are 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 subbasin of the Santa Ana watershed is dominated by urban land uses and the population density is about 1,500 people per square mile. When steep and unbuildable lands are excluded from this area, then the population density in the watershed is 3,000 people per square mile. However, the most densely populated portion of the basin is near the city of Santa Ana where density reaches 20,000 people per square mile (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 watersheds 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 United States Geological Survey 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). As a result of the changes, the biological community in the basin is heavily altered (Belitz *et al.* 2004).

Table 7. 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 (Knatzer and Sheton 1998 *in* 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 subbasins--22 pesticides were detected in 20% of the samples and concentrations of seven exceeded water quality standards (Dubrovsky *et al.* 1998). Water chemistry in the Salinas River is strongly influence by intensive agriculture—water hardness, alkalinity, nutrients and conductivity are high in areas where agricultural uses predominate.

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 comprise 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% is suspected of discharging metal-rich waters in the basins. The Iron Metal Mine in the Sacramento Basin releases more tha 500 kg of copper and more than 350 kg of zinc to the Keswick Reservoir below Shasta Dam, as well as elevated levels of lead (Cain *et al.* 2000 in 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 sublethal effects including reduced feeding, overall activity levels, and growth. The Sacramento Basin and the San Francisco Bay watershed 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 today. Based on sediment cores, we know that pre-mining concentrations were about 5 times lower than concentrations detected within the Bay today (Conaway *et al.* 2003 in EPA 2006).

Hydromodification Projects

Several of the rivers within the area have been modified by dams, water diversions and drainage systems for agriculture and drinking water, and some of the most drastic channelization projects within the nation. In all, there are about 1,400 dams within the State of 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 Federal 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 each year to southern California. The State Water Project has 20 major reservoirs and holds nearly 6 million acre-feet of water, delivering about 3 million acre feet. Together these diversions irrigate about 4 million acres of farmland and deliver drinking water to about 22 million residents.

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 the last free flowing rivers in coastal southern California has 9 dams in its watershed. All major tributaries of the San Joaquin River are impounded at least once 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 hydrograph of the San Joaquin River is seriously altered from its natural state, the temperature regime and sediment transport regime are altered, and such 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 within the basin, a run once estimated as producing 300,000 to 500,000 fish (Carter and Resh 2005).

Commercial and Recreational Fishing

The region is home to many commercial fisheries. The largest in terms of total landings in 2006 were northern anchovy, Pacific sardine, Chinook salmon, sablefish, Dover sole, Pacific whiting, squid, red sea urchin, and Dungeness crab (CDFG 2007). Red abalone are also harvested off of 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 (Daniels and Floren 1998). 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 and others, 1884-1887, cited in NRC 1996).

The Risk of Fire in the Region

Peak fire season in the Southwest Coast 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 Mediterranean and Mediterranean Mountain ecoregions that encompasses most of this region, as every year to 3 years in the lowland or Mediterranean ecoregion, and less frequently in the Mediterranean Mountains – approximately every 9 to 17 years.

Pacific Northwest Region

This region encompasses Washington, Oregon, Idaho, and includes parts of Nevada, Montana, Wyoming, and British Columbia. The region is ecologically diverse, encompassing northern marine lowland forests, mountain forests, alpine meadows and Northern desert habitat. In this section we focus on three primary areas that characterize the region, the Columbia River Basin and its tributaries, the Puget Sound Region, and the Coastal Drainages north of the Columbia River. 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 Dessert, and Temperate Steppe and Temperate Steppe Mountains. Puget Sound and the coastal drainages are contained within the Marine Division, while the Columbia River watershed encompasses portions of all five ecoregions.

Columbia River Basin

Natural History

The most notable of all basins within the region is the Columbia River. The largest river in the Pacific Northwest and the fourth largest river in terms of average discharge the United States drains an area over 258,000 square miles (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 8 for a description of select Columbia River Tributaries). The Snake River is the largest tributary at more than 1,000 miles long; its headwaters originating 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 Bitteroot Range, and the Cascade Mountain Range.

The average annual runoff at the mouth of the Columbia River is 265,000 cubic feet per second (cfs; Kammerer 1990). A saltwater wedge extends 23 miles upstream of the mouth with tidal influences extending up to 146 miles up river (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 not uncommon 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 8. 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 (4 T, 1 E), 6 (1 T, 5 E) snails, 1 plant (T)
Yakima River	214	6,139	CS, CU	7	3,602	50	2 (T)
Willamette River	143	11,478	CS, PB	60	32,384	61 (~31)	5 fish (4 T, 1 E),

* 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 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).

Human Activities and Their Impacts

Land Use

More than 50% of the United State's 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 9 for a summary of land uses and population densities in several subbasins within the Columbia River watershed (data from Stanford *et al.* 2005).

Table 9. Land Uses and Population Density in Select Tributaries of the Columbia River (data from Stanford et al. 2005)

Watershed	Land Use Categories (Percent)				Density (people/mi.^{2})
	Agriculture	Forest	Urban	Other	

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 causing 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, over harvest, and competition from hatchery fish. Critical ecological connectivity (mainstem to tributaries and riparian floodplains) has been disconnected by 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 was forested, 30% was agricultural fields and 16% was urban or suburban lands. In the Flathead River aquatic invasive plants such as pondweed, hornwort, watermilfoil, 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).

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 United States (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 1800. 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 acre feet 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 restricting 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 impacts from agricultural activities include alteration of the natural temperature regime, and insecticide and herbicide contamination, and increased suspended sediments.

The U.S. Geological Survey 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. Water volumes, crop rotation patterns, crop-type, and location of 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. One study conducted by the U.S. Geological Survey between May 1999 and January 2000, detected 25 pesticide compounds (Ebbert and Embrey 2001). Another study detected at least two pesticides or their breakdown products in 91% of the samples collected, with the median number of chemicals being eight, and the maximum was 26. The herbicide 2,4-D occurred most often in the mixtures, along with azinphos-methyl, the most heavily applied pesticide, and atrazine, one of the most mobile pesticides in water (Fuhrer *et al.* 2004). However, the most frequently detected pesticides in the Yakima River Basin are total DDT, as well as its breakdown products DDE and DDD, and dieldrin (Johnson and Newman 1983; Joy 2002; Joy and Madrone 2002; Furher *et al.* 2004). In addition to current use-chemicals these legacy chemicals continue to pose a serious problem to water quality and fish communities despite their cancellation in the 1970s and 1980s (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 examining 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).

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 500,000 people, whereas the next largest cities, Spokane, Salem, Eugene, and Boise, have more than 100,000 people (Hinck *et al.* 2004). Overall, however the population within the basin is one-third the average, and while the basin covers about 8% of United States' land, only about 1.2% of the United States population lives within the basin (Hinck *et al.* 2004).

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 waste water 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 examining 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 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).

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 encompasses the operations of 14 major dams and reservoirs on the Columbia and Snake Rivers, operated 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 Bureau of Reclamation 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 Bureau of Reclamation has operated irrigation projects within the basin since the 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 crop lands 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. Both upstream and downstream migrating fish are impeded by the dams, 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. More than 55% of the Columbia River Basin that was accessible to salmon and steelhead before 1939 has been blocked by large dams (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 as a result of controlling peak flows and associated revetments. Consequently, the dynamics of estuary has changed substantially.

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 of lost natural production of salmon within the basin from the dams on fishing. The hatcheries are operated by Federal, state, and tribal managers. For more than 100 years, hatcheries in the Pacific Northwest have been used to produce fish for harvest and replace natural production lost to dam construction, and have only minimally been used to protect and rebuild naturally produced salmonid population (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, are a contributing factor to the 90% reduction in natural coho salmon runs in the lower Columbia River of the past 30 years (Flagg *et al.* 1995). 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 included: the loss of genetic variability within and among populations (Busack 1990 and Riggs 1990 *cited in* Hard *et al.* 1992; Reisenbichler 1997), disease transfer; increased competition for food, habitat, or mates; increased predation; altered migration; and displacement of natural fish (Steward and Bjornn 1990 *cited in* Hard *et al.* 1992; Fresh 1997); and species with extended freshwater residence are likely to face higher risk of domestication, predation, or altered migration than are species that spend only a brief time in fresh water (Hard *et al.* 1992) to name a few. 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 population (Hard *et al.* 1992).

Currently, NMFS is working on hatchery reform project in the Columbia River Basin, which will include a collaborative review of how harvest and hatcheries—particularly federally-funded hatcheries— are affecting the recovery of listed salmon and steelhead in the Basin. Eventually, the project team would create a management approach that allows tribal, state and Federal managers to effectively manage Columbia River Basin hatcheries to meet conservation and harvest goals consistent with their respective legal responsibilities. This effort was mandated by Congress in 2005, and is currently in its early stages.

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 in a variety of methods and 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 United States 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 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 (Quigley 1997 in 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 such as cadmium, copper, lead and zinc (Hinck *et al.* 2004).

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 with canning techniques. Harvest techniques also changed over time, from early use of hand-held spears and dip nets, to river boats that used seines and gill-nets, eventually, transitioning to large oceangoing 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 are made north of Cape Falcon, Oregon. Over the past five years, the number of spring and fall salmon commercially harvested in tribal fisheries has averaged between 25,000 and 110,000 fish (Mann 2004 in 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).

Puget Sound Region
Natural History

The Puget Sound watershed 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 feet 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 feet above sea level with the highest peak, Mount Rainer towering over the region at 14,410 feet above sea level. As the second largest estuary in the United States, Puget Sound has about 1330 miles 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 feet at its shallowest point (King County 2001). The deepest point in Puget Sound is found in the Central Basin and is over 920 feet. 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, subestuaries (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 1300 feet. Geology in the region consists of mostly Tertiary sedimentary bedrock formations.

The land and vegetation surrounding Puget Sound waters is classified as Puget Lowland Forest and occupies 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 as a result 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 treeline (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 inches, 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; more than 140 mammals, of which less than a third are marine mammals. 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.

Human Activities and Their Impacts
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" forest land and by 2004 the total acreage was nearly half that surveyed more than 70 years earlier (PSAT 2007). 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 declined by 11.1% between 1991 and 1999 (Ruckelshaus and McClure 2007). 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—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 in 2003 was an estimated 3.8 million people, with 86% residing in King, Pierce and Snohomish Counties (Snohomish, Cedar-Sammamish Basin, Green-Duwamish, and Puyallup River watersheds), and the area is expected to attract four to six million new human residents in the next 20 years (Ruckelshaus and McClure 2007).

According to the State of the Sound report (PSAT 2007) in 2001, impervious surfaces covered 3.3% of the region, with 7.3% of lowland areas (below 1,000 feet elevation) covered by impervious surfaces. In one decade, 1991 – 2001 impervious surfaces increased 10.4% region wide. The Snohomish River watershed, one of the fastest growing in the region, increased 15.7% in the same period.

Much of the region's estuarine wetland losses 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 achieving 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 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 miles 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 acres of intertidal or shore wetlands had been lost at eleven deltas in Puget Sound (Bortleson *et al.* 1980). Tidal wetlands in Puget Sound amount to 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 has risen in the region a number of new and legacy pollutants are of concern. According to the State of the Sound Report (PSAT 2007) in 2004, more than 1,400 fresh and marine waters in the region were listed as "impaired." Almost two-thirds of these water bodies were listed as impaired due to contaminants, such as toxics, pathogens, and low dissolved oxygen or high temperatures, and less than one-third had established cleanup plans; more than 5,000 acres 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), and roughly one-third (180,000 acres) the submerged lands within Puget Sound are considered moderately contaminated. PBDEs biomagnified in the food chain, and in the past 20 years the body burden in harbor seals has increased dramatically from 50 ppb to more than 1,000 ppb. 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 (DOE 2002). Hypoxic dissolved oxygen concentration (<3 mg/L) were found at several (11 out of 54) stations. Dissolved oxygen 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 through 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 in recent years for some chemicals found in sediments (DOE 2005). Less than one third (32 percent) of almost 13,000 chemical measurements made were detected during testing. Those detected most often exceeded sediment quality guidelines in urban embayments: Sinclair Inlet (mercury), Thea Foss Waterway (PAHs).

In general, metals concentrations in 2000 were lower than in 1989 thru 1996 more often than they were higher, while the opposite was true of PAHs (DOE 2005). 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 HPAH and 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. Also, 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 NOAA (DOE 2003). 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) (DOE 2003). 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 had been 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). Sediments in which results of the three kinds of analyses were not in agreement 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 suggest.

Researchers detected arsenic, copper, lead, and mercury throughout the Sound. They found cadmium at 59% of the stations and tributulin, an antifouling chemical found in ship hull paint, at 50% of the stations. PAHs were common while phthlalate esters, PCBs, DDTs and dibenzofurans appeared at fewer stations (PSAT 2004). 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 (DOE 1997-2003 posters).

The USGS assessed water quality of streams, rivers and groundwater in the Puget Sound Basin as part of the National Water-Quality Assessment (NAWQA) Program between 1996 and 1998. This assessment focused on the quality of surface and ground waters and biological indicators such as fish status, algal status 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 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). 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 2007).

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) has been a significant modification in 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, and bank hardening for erosion control, and agriculture uses. The first dike built 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 and allow for floodplain activities (like agriculture or development), and to power local timber mills (Ruckelshaus and McClure 2007).

In the next couple of years, however a highly publicized and long discussed dam removal project is expected to begin in the Elwha River. The removal of two dams in the Elwha River, a short but formerly very productive salmon river, is expected to open up more than 70 miles of high quality salmon habitat (Wunderlich *et al.* 1994 in Ruckelshaus and McClure 2007). Estimates suggestion that nearly 400,000 salmon could begin using the basin within 30 years after the dams are removed (PSAT 2007).

About 800 miles of Puget Sound's shorelines are hardened or dredged (PSAT 2004 in Ruckelshaus and McClure 2007). The area most intensely modified is the urban corridor (eastern shores of Puget Sound0 from Mukilteo to Tacoma); here nearly 80% has been altered, mostly from shoreline 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 rising flood waters.

Mining

Mining has a long history in the State of 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 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 he rate of harvest and the natural rate of replenishment, as well as flood and precipitation conditions during or after the mining operations.

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 sought by Tribal fisheries, and by charter, and recreational anglers. Nets and trolling are used in commercial and Tribal fisheries, whereas recreational anglers typically use hook and line, and may fish from boat, river bank, and docks. Entanglement of marine mammals in fishing gear is not uncommon and can lead to mortality or serious injury.

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 feet. 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 sq. miles and is a little over 110 miles long and the Nehalem River drains a basin of 855 sq. miles and is almost 120 miles 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, and is 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, and 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.

Human Activities and Their Impacts

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 (Maser and Johnson 1999). 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 (Maser and Johnson 1999).

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) only about 30 miles of salmon habitat are permanently blocked by dams in the coastal streams of Washington.

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 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, the effects of the channel scouring and loss of channel complexity resulted in the long term loss of salmon habitat (NRC 1996).

Mining

Oregon is ranked 35th nationally in total nonfuel mineral production value in 2004, while Washington was ranked 13th nationally in total nonfuel mineral production value 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 he 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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The Risk of Fire in the Region

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. Whereas, 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 Dessert, Temperate Steppe, and Temperate Steppe Mountain ecoregions, is more frequent—ranging from every 8 to 18 years in the Temperate Dessert, every 14 to 30 years in the Temperate Steppe ecoregion, and every 26 to 46 years in the Temperate Steppe Mountain ecoregion (Malamud *et al.* 2005).

In the state of Oregon, between January 1 and September 21, 2007, there were more than 1,000 fires that burned more than 58,000 acres of forestlands protected by the Oregon Department of Forestry. The ten year average area of fires burned annually is slightly more than 20,000 acres (ODF 2007).

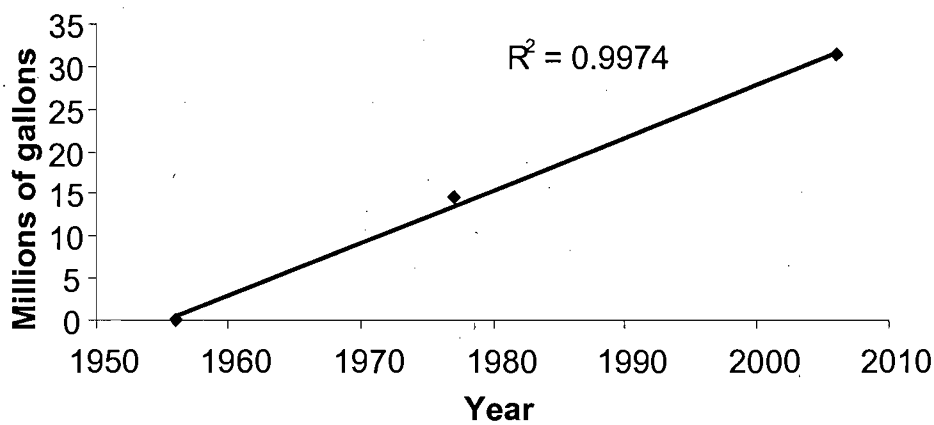
Effects of the Proposed Action

Retardant Application

In 1930, the USFS began aerial application of water to suppress fires. These early efforts were not as successful as hoped because the air turbulence created by the aircraft caused most of the water to drift off course and evaporate before reaching the fire on the ground. By 1955, the agencies were using retardant to fight fires and they found that adding sodium calcium borate to the mixture held the retardant together. The sodium calcium borate significantly reduced loss due to air turbulence so that more retardant reached the fire on the ground. However, sodium calcium borate is corrosive to airplane tanks and retardant mixing equipment, forms lumps, separates, and is a soil-sterilizing agent. In 1963, fertilizer-based retardants containing diammonium phosphate, ammonium phosphate, and ammonium sulfate were first used and continue to be used today. Currently, fire retardant is about 85% water, 10% either ammonium phosphate or ammonium sulfate or a combination of the two, and five percent additives, such as gum thickeners, coloring agents, and corrosion inhibitors. Corrosion inhibitors, such as sodium ferrocyanide, are needed to minimize the deterioration of retardant tank structures and aircraft, which contributes to flight safety (Raybould *et al.* 1995), but none of the eight qualified chemicals considered in this consultation contain sodium ferrocyanide.

In 1956, 23,000 gallons of retardants were applied on or around fires nationwide. By 1977, the volume of retardant dropped on Federal land increased to more than 14.55 million gallons. From 2000 through 2006 across all federally owned lands, approximately 30.7 million, 29.9 million, 33.6 million, 23.8 million, 12.1 million, 18.6 million, and 31.3 million gallons were used each year, respectively. Each load of fire retardant is on average 1,500 gallons, which means the number of loads increased from 15 in 1956 to 9,704 in 1977 to 20,867 in 2006 on all Federal and state lands (Figure 10). The general linear trend between 1977 and 2006, indicates there has been an increase of 16.75 million gallons over 29 years. Based on this trend, NMFS anticipates the USFS may apply an additional 578,000 gallons of fire retardant each year in the future.

Figure 10. Retardant Usage



From 2000 through 2006 across all federally owned lands, approximately 25 million gallons of retardant was applied to roughly 17,850 acres each year. Typically, 70% of all retardant dropped in a year is dropped in Washington, Oregon, and California (Norris *et al.* 1978), with much of the rest being applied to Idaho, Montana, and Alaska. If it is assumed that a proportional amount of land receives fire retardant along the West Coast, then 70% of the national average is 17.5 million gallons of retardant dropped on 12,495 acres. This is equivalent to 1,400 gallons per acre or approximately 3.21 gallons per 100 square feet. Our estimated application rate is within the range used by USFS to calculate the probable risk of fire retardant application (see Labat 2007).

As the application of long-term fire retardants has increased since its inception, the USFS has developed means of evaluating which fires should be fought and which resources in particular areas are of the most importance and should be avoided or protected. For every fire, a Wildland Fire Implementation Plan (WFIP) is initiated, which helps resource managers determine whether a fire can be managed for resource benefit or if it needs to be suppressed. When a fire exceeds its initial containment or anticipated prescription purpose, the USFS is required to conduct a Wildland Fire Situation Analysis (WFSA), which is a decision making structure that considers the objectives and constraints of fighting the fire, compares multiple strategic wildland fire management alternatives, evaluates the expected effects of the alternatives, selects the preferred alternative, and documents the decision. This process provides several alternative methods for fighting a fire and takes into consideration such resource considerations as archaeology, critical habitat, listed species, and socio-economic factors.

In 2006, only three of the eight qualified chemicals were used to fight fires. Phos Chek D75-F was used for 5,085 loads, delivering over 5.9 million gallons of retardant, while 6.4 million gallons of Phos Chek D75-R was used in only 3,566 loads, showing that the loads of D75-R consist of larger volumes. The main Phos Chek fire retardant used in 2006 was LC-95A-R, which accounted for more than twice the volume of the other two chemicals with 13.5 million gallons spread out over 11,383 loads (Table 10). Also during the 2006 fire season, Fire Trol products (long-term retardant), Phos Chek Aqua-gel K (water enhancer gel), and Barricade (water enhancer gel) were applied in the United States, but those retardants are not included by the USFS as part of its action and therefore not evaluated in this consultation nor is NMFS aware what entities may have used these products. In 2006, 24,251 loads of fire retardants were applied nationwide. The USFS used approximately 63% of the total fire retardant in 2006, which amounted to 15,278 loads on NFS lands.

Table 10. Fire retardants used Nationwide, the number of loads dropped, and volume of each drop.

Fire Retardant	Volume	Loads	Average Load Size
Phos Chek D75-F	5.9 million gallons	5,085	1,160 gallons
Phos Chek D75-R	6.4 million gallons	3,566	1,795 gallons
Phos Chek LC-95A-R	13.5 million gallons	11,383	1,186 gallons

Of the eight fire retardant formulations on the long-term fire retardant QPL, it is unclear to NMFS when certain retardants would be used in a particular situation. According to the USFS, the retardants used on a fire are often already loaded on a plane in anticipation of the outbreak of a wildfire. It is unclear if certain formulations are more effective on a certain fuel type, and what influences the distribution and use of particular chemicals. We understand that the USFS is compelled by many rules and agreements to fight fires and minimize the impact to people, property, and resources, and that decisions must be made on the ground by the Incident Commander. However, it appears to NMFS that there is a decision made prior to the Incident Commander's decision to use fire retardants, regarding where a particular formulation will be distributed and stored. For example, during this consultation we learned that Phos Chek LC-95A-R was not used on southeastern forests, and D75-F was not used in USFS regions 1, 2, or 3, along the northern and southern Rocky Mountains. Phos Chek D75-R, however, was used in small amounts in every region. The reasons for these regional differences in use patterns are not apparent to NMFS, yet this information could have informed our evaluation of the potential exposure patterns and the ultimate risk the action poses listed species.

Direct Effects

There are two primary ways that waterways containing listed fish species could be exposed to fire retardants. One is through the intentional application of retardants –a planned release across a waterbody or immediately adjacent—and the other is through the accidental drop or spill during aerial application or during on-the-ground activities. By following the 2000 Guidelines, the USFS may still drop fire retardants into bodies of water, both visible and out of sight. One of the USFS's obligations is to protect resources of value that are found on USFS lands. The Incident Commander uses the WFSA as a tool to find multiple alternatives for fighting fires in a particular area, taking listed species and their critical habitat into account, along with other important NFS resources. If the Incident Commander, after reviewing the WFSA alternatives, determines aerial application of fire retardant adjacent to a waterway is necessary, then even with the 2000 Guidelines in place, the USFS could drop fire retardant into and adjacent to streams. While there could be multiple misapplications in one watershed while fighting a fire, the intent of the 2000 Guidelines and the WFSA alternatives are to prevent this from happening. While the 2000 Guidelines are flexible, and allow for the Incident Commander to make exceptions to conduct a drop that would expose a waterbody to retardants, according to the USFS no exceptions have been taken since institution of the Guidelines (C. Werhli, email, Sept. 21, 2007). Nonetheless, between the Misapplication List, misapplications that were never consulted on, and formal emergency consultations completed by NMFS, on at least 14 occasions over a four year period fire retardant has entered rivers on USFS lands demonstrating that even with the 2000 Guidelines in place, the USFS is unable to assure that fire retardant will stay out of streams (Appendix C).

Furthermore, the 2000 Guidelines only address visible water, so if water is not visible from the airplane at the time of the drop, no accidental introduction would be anticipated and unless evidence of an application to headwater systems is found during burned area emergency response (BAER) monitoring, it would not be reported. We expect that in most instances the largest stream that may be accidentally hit with retardant and not seen through the trees would be a third order stream. This would be expected during smoky conditions, which could be often as most retardant would be applied downwind of the fire as a means of slowing its progression. Even during clear conditions, the pilots would be expected to watch where they are flying and not where the applications lands and would likely have difficulty detecting when a fire retardant entered a stream. We learned that even when multiple people are aboard an airplane, none of those people are there to monitor where the application lands, but rather they have other duties to tend to while in the air.

Fire retardant is designed to perform in several ways: to stay together during the drop from high up so that it all hits in the same general area, to cling to what it hits initially, and in some cases is thinned to drip through branches to the ground. The mix ratios of many formulations are variable so that the retardant can be more or less concentrated so that the appropriate application can be achieved in different environments. In forestlands for instance, to reach fires burning at ground level the retardant would be less concentrated so that it would seep through the leaves and branches and reach the ground (Johansen and Dieterich 1971). This application style would be expected when fighting ground fires in most West Coast forest land. Another aspect of attempting to apply retardant to fuels beneath the canopy is that it poses a much greater risk of contaminating streams that are not visible from aircraft.

NMFS is unsure if long-term retardant in runoff is ever monitored by the USFS because it likely only enters streams in sub-lethal levels. Labat (2007) analyzed the risk of runoff using mortality as the only measurement endpoint. Labat (2007) did not evaluate persistent or sub-lethal effects, but stated that because retardant drops are likely to be intermittent one-time events a chronic analysis for the products was not conducted. Labat (2007) does mention that the USFS is engaged in evaluating the possible sub-lethal effects from the ingredients in approved products, including those from longer-term exposures, but no information was provided to NMFS for the purposes of this consultation.

We expect that runoff is particularly problematic and extensive in areas of recently disturbed riparian vegetation, areas without riparian vegetation, and areas of incomplete retardant coverage that burn but leave behind retardant. Little and Calfee (2002) showed that when retardants are applied to riparian areas or even across a dry streambed, the retardants remain toxic for 21 days. Any rain event that happens within three weeks after application to the riparian area poses a risk of introducing lethal levels of ammonia to a stream, potentially after any sort of monitoring had been conducted and after the effects to listed fish had been analyzed.

Monitoring and Reporting Accidental Exposures

Monitoring and reporting is a standard part of all smaller, local actions. Nationally, there does not appear to be a means of compiling all BAER reports, BAs for emergency consultations, Opinions written for emergency consultations, and general fire information into one database on the effects of fire retardant applications and misapplications. The USFS provided NMFS a Misapplication List that notes there have been 11 observed misapplications of long-term fire retardant between 2001 and 2005.

To supplement information provided by USFS, we surveyed NMFS' Public Consultation Tracking System to determine the number of post-fire emergency formal consultations that had been conducted, and separately discussed several consultations with regional staff; in particular we concentrated on those emergency actions denoted in USFS' Misapplication list. Based on our comparative review, we found that in many cases formal (post emergency) consultations were not completed by the USFS, despite observations or expectations that adverse effects had occurred; we learned that USFS infrequently conducted post-fire monitoring, most of which focused on the effects and remediation of the effects of sediment on aquatic systems; and no monitoring of sub-lethal effects or effects to critical habitat. NMFS found no evidence that the USFS monitored the cumulative effects of their use of long-term fire retardant in sub-watershed, watersheds, or on the listed species. The USFS's Misapplication List reported accidental application to waterways on the: Biscuit, Eyerly and Cache, Forks, Bowl, East Fork, St. Mary's Mission, Fall River, Cannon, Elk Heights, Canyon, and Nick Fires. NMFS found three other misapplications that occurred in that time, the Desolation, Rattlesnake, and Fly Creek Fires, and knows of other misapplications that have occurred since then that have had dead fish collected as a result of the misapplications, such as the Burnt Log fire on the Boise National Forest. The USFS was aware that Fire Trol was dropped in seven of these 14 events, Phos Chek was dropped in two cases, and was unaware of what retardant entered the waterway in five cases, but even when the manufacturer was known, in less than half the reported events, was the misapplied formulation known. There was no record of the location for the Fall Creek, Elk Heights, or Canyon fire misapplications, but after some research, the Fall Creek Fire misapplication was on the Deschutes National Forest, the Elk Heights Fire was on state and private land, and the Canyon Fire was on the Boise National Forest near McCall, Idaho. In the case of both the Fall Creek Fire and Canyon Fire, the USFS national office, despite having fought the fires regionally, did not know the location or agency at fault for these misapplications. This is likely because neither fire was over 100 acres, and therefore the USFS did not conduct a BAER assessment nor was consultation initiated.

Other agencies may not conduct BAER assessments, but their monitoring programs appear to identify the effects of misapplications more accurately than the USFS post-fire monitoring. Based on the Misapplication List of the 11 reported accidents, nine misapplications were on USFS lands and two on state or private lands, but the USGS monitored one of the accidents on USFS land. Of the eight misapplications on USFS land that were monitored by USFS employees, a total of one dead listed fish was reported. In contrast, for the three misapplications that were monitored by the USGS or state agencies, over 30,000 dead fish, well over half of them listed species, and over 10 miles of destroyed critical habitat were reported. Additionally, two of the three accidents that were not on the Misapplication List were on USFS land and one of those accidents found 5 dead listed fish. NMFS assumes it was never reported to the Washington Office because it was not included on the Misapplication List.

Of the most concern is that as far as NMFS knows, a BA was finalized and consultation conducted for only four fires where the USFS observed fire retardants had entered streams with listed fish species; the Nick Fire, Desolation Fire, Fly Creek Fire, and Bowl Fire incidents, but not the Biscuit Fire or Forks Fire, which had listed fish present. For the four fires that had emergency consultations completed, the USFS did not acknowledge in the Misapplication List that NMFS authorized incidental take of listed species or that adverse effects were likely. In all cases, the Misapplication List indicates that no dead fish were found, but the Opinions provided incidental take coverage of over 6,500 listed fish of various ages, including parr, smolt, juvenile, and adult life stages. Furthermore, in situations where listed fish were not affected, we are unaware what monitoring or documentation was provided to the USFS Washington Office, which could have better informed them of the cumulative impacts of misapplications to listed fish. Of the two accidental applications of Phos Chek retardants, one occurred on the Deschutes National Forest, which killed 260 non-listed rainbow trout, while the other occurred on the Klamath National Forest, but since the USFS determined the misapplication was not likely to adversely affect Southern Oregon/Northern California coast coho salmon, they never prepared a final BA or initiated formal consultation.

Likelihood of Observing Accidental Exposures

According to the USFS instances of accidental spills or misapplied retardants are rare. It's unclear, however, whether the misapplication of fire retardants would be detected and recorded while all other aspects of fighting a fire are also happening. In an environment where everyone needs to be alert to their jobs at all times, no single person is responsible for monitoring the application of fire retardant to ensure it hits its intended target. Unobserved accidents may be found after the fact during the BAER analysis by observing the coloring agent of a fire retardant around a stream, at which point an evaluation for any impacts would be conducted, but this could be long after the actual fire and misapplication. When an accident is observed reports are made to the Resource Advisor. The reports make their way up the chain of command to the District Ranger or Forest Supervisor and the Incident Commander. The Incident Commander is responsible for reporting the accident to the National Interagency Fire Center.

Not all observed accidental applications to water must be reported to the Wildland Fires Chemicals System. Prior to reporting the accident to the National Interagency Fire Center, the 2007 Redbook instructs the USFS to first determine if there have been adverse effects.
It is unclear how quickly (and likely variable based on the conditions of the site) personnel would monitor the stream for dying or distressed fish, or adverse changes in water quality. NMFS believes the application of large amounts of fire retardant to rivers poses both a lethal and sub-lethal risk to listed species. If the USFS determines that there were no adverse effects, even when in some cases they don't monitor immediately after the accident due to safety constraints, there is no requirement to report the misapplication or to conduct an emergency consultation (Redbook 2007). NMFS understands there are human safety issues with monitoring water quality and surveying for fish kills immediately after a misapplication. However, the lack of dead fish, even if monitored immediately after a drop, is a poor indication that the drop had no effect on fish in the area. NMFS believes that a number of retardant drops into waterbodies may never be observed, and when they are observed by personnel there is a low likelihood that USFS employees would find a dead or distressed fish. Based on discussions with USFS, it would appear that water quality monitoring is only included in BAER reports if there is evidence that

long term retardants entered the streams. Consequently, NMFS suspects that the number of misapplications reported to the National Interagency Fire Center and potential effects those misapplications caused may be underestimated by the USFS.

While the USFS has not reported any misapplications to headwater streams, NMFS expects numerous accidental introductions that have not and would never be reported because those streams are not addressed by the 2000 Guidelines. NMFS anticipates that there will be occasions of unreported accidental introductions and introductions that are later not reported because no fish kill was identified. Despite the lack of reporting to date, we are aware that as incidents of fire retardant use increases through time, so do incidents of misapplication (Norris *et al.* 1978). As noted above, there have been 14 documented fire retardant misapplications between August 2001 and December 2005, which comes to approximately 3.25 incidents each year. There are other misapplications that have not been documented due to lack of reporting, but due to limited consultation time, NMFS has not been able to investigate every known misapplication. Norris *et al.* (1978) and the USFS during this consultation have reported that fish kills discovered after fighting fires may be caused by fire retardants or by the fires themselves. As discussed in the 2005 court case that initiated this consultation, in the course of one year while following the 2000 Guidelines, eight misapplications were reported. That represents the highest annual rate of misapplications between 2001 and 2005, but for the purposes of evaluating the potential exposure, each aerial application has the potential to enter streams and the 2000 Guidelines provide no upper limit for misapplications. The number of accidental drops in 2006 and 2007 are not yet available, but those fire seasons have been two of the most destructive on record and required more loads of fire retardant than most previous years. The overall rate of accidental introductions varies by total applications, year, fire locations, terrain, and Incident Commanders working on the fires. Based on the average number of fish kills each year, an observed load of fire retardant would enter a stream approximately once every 4,701 drops using the 2006 level of application.

The disconnect between the outcome of the emergency consultation, monitoring practices, and the fact that the USFS has not assessed the cumulative impact of fire retardant use in a watershed or ESU is disconcerting to NMFS. Our evaluation of these misapplication instances, however, did not reveal any information to suggest whether USFS personnel are more likely than not to detect misapplications when they occur, nor did our evaluation indicate why in some instance the USFS is choosing not to consult on their emergency actions, when (among other effects of fire suppression) fire retardants are observed entering waterways containing listed species. With better monitoring and evaluation, NMFS believes that the Services and the USFS may identify alterations or amendments to the 2000 Guidelines that would provide additional protection to listed resources.

When fires occur, without the use of fire retardant, there are severe effects to rivers and streams in some cases. Fire increases the temperature of streams, which reduces the DO, since water with higher temperatures can hold less oxygen. The smoke and ash from the fire causes an increase in ammonia and respiratory distress, respectively. Minshall and Brock (1991) believe that increased temperatures, which can range from 4 to 10°C (Gresswell 1999), can kill fish in first and second order streams but doubt third order streams get hot enough to kill organisms. Mortality in second and third order streams could be caused by smoke and ash (Minshall *et al.*

1989). In larger streams, the impacts of fire are likely less (Gresswell 1999) for many of the same reasons as the impacts of fire retardant in larger streams 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 (Propst *et al.* 1989, Rieman *et al.* 1997), and similar responses would be expected if fire retardant was dropped in a headwater system. Larger, better connected populations are more resilient (Rieman *et al.* 1995, Dunham *et al.* 2003) so individuals from downstream that aren't harmed by the retardant may migrate back into the headwater system to spawn, helping fish re-establish in that area.

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 systems at the time of application makes fish all the more susceptible to lethal and sub-lethal effects. The risk assessment conducted below evaluates how the misapplication of fire retardants impacts listed species and their critical habitat as a separate stressor from natural wildfires.

Northwest and Southwest Regions

The Northwest and Southwest are home to most of the National Forests in this country and most of the USFS land with listed species in their watersheds. In the Northwest, there are 18 National Forests with listed species and critical habitat designations (Table 11). The Southwest is home to 10 National Forests with listed species and critical habitat designations (Table 12). Initially NMFS considered evaluating the proportion of a species' range that is in National Forest land to estimate the potential for exposure, but as more was learned about the USFS fire fighting program, it was clear they also had authority to fight fires adjacent to their land. The distance from USFS land is unspecified, making any sort of measurements about the area of effects as vague as the regulations (FSM 5132). 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 without information on the life stages present, the subpopulation and or genetic structure of the species present on NFS lands and 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. Frequently, much of the most pristine salmonid habitat is located on USFS lands, while, as described in the baseline section, most severe and chronic watershed degradation is the result of private, developed lands. Based on habitat quality, the actual area of a species' habitat that is on USFS land is not really correlated with the value of that habitat to the species, as larger, impaired areas would have fewer listed fish than smaller, pristine areas. Therefore, NMFS did not rely on the percentage of the stream miles contained within NFS relative to the ESU or DPS as a metric evaluating exposure. NMFS, as described in the Approach to the Assessment section, evaluated the ability of the 2000 Guidelines to prevent exposure and whether any other information indicated that exposure was likely—based on information provided by USFS, information on past consultations, and numerous other sources, NMFS concluded exposure of listed salmonids is highly likely, but that the propensity for a particular ESU to be exposed varied according to fire regimes and other regional variables.

Table 11: Northwest National Forests and the NMFS trust resources that reside there.

National Forest	Listed Species	Critical	Status

		Habitat	
Columbia River Gorge	Columbia River chum salmon, LCR coho salmon, Snake River spring/summer Chinook salmon, Snake River fall-run Chinook salmon, LCR Chinook salmon, Snake River Basin steelhead, LCR steelhead, MCR steelhead, UCR steelhead	Y, N, Y, Y, Y, Y, Y, Y, Y	Threatened, Threatened, Threatened, Threatened, Threatened, Threatened, Threatened, Threatened, Endangered
Okanogan/Wenatchee	UCR spring-run Chinook salmon, MCR steelhead, UCR steelhead	Y, Y, Y	Endangered, Threatened, Endangered
Wallowa-Whitman	Snake River sockeye salmon, Snake River spring/summer Chinook salmon, Snake River fall-run Chinook salmon, Snake River steelhead	Y, Y, Y, Y	Endangered, Threatened, Threatened, Threatened
Gifford Pinchot	LCR coho salmon, LCR Chinook salmon, LCR steelhead	N, Y, Y	Threatened, Threatened, Threatened
Malheur	MCR steelhead	Y	Threatened
Mount Baker-Snoqualmie	Puget Sound Chinook salmon Puget Sound steelhead	Y N	Threatened Threatened
Mt. Hood	LCR Coho salmon, Upper Willamette River Chinook salmon, LCR Chinook salmon, LCR steelhead	N, Y, Y, Y	Threatened, Threatened, Threatened, Threatened
Ochoco	Middle Columbia River Steelhead	Y	Threatened
Olympic	Hood Canal summer-run chum salmon, Puget Sound Chinook salmon Puget Sound steelhead	Y, Y N	Threatened, Threatened Threatened
Rogue River	Southern Oregon/Northern California Coast coho salmon	Y	Threatened
Suislaw	Oregon Coast coho salmon	Y	Threatened
Siskiyou	Southern Oregon/Northern California Coast coho salmon Oregon Coast coho salmon	Y Y	Threatened Threatened
Umpqua	Oregon coast coho salmon	Y	Threatened
Umatilla	Snake River spring/summer Chinook salmon, Snake River fall-run Chinook salmon, Snake River Basin Steelhead, Middle Columbia River Steelhead	Y, Y, Y, Y	Threatened, Threatened, Threatened, Threatened
Willamette	Upper Willamette River Chinook salmon, Upper Willamette River Steelhead	Y, Y	Threatened, Threatened
Clearwater	Snake River Basin steelhead, Snake River Spring/summer Chinook salmon, Snake River fall Chinook salmon	Y, Y, Y	Threatened, Threatened, Threatened
Bitterroot	Snake River steelhead	Y	Threatened
Nez Perce	Snake River steelhead, Snake River spring /summer Chinook salmon, Snake River fall Chinook salmon, Snake River sockeye salmon	Y, Y, Y, Y,	Threatened, Threatened, Threatened, Endangered
Sawtooth	Snake River sockeye salmon	Y	Endangered
Salmon/Challis	Snake River sockeye salmon, Snake River spring/summer Chinook salmon, Snake River steelhead	Y, Y, Y	Endangered, Threatened, Threatened
Payette	Snake River steelhead	Y	Threatened

	Snake River spring/summer Chinook salmon	Y	Threatened
Boise	Snake River steelhead Snake River spring/summer Chinook salmon	Y Y	Threatened Threatened

Table 12: Southwest National Forests and the NMFS trust resources that reside there.

National Forest	Listed Species	Critical Habitat	Status
Angeles	Southern California steelhead	Y	Endangered
Eldorado	Central Valley steelhead	Y	Threatened
Klamath	Southern Oregon/Northern California Coast coho salmon	Y	Threatened
Lassen	Central Valley spring Chinook salmon Sacramento winter run Chinook salmon Central Valley steelhead	Y Y Y	Threatened Endangered Threatened
Los Padres	South-Central California Coast steelhead Southern California steelhead	Y Y	Threatened Endangered
Mendocino	Northern California steelhead Central Valley spring Chinook salmon California Coastal Chinook salmon Sacramento winter run Chinook salmon Southern Oregon/Northern California Coast coho salmon Central Valley steelhead	Y Y Y Y Y Y	Threatened Threatened Threatened Endangered Threatened Threatened
Plumas	Sacramento winter run Chinook salmon Central Valley steelhead	Y Y	Endangered Threatened
Shasta-Trinity	Southern Oregon/Northern California Coast coho salmon Sacramento winter run Chinook salmon Central Valley steelhead Central Valley spring run Chinook salmon California Coastal Chinook salmon Northern California steelhead Green sturgeon	Y Y Y Y Y Y N	Threatened Endangered Threatened Threatened Threatened Threatened Threatened
Sierra	Green sturgeon	N	Threatened
Six Rivers	Southern Oregon/Northern California Coast coho salmon Northern California steelhead California Coastal Chinook salmon	Y Y Y	Threatened Threatened Threatened
Tahoe	Sacramento winter run Chinook salmon Central Valley steelhead	Y Y	Endangered Threatened

The likelihood of exposure to fire retardant varies, with the size of the DPS or ESU, fire return intervals, the application necessary to reduce fire speed, and the natural severity of fires in those regions. During the 2004 and 2005 fire seasons, long-term retardant misapplications on the Nick Creek and Fly Creek Fires affected Snake River steelhead DPS and Snake River Spring/Summer Chinook salmon ESU. In addition, the Marble Fire in 2004 required emergency consultation as a result of the WFSA process not including a fish biologist, which, while not resulting in a misapplication of fire retardant did result in excess harm to those same two Snake River ESUs. The Snake River steelhead population is estimated to be approximately 28,000 adult fish and there are on average approximately 18,000 spring/summer Chinook salmon adults. Emergency consultation revealed that these misapplications affected the PCEs for rearing and migration. In 2002, the Southern Oregon/Northern California coast coho salmon were hit by fire retardant applications on the Biscuit and Forks Fires, but neither had an emergency consultation initiated. The Southern Oregon/Northern California Coast coho salmon population is estimated to be approximately 7,000 (Good *et al.* 2005). The misapplications affected the PCEs for spawning, rearing, and migration. In 2001 and 2003, the same creek on the Colville Confederated Tribe's land received an accidental application of fire retardants, resulting in over 10,000 dead UCR steelhead, which has an estimated adult return of approximately 2,200 fish. The misapplications affected the PCEs for spawning, rearing, and migration. In two other misapplications of long-term fire retardants in 2002, the Deschutes National Forest had at least two misapplications that resulted in fish kills of over 21,000 fish, but NMFS does not have any listed fish on the Deschutes National Forest so only the USFWS needed to evaluate the effects to bull trout. The data provided by the USFS in the Misapplication List in at least five instances does not indicate which species were affected by misapplications.

When a stream is exposed to a fire retardant, the life stage of the fish present is an important factor in the severity of effects to the species affected. Some researchers have found that swim up fry are most sensitive to fire retardants (Johnson and Sanders 1977, Gaikowski *et al.* 1996, Poulton *et al.* 1997, Kalambokidis 2000), and are clearly less capable of vacating an impacted area. Other researchers have found that swim up fry are just as susceptible as juveniles and adult fish (Rice and Stokes 1975), but eggs and alevins are clearly more resistant.

The risk of various life stages being exposed to fires, and therefore long-term fire retardants, is variable, because of the vegetation type, wind direction and speed, fire season length, and many other factors. In the Northwest, adult salmonids will be present on every national Forest during some point between April and October. In the Southwest, salmonid movements depend much more on high flow events, as there is much less rain in California than in Oregon or Washington systems. All species of California salmonids adults will be present during the fire season. Swim up fry in the southwest will be present during the fire season for Sacramento winter run Chinook salmon and all species of steelhead. Swim-up fry will be present on the Nez Perce, Clearwater, Umatilla, Columbia River Gorge, Wallowa-Whitman, Bitterroot, Salmon/Challis, Boise, Payette, Sawtooth, Mt. Hood, Gifford Pinchot, Lassen, Mendocino, Plumas, Shasta-Trinity, and Tahoe National Forests. Smolts will be present on every National Forest early in the year but they have usually outmigrated by June, limiting the amount of fire season to which they could be exposed. Juveniles will be present on every National Forest in the Northwest and Southwest Regions during the entire fire season.

In some systems in North America (such as ponderosa pine and loblolly pine forests which historically had high frequency, low severity fires) reduced fire frequency beginning in the late 19th century has led to substantial fuel accumulation. These fuels increase fire hazard and burn severity, a condition that can be exacerbated by a longer fire season, as has been the case recently and is anticipated to continue (e.g Westerling et al, 2006). A number of studies published over the past two decades suggest that fire hazard will increase, likely leading to increases in the annual area burned as well as in the severity of fires (Brown and Smith 2000, Flannigan *et al.* 1998, Fosberg *et al.* 1996, Lenihan *et al.* 1998, Stocks *et al.* 1998, Wotton and Flannigan 1993). More recently, two USFS scientists reported to Congress that the USFS anticipates more frequent and more severe fires in the future.

The Northwest is covered by western grasses, such as the Palouse dry steppe; shortneedle closed conifer systems, in both the Cascade and mountainous regions and Willamette lowlands; and sagebrush semi-desert. The primary region that burns in the southwest is the mixed chaparral located along the Southern California coastal range. Some upland areas in California have shortneedle conifer forests also. Virtually all fires in both the Northwest and Southwest occur between April and October. Many of the fires along the west coast are severe fires and the trees in this region have evolved to utilize fire for their reproduction. Most of these fires are mixed severity fires that burn in a mosaic pattern, with some stand replacement. This century has had some of the largest fire seasons on record with well above average years in 2000, 2005, 2006, and 2007, although the USFS was unable to provide any misapplication information for those years and NMFS only searched for emergency consultations from 2005, providing two misapplications that were unknown to the USFS.

There are different fire retardant application rates for these various regions throughout the North and Southwest. Palouse grasses receive one gallon per 100 square feet, while shortneedle conifer systems receive between two and four gallons per 100 square feet with more being applied in the Rockies and Sierras and less near the coast, sagebrush receives three gallons per 100 square feet, and Chaparral receives at least six gallons and often more per 100 square feet (Labat 2007). The amount of retardant needed per 100 square feet is generally indicative of the intensity of the fires in those regions. Each fire is attacked in a different fashion, dictated by the decisions made by the Incident Commander. The decision to use fire retardants is not made on every fire, therefore every fire will not expose listed fish to retardants, but this same variability could expose several rivers within one ESU or DPS to multiple fire retardant applications.

Northeast and Southeast Regions

In National Forest land along the East Coast, shortnose sturgeon are likely present on the Francis Marion (Santee-Cooper System), and Ocala (St. Johns River) National Forests (Dennis Krusac, pers. comm., September 10, 2007). The only NMFS trust resources expected to be found in these drainages are shortnose sturgeon. Due to dams or extirpations, no shortnose sturgeon are expected to be on any other East Coast National Forests.

The southeastern woodlands experience a fire return frequency of less than 35 years, but the severity is low or mixed. This means that most often, under natural conditions, there are just surface fires and worst case scenario would replace fewer than 25% of the trees affected by the fire (Hann *et al.* 2003). Severe fires are rare along much of the East Coast and due to the climatic conditions, the use of fire retardant is expected to be extremely rare. If retardant had to be used in southern hardwood forests, the necessary coverage is only two gallons per 100 square feet (Labat 2007), but there are no assurances that more retardant would not be used during a large fire. The fire season in the Francis Marion National Forest is typically October to June. In Florida, the pine scrub forests will burn at greater intervals than other trees in the region, every 35 to 100+ years, but the fires usually result in over 75% of the trees in the area being destroyed (Hann *et al.* 2003). In the high intensity fire areas of Florida, the fire season is basically all year (September to July).

Since the fire season on the Francis Marion National Forest is October to June, there is a good chance of sturgeon of all life stages being present during a fire. Any fires would be expected to be low to mixed severity and having a rate of return of at least every 35 years (Hann *et al.* 2003). These fires should not require aerial retardants because of the nature of their burn, but NMFS is unable to assume that fires in this National Forest would be allowed to burn due to the risk to surrounding areas.

The Ocala National Forest has a very different fire regime from the Francis Marion, as it is a fire dependent community of sandhills, pine flatwoods, scrub, and marsh. The primary locations on the East Coast that have major stand replacing fires are Florida scrub pine forests. Florida is heavily populated and any major fire in the region would likely receive aerial applications of fire retardant. Scrub pine forests typically burn every 35 to 100+ years, with the last major fire in the forest occurring in 1985. And if retardant was dropped on a fire in the near future, there is not much likelihood for exposure of listed shortnose sturgeon to toxic ammonia concentrations, as there is uncertainty as to whether shortnose sturgeon in the St. Johns River, naturally the southern-most end of their range, have been extirpated. A shortnose sturgeon was captured there in 2002, but Rogers and Weber (1994) suggest the St. Johns River population has been extirpated. The Florida Fish and Wildlife Conservation Commission (2007) believes the captured sturgeon is most likely a transient from a river to the north and not originally from the St. Johns River. If transient sturgeon are making their way back to this system to repopulate it, any exposure could be dire.

Ecological Responses

When 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). The peak of the spike 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 of the stream. In simulations of only 267 gallons (a normal load being approximately 1,500 gallons) of fire retardants hitting the surface of a stream, peak ammonia concentrations reached 5,026 mg/l (Buhl and Hamilton 1998). When the volume of retardant hitting the stream is doubled, the zone of mortality is extended 10 times farther downstream (Norris *et al.* 1991). 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 fire retardant enters a stream and the causes 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. The chemical balance between these two forms of ammonia is determined by pH, temperature, and total ammonia concentration. 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 Phos Chek 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 feet 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. 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 2730 meters) 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 miles 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 4 miles downstream.

Backer *et al.* (2004) found the response of fish to fire retardants could be more significant than their response to fire. Fish response does not only depend on the amount of retardant to hit the water and variables within the stream, but also on interactive effects between the various ingredients in the retardant or on the interaction of retardant effects coupled with the effects of the nearby fire to the stream.

The responses of steelhead, Chinook salmon, and coho salmon to specific fire retardants and elevated levels of ammonia have been evaluated by various researchers. 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 LC50s (the concentration at which half of the effected population will die in an established time period) were not significantly different, meaning that the values given below represent both the 24 hour and 96 hour LC50s.

For rainbow trout, more is known about their responses to fire retardants than for any other fish species. When exposed to Phos Chek 259, their LC50 was between 94 and 250 mg/l (Johnson and Sanders 1977). Buhl and Hamilton (2000) found the LC50 of rainbow trout to Phos Chek 259-F was 168 mg/l. In research on Phos Chek D75-R, the rainbow trout 96 hour LC50 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 LC50 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 LC50 of 218 mg/l (170 to 280 mg/l). Poulton *et al.* (1993) found that Phos Chek D75-F was twice as toxic to rainbow trout in hard water compared to soft water. 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. Gaikowski *et al.* (1996) tested various early life stages of fish and found that in hard water, all early stages were affected the same, and in soft water, there were minor differences in tolerance, but they were not significantly different. The rainbow trout LC50s in response to Phos Chek 259-R, G75-F, G75-W, LV-R, and LC-95A-R have not been researched.

For Chinook salmon, less is known about their response to fire retardants, but there is still information available. 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 LC50 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 not significantly different from 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 LC50s of rainbow trout and Chinook salmon. The Chinook salmon LC50s in response to Phos Chek D75-R, 259-F, 259-R, G75-F, G75-W, LV-R, and LC-95A-R have not been researched.

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 LC50s in response to Phos Chek 259 as rainbow trout have, 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. The coho salmon LC50s in response to Phos Chek D75-R, D75-F, G75-F, G75-W, LV-R, and LC-95A-R have not been researched.

There is no information on 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 LC50 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 LC50 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 LC50 for un-ionized ammonia is 0.2 mg/l (Alabaster *et al.* 1983). The response of shortnose sturgeon to total ammonia and un-ionized ammonia is very similar to the response of salmonids.

Fire retardants, and the ammonia plume that develops when retardants enter a stream, do not persist above the lethal concentrations described above for long periods of time. Buhl and Hamilton (1998) showed that when 267 gallons of fire retardant enters a stream, a relatively small amount, the ammonia concentration reaches 5,026 mg/l. At such extreme levels, mortality would be nearly immediate, but downstream as the plume is diluted, longer exposure to LC50 levels described above can be lethal. Buhl and Hamilton (1998) provide a case study of a 1995 Fire-Trol LCG-F misapplication in which 23,000 fish were killed, and although the retardant contained sodium ferrocyanide, the cause of mortality was determined to be ammonia concentrations. Their research concluded that fire retardant misapplications have biologically significant effects to fish communities.

The Federal regulatory agencies, led by EPA, use 5% of the LC50 value to represent the no effect concentration (NOEC) for threatened and endangered species. Therefore the NOEC for rainbow trout in response to Phos Chek 259, D75-R, and D75-F would be between 4.7 and 12.5 mg/l, between 7.1 and 9.7 mg/l, and between 9.2 and 13.5 mg/l, respectively. The NOEC for Chinook salmon in response to Phos Chek D75-F is between 8.5 and 14 mg/l. And finally the NOEC for coho salmon in response to Phos Chek 259 is between 4.7 and 12.5 mg/l. Buhl and Hamilton (1998) found that following an accidental drop of only 267 gallons of Phos Chek D75-F, the ammonia would need to be diluted 660 times to reach the LC50 concentration and 13,200 times before it reaches a NOEC for Chinook salmon. McDonald *et al.* (1997) found that a larger load of D75-F would need to be diluted 2,713 times to reach the LC50 level. Buhl and Hamilton (2000) and USGS (2000) found that Phos Chek 259-F was even more toxic than D75-F and would need to be diluted 813 times, just to reach the LC50 concentration and 1,750 times to reach a 10% of the LC50, a level still about the safe NOEC for listed species.

Because only three of the eight fire retardant formulations (Phos Chek 259-F, D75-F, and D75-R) have been analyzed on actual fish to determine their toxicities, it is difficult to determine the response of listed fish to the untested long-term retardants. The risk quotient (RQ) calculated by Labat (2007) is the ratio of the estimated dose or water concentration (typically, the Expected Environmental Concentration (EEC) or peak water concentration) to an estimated threshold effect, in this case the LD50 or the LC50. The intent of the RQ is to approximate risk by comparing the RQ to an established level of concern (LOC). The presumption is that a RQ $\geq$ 0.05 for a fire retardant formulation is considered likely to pose a risk to the listed species and an RQ $<$ 0.05 would indicate that the estimated concentration of the product is below the level expected to pose a risk to the listed aquatic species (EPA 2006).

Essentially, the risk ratio provides a generic assessment of the level at which exposure may provide a safe starting point for listed species. The risk quotient, however, is merely a crude indictor of potential risk to a listed species, and is typically used as a screening level assessment to determine whether or not additional field-testing or species specific assessments are needed. A key question that remains as to whether our reliance on the RQ as a screening tool would produce a reliable evaluation technique, that would correspond to our statutory obligation to ensure the fire retardants are not likely to jeopardize the continued existence of threatened and endangered species or do not result in the destruction or adverse modification of designated critical habitat. Since the risk the action poses to the species forms the foundation for this determination, and is a function of exposure and toxicity of the formulation of concern, the validity of the RQ in this assessment is of paramount importance. Unfortunately, we do not know if the RQ is acceptable for all or some of the threatened or endangered species likely to be exposed to fire retardants.

Exposure scenarios relied upon by Labat (2007) to characterize the risk of the fire retardants appear generally conservative given the little information we have on likely field exposures. Yet we are aware that environmental stochasticity, variable mixture concentrations (allowing for human error), basin area and discharge patterns are some of the factors that limit the precision around this exposure assumptions used by Labat (2007). The test values (measurement endpoints) used to generate the acute toxicity values, however, are typically derived from laboratory studies and assume that:

- The standard age of test organisms represents the most sensitive life stage
- Differences in life history variables among species do not influence susceptibility to stress from a pollutant,
- Responses of organisms tested using a single formulation or ingredient in controlled laboratory systems provides reasonable predictors of organisms' responses to similar chemicals in the wild when exposed to background levels of toxicants or other stressors,
- Available data on one or two fish species are sufficient to accurately characterize risk to other fish species

A comprehensive evaluation of these assumptions, plus any related assumptions, is necessary to understand if the risk approach used by the USFS generally produces protective decisions in the context of section 7 or if the approach generally underestimates potential risk. Simply, the use of lethality endpoints without consideration of potential sublethal effects from even short-term or transient exposures fails to acknowledge that sublethal and indirect effects on osmoregulation, gamete development, or other endpoints can play an essential role in ensuring the survival and recovery of listed species.

Responses of organisms tested in controlled laboratory systems do not necessarily provide reasonable predictors of organisms' responses to similar chemicals in the wild, although admittedly in many cases this is the only type of data available to us from which to conduct an evaluation. In many cases, the conditions simulated in a laboratory test have almost nothing to do with the environment in which most species live in the wild, and as such are unlikely to resemble "worst case field conditions." In laboratory tests, species are generally isolated from confounding factors so that researchers are able to isolate the species responses to the chemical (or stressor) under study. Lab studies do not replicate typical environmental conditions where intraspecific competition for food or shelter occurs. Instead, all the test organisms are about the same size, provided with abundant food, and minimal habitat complexity. Interspecific competition generally does not occur in lab tests either, as most lab environments isolate the species under study from typical predators. Physical conditions are maintained at optimal or constant levels (e.g., velocities, water temperature, and dissolved oxygen are not representative of fluctuating conditions in a natural aquatic environment, particularly during a wildfire) and generally, there are no other chemical stressors present.

While the screening level assessment or RQ uses data on surrogate species to predict the effects on listed species together with a series of conservative assumptions about exposure, in the event a species specific assessment were conducted it may be necessary to make adjustments in exposure estimates to reflect actual site specific conditions. Typically, the goal of species specific assessments is to better estimate the actual potential for exposure of listed species and where feasible implement changes in the chemical's use to reduce potential exposure so that established LOCs are not likely to be exceeded.

Based on Labat (2007) the USFS is aware the RQ for rainbow trout, the most closely related test species to most of the species considered herein, was consistently greater than the LOC 0.05 for all currently used long-term fire retardants for which they evaluated (Phos Chek LC-95A-R was not evaluated), when the retardant was accidentally applied across a small stream. According to Labat (2007) two commonly used long-term fire retardants, Phos-Chek 259-F and 259-R, approach the LOC in large streams. Despite these results, the USFS has not proposed additional measures beyond the use of the 2000 guidelines for reducing potential exposure to fire retardants nor is NMFS aware of any additional or on-going studies to directly evaluate the acute toxicity of 259-F or the sub-lethal toxicity of any of the currently used retardants. Furthermore, NMFS is skeptical as to the ability of pilots to avoid exposing small streams to fire retardants even with strict adherence to the 2000 Guidelines. The maximum relative risk when applied across a stream posed by D75-F, D75-R, and 259-F is 0.162, 0.106, and 0.342, respectively. Labat

(2007) also showed that 259-R posed a similar risk as 259-F with a risk quotient of 0.313. The other fire retardant formulations, G75-W, LV-R, and G75-F had risk quotients of 0.0925, 0.0848, and 0.0834, respectively. Labat's (2007) analysis determined that the seven modeled retardant formulations pose a lethal risk to listed species under worst case scenarios. The USFS maintains that formulations that only differ by their coloration would be redundant to analyze as the colorants are inert, but NMFS has not been provided any information nor has it found anything in the literature to support this claim.

Information provided to NMFS on October 1, 2007, informed NMFS that the "F" (fugitive) coloration is photosensitive and after a year in the sunlight will no longer be visible on land, while "R" (iron oxide) coloration is unaffected by UV light and can persist on land for longer (FSM 5100-304c). The USFS has stated (October 4, 2007) that the coloring agent "R" is less toxic than "F" and therefore testing "F" formulations is sufficient to determine the maximum toxicities of all other related retardants. The December 8, 2006, draft Aquatics Report is the only documentation NMFS has received that shows the toxicities of "R" and "F" formulations and in that document, "R" formulations were more toxic. Furthermore, in the only peer reviewed paper that tested the toxicities of the same retardant using both the "R" and "F" varieties, Calfee and Little (2003) showed that the "R" formulation was 27% more toxic (Table 13).

Labat (2007) recently modeled the relative risks of seven of the eight qualified fire retardants, based on modeled exposure and response risks, allowing for a relative assessment of the toxicities of those retardants (Table 13). The expected responses are based on the same assumptions for "R" and "F" above. Likewise, in separate publications, the toxicity of 259-F and D75-R was found to be the same, but in Labat's (2007) analysis, 259-F is more than three times more risky. Because Labat (2007) was not peer reviewed and makes assumptions that run counter to peer reviewed literature, NMFS questions the merits of their assumptions.

Table 13: The calculated relative risk in small stream environments correlated with the measured LC50s to rainbow trout

Fire retardant formulation	Rainbow Trout LC50 (mg/l)	Risk Quotient Range
PC 259-F	168	0.0570 to 0.342
PC 259-R	No Data	0.0522 to 0.313
PC D75-F	228	0.0270 to 0.162
PC D75-R	168	0.0176 to 0.106
PC G75-W	No Data	0.0154 to 0.0925
PC LV-R	No Data	0.0141 to 0.0848
PC G75-F	No Data	0.0139 to 0.0834
PC LC-95A-R	No Data	No Data

The only other locations with toxicity information on all eight retardant formulations are the Material Safety Data Sheets (MSDS). The actual toxicity has not been tested for any of the eight qualified fire retardants, making an actual comparison of their toxicities impossible. The MSDS use a similar, yet unnamed retardant mixture, resulting in the determination that the retardants were all "practically nontoxic." Buhl and Hamilton (1998) showed that the laboratories that test these chemicals routinely underestimate their toxicity compared to findings by other researchers. One source of the discrepancy could be that Phos Chek retardants have been found to be more toxic than Fire Trol retardants that lacked cyanide (Johnson and Sanders 1977, Norris *et al.* 1991, Gaikowski *et al.* 1996, Buhl and Hamilton 1998).

While there has been a fair amount of research conducted in laboratory environments, the response of fish to an accidental fire retardant drop in the natural environment with additional stressors, such as low DO, ash, hot water, and other conditions expected as the result of the nearby fire, has not been studied. Salmonids and shortnose sturgeon are particularly sensitive to elevated temperatures and are not very tolerant of water with low DO, and since warm water holds less oxygen, encountering water with low DO is a distinct possibility during a wildfire. There have been several studies done on the interactive effects of ammonia and DO, all showing the LC50s of rainbow trout to fall dramatically when DO is low. Alabaster *et al.* (1983) showed that at 10 ppm DO, rainbow trout wouldn't die until concentrations of un-ionized ammonia reached 0.2 mg/l, but when the DO fell to 3.5ppm, the lethal concentration of un-ionized ammonia became only 0.08 mg/l. Thurston *et al.* (1981) showed that when DO dropped from 8.5ppm to 5ppm, rainbow trout became 30% less tolerant of ammonia. In other work on rainbow trout response to many toxins in a low DO environment, Lloyd (1961) found that the greatest response was to ammonia, besting other toxins such as lead, zinc, and copper.

Other impacts of fire could make salmonids more susceptible to fire retardants as well. Gresswell (1999) showed that smoke in the air is adsorbed by water and increases the ammonia concentrations in rivers even without an accidental application of retardant. Crouch *et al.* (2006) showed that in burning watersheds, prior to treatment with retardants, there is increased ammonia, phosphorous, and total cyanide. Since 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. Wells *et al.* (2004) and Little *et al.* (2006) showed rainbow trout avoided concentrations of 1.3 mg/l (1% of LC50), which likely means fish are likely to swim away from areas of high ammonia concentrations. Recently, Wicks *et al.* (2002) found that rainbow trout and coho salmon swimming through water with elevated ammonia levels experience reduced LC50s, declining from approximately 207 mg/l to 32 mg/l.

Ash and guar gum have both been identified as respiratory inhibitors in the water. Ash has been identified as the cause of fish kills during wildfires and volcanic eruptions (Newcombe and Jensen 1996), while guar gum is an ingredient in fire retardants and would further exacerbate the effects of increased ammonia concentrations. Little *et al.* (2006) showed spikes in the salinity, as a result of the ammonia salts contained in the aerially applied fire retardants, which would negatively impact all fish living in freshwater environments, even adults. Buhl and Hamilton (1998) stated, "these results indicate that although ammonia is a major toxic component in D75-F, other components in the formulation may have had a significant influence on the toxicity of D75-F to Chinook salmon (p. 1594)."

Even though losses of all stages of fish are critical, losses of adults before they spawn is potentially the most devastating loss as they have generally lived three to five years at that point without being able to contribute to future populations levels. Every National Forest in the northwest and southwest and the rivers downstream of those forests will have adult salmon present during the April to October fire season, and any accidental application of fire retardant could kill migrating or spawning adults along with juvenile and recently hatched listed fish.

To evaluate the risk to listed species, NMFS evaluated the data provided by the USFS about the fish kills between 2001 and 2005. Because all agencies receive retardant from the same bases and follow the same 2000 Guidelines, NMFS believes it is fair to assume that a misapplication has as good of a chance of occurring on Forest Service land as on other federal, state, or county land. As was discussed above, in those four years, at least three ESUs were affected multiple times by fire retardant applications (Snake River steelhead, Snake River spring/summer Chinook salmon, Southern Oregon/Northern California Coast coho salmon) on USFS lands and at least four times overall. Many salmonids spend several years in freshwater before migrating to sea. NMFS is not aware of any evaluations of the effects of multiple year classes lost, multiple year classes suffering sub-lethal effects, multiple portions of a species' range being impacted simultaneously, or what the cumulative effects of multiple retardant misapplications to a DPS or ESU over a single generation would mean.

The hardest to measure, and potentially most significant effects of fire retardant misapplication could be sub-lethal impacts to fish and the duration of the impacts to critical habitat. We expect that the extent of the sublethal impacts will extend downstream much farther than the 6.2 miles (the distance shown where lethal impacts could occur), due to the fact that ammonia concentrations below lethal limits will persist beyond the extent of lethal concentrations. The distance and the extent of sub-lethal effects from elevated ammonia levels is not known, but may extend for some distance downstream and is an area of research that should be analyzed in the future. Laboratory studies show that rainbow trout exposed to NH_3 levels over 0.1 mg/l they developed skin, eye, and gill damage. Other reactions to sub-lethal levels of ammonia are reduced hatching success, reduced growth rate; impaired morphological development; injury to gill tissue, liver, and kidneys; and the development of hyperplasia. Hyperplasia in fingerling salmonids can result from exposure of ammonia levels as low as 0.002 mg/l for six weeks. Considering the research in California (Norris *et al.* 1978) that showed detectable levels of ammonia for an entire year following retardant introduction, it is possible that hyperplasia could be a concern for listed salmonids. The presence of ammonia in the water can also lead to suppression of normal ammonia excretion and a buildup of ammonia on the gills. Fire retardants may also inhibit the upstream movement of spawning salmon (Wells *et al.* 2004).

Indirect Effects

Fire retardants have negative direct impacts to many resources on which ESA-listed resources depend. Many rivers along the West Coast are nutrient deficient whereas many rivers along the East Coast are impaired according to the EPA 303(d) water quality standards by excess nutrients. The fire retardants are nitrogen based and when they hit the water and break down, the retardants eventually become nitrogenous nutrients. Eutrophication can be a significant problem in many slack water areas along the course of a river. In rivers with large agricultural or urban development, nutrients are usually already a water quality problem, without having more nutrients accidentally introduced. The most likely places that are impacted by eutrophication and the biotic organisms that grow in poor water quality are reservoirs, estuaries, and bays. Eutrophication in those places impairs light penetration, submerged vegetation, and nursery habitat. The application of nutrients into these waters could lead to shifts in phytoplankton composition or provide a competitive advantage to organisms that are not naturally suited for the oligotrophic waters of the West Coast. The additional application of nutrients into rivers along the East Coast, as well as reservoirs and dams in the Pacific Northwest, could further degrade water quality and also lead to eutrophication. Increased nutrients can also impacts food resources, such as macroinvertebrate abundance and macroinvertebrate species composition, both in the area the retardant hits and downstream all the way to the ocean.

When fire retardant hits the water and ammonia concentrations increase quickly, macroinvertebrates, the main food source for juvenile salmonids and shortnose sturgeon, exhibit highly variable responses. Macroinvertebrates that react similarly to small amounts of ammonia have up to a four fold difference in their resistance to acute toxicity (Williams *et al.* 1986). Adams and Simmons (1999) reported that mayflies and stoneflies in Australia were not affected by Phos Chek D75-F. McDonald *et al.* (1997) reported though, that D75-F 96 hr LC50 for *Hyalella azteca*, a very tolerant species of macroinvertebrate, was between 53 and 394 mg/l depending on pH, which is not only lethal, but more lethal than for many species of fish. Almost all macroinvertebrates will drift in the presence of elevated ammonia, but even then, many die. It can take years (Minshall *et al.* 1997) for macroinvertebrates to recolonize a stretch of stream that is negatively impacted during a wildfire. As long as there is depressed individual and species abundance, fish that depend on those macroinvertebrates as a food source will not recolonize.

Critical Habitat

Our critical habitat analysis determines whether the proposed action will destroy or adversely modify critical habitat for ESA-listed species by examining any change in the conservation value of the essential features of critical habitat. This analysis does not rely on the regulatory definition of 'adverse modification or destruction' of critical habitat. Instead, this analysis focuses on statutory provisions of the ESA, including those in Section 3 that define "critical habitat" and "conservation," those in Section 4 that describe the designation process, and those in Section 7 setting forth the substantive protections and procedural aspects of consultation.

NMFS has not designated critical habitat for shortnose sturgeon, whereas critical habitat is designated for all listed Pacific salmon except for LCR coho salmon, all listed steelhead, and on all National Forest lands considered in this Opinion. The PCEs for each listed species, where they have been designated, are described in the *Status of Listed Resources* section of this Opinion. The PCEs identify those physical or biological features that are essential to the conservation of the species that may require special management considerations or protections. The species addressed in this Opinion have similar life history characteristics and therefore, many of the same PCEs. These PCEs include sites essential to support one or more life stages (sites for spawning, rearing, migration and foraging) and contain physical or biological features essential to the conservation of the ESU/DPS, such as:

1. freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development;
2. freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade,

submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks;

3. freshwater migration corridors free of obstruction, along with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival;
4. estuarine areas free of obstruction, along with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation;
5. nearshore marine areas free of obstruction with water quality and quantity conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation; and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and
6. offshore marine areas with water quality conditions and forage, including aquatic invertebrates and fishes, supporting growth and maturation.

At the time that each habitat area was designated as critical habitat, that area contained one or more PCEs within the acceptable range of values required to support the biological processes for which the species use that habitat. Based on the preceding analysis, the proposed action will affect freshwater rearing, spawning, migration and foraging areas, and the PCEs that these habitat types provide listed salmon and steelhead. Of particular concern is the indirect affect the USFS' aerial application of the long-term fire retardants will have on the water quality in these areas.

Any exposure of fire retardant directly to waters or the riparian zone on these USFS lands will have an effect on Pacific salmon or steelhead critical habitat. As noted in the direct effects section above, there would be a huge spike in ammonia concentration in the river that could persist at significantly elevated levels for days and cover well over six miles of a river with listed fish. The water quality could be impacted for well over a year, at levels causing sub-lethal effects to fish utilizing the critical habitat (Norris *et al.* 1978). Additionally, increased runoff can be expected following a fire. Any soil that contains retardant would cause smaller spikes in ammonia concentration with every rainfall that causes runoff. The impacts to critical habitat could be fairly long-lived, remaining at an elevated detectable level for the duration of a 15 month study, but the study ended before ammonia concentrations in the system returned to the pre-misapplication rate. The extent of downstream impairment is also unknown, as only areas with lethal concentrations have been measured, neglecting areas with sub-lethal levels of ammonia. Nevertheless, under the proposed action reductions in water quality will reduce areas available for spawning, rearing, migrating and foraging for California coastal Chinook salmon, Central Valley spring-run Chinook salmon, LCR Chinook salmon, Puget Sound Chinook salmon, Sacramento River winter-run Chinook salmon, Snake River fall-run Chinook salmon, Snake River spring/summer-run Chinook salmon, UCR spring-run Chinook salmon, Upper Willamette River Chinook salmon, Columbia River chum salmon, Hood Canal summer run chum salmon, Southern Oregon Northern Coastal California coho salmon, Oregon Coast coho salmon, Snake River sockeye salmon, California Central Valley steelhead, LCR steelhead, MCR steelhead, Northern California steelhead, Snake River Basin steelhead, South Central California coast steelhead, Southern California steelhead, UCR steelhead, and Upper Willamette River steelhead. The precise change in the conservation value of critical habitat within the ESU/DPS from the proposed action cannot be quantified and will likely vary according to the specific designated critical habitat. However, based on the effects described above, it is reasonably likely that the proposed action will have a large, local, negative reduction in that conservation value of the critical habitat designated for these species. The duration, frequency, and severity of these reductions will vary according to fire return intervals, and the misapplication of fire retardants in areas of designated critical habitat, among other variables.

Cumulative Effects

Cumulative effects include the effects of future State, tribal, local, or private actions that are reasonably certain to occur in the action area considered in this Opinion. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

At the large spatial scale of this consultation, we could not identify specific future State, tribal, local, or private actions that were reasonably certain to occur in the action area. NMFS conducted electronic searches of business journals, trade journals, and newspapers using *First Search*, Google, and other electronic search engines. Those searches produced no evidence of future private action in the action area that would not require Federal authorization or funding and is reasonably certain to occur. Therefore, we are not aware of any actions of this kind that are likely to occur in the action area during the foreseeable future.

Integration and Synthesis of Effects

The USFS has proposed to continue aerial application of long-term fire retardants on NFS and adjacent lands using the 2000 Guidelines to minimize the number of introductions of long-term fire retardants to streams. The 2000 Guidelines establish a 300 foot buffer on either side of rivers on USFS land, beyond which the USFS assumes long-term retardant application has no effect on listed aquatic species. While the USFS will fight fires with long-term retardants on all National Forests, there are 30 National Forests, in the Northwest, Southwest, and Southeast regions with Pacific salmonids, green sturgeon, and shortnose sturgeon present.

Throughout the course of this Opinion, NMFS focused on the following specific questions:

1. Do the 2000 Guidelines contain particular features that would prevent listed resources from being exposed to long-term fire retardant?

2. What features do the 2000 Guidelines contain that would mitigate how listed resources respond when exposed to long-term fire retardants?

3. What features do the 2000 Guidelines contain that would mitigate the risks any responses pose to listed individuals, population, species, or designated critical habitat, when listed resources are likely to be exposed and respond to their exposure to long-term fire retardants?

The USFS has narrowly constrained the proposed action to only include USFS lands despite the fact that the USFS is the only agency that purchases fire retardants from the manufacturer, every year they distribute retardants to other Federal and state agencies, and at least partially fund the contractors at the aerial retardant tanker bases. The USFS also appears to have QPLs for foam formulations and water enhancer formulations that were not considered in this consultation. While this is outside of the scope of the draft NEPA analysis, NMFS believes the USFS is responsible for consulting on these parts of the program under Section 7(a)(2) of the ESA, which requires Federal agencies, in consultation with the Services, ensure that any action that they authorize, fund, or carry out is not likely to jeopardize the continued existence of any endangered or threatened species, or result in the destruction or adverse modification of a species' critical habitat. Additionally, the USFS has the ability to fight fires on lands adjacent to USFS lands, and to the extent information was provided to NMFS to consult on these actions they were captured in the analysis.

The Pacific salmonids, green sturgeon, and shortnose sturgeon are sensitive species, being adversely affected by impaired water quality that may not affect other species. For that reason, NMFS conducted a thorough analysis of the baseline conditions in the major rivers of these species' ranges. As described in the baseline section, these fish are listed due to past anthropogenic actions, in large part initially due to excessive fishing. After the initial population reductions, several populations of Pacific salmonids continue to decline while southern populations of shortnose sturgeon are so reduced that reliable population estimates have not been made. These listed fish are negatively impacted by sedimentation in their spawning areas; reduced fish passage between their spawning areas and the ocean; bycatch in ocean fisheries; and impaired water quality as a result of mining, industrial waste, stormwater discharge, agricultural runoff, and urban runoff. Furthermore, Pacific salmonids are also impacted by predation from both native and non-native species around dams and impairment of critical habitat. When fires are burning, the heat and smoke generated typically reduces DO, increases temperature, increases ammonia, and adds other pollutants that are problematic to fish such as the toxin cyanide and ashes that clog their gills.

When a fire escapes the initial suppression effort, a WFSA must be conducted, which provides a list of alternative ways to manage the fire that take into account listed species and their critical habitat. The WFSA provides the Incident Commander with alternative ways of attacking the fire that, along with the 2000 Guidelines, is intended to protect listed species. The goal of the 2000 Guidelines is to avoid exposure except during periods when Incident Commanders elect to invoke the exemptions to the 300 foot buffer zone around visible aquatic habitats. To date, an Incident Commander has not invoked an exception to the buffers in the Guidelines. While the buffer has never been intentionally abandoned, there have been at least 15 misapplications (11 reported by the USFS and four identified by NMFS through a review of emergency consultations) of fire retardant between August 2001 and December 2005. It is possible that there has been an improvement from the way fire fighting was handled prior to the 2000 Guidelines; however, NMFS was not provided with and therefore did not evaluate data on the misapplication of fire retardants before 2001. Nevertheless, even with the 2000 Guidelines there it is likely that listed species will be exposed to the USFS' continued use of long-term fire retardants.

The 2000 Guidelines also only restrict the application of long-term fire retardants to areas where water is visible, which means that most first, second, and third order streams would not be seen through the trees from the air and therefore would likely be exposed to long-term fire retardants without ever being monitored or the misapplications observed and reported. No one is charged with monitoring the application of fire retardant. All fire personnel seem to have a secondary job of reporting a misapplication if they see it. Furthermore, there does not appear to be anyone who monitors the cumulative use across the nation or the use over multiple Forests that overlap with individual listed resources. On fires over 300 acres, a BAER team conducts an analysis of the effects of fire, and at this point it would be expected that any misapplication that went unnoticed while fighting the fire would be discovered, but as shown in the evaluation of the USFS' Misapplication List, even when an accidental application of long-term fire retardant is introduced to water, it appears that USFS only monitors obvious physical effects of fires and fire retardant misapplication greater than 300 acres.

Emergency consultations are meant to provide a feedback loop for determining the effects of long-term fire retardant misapplication, what the probable take from each misapplication is, and how to avoid making the same mistakes on future fires. As the USFS operates now, following the Redbook (2007), misapplications are only reported and consulted on when the USFS determines that the misapplication has resulted in adverse effects, as BAs and emergency consultations on misapplications that were determined to be 'not likely to adversely affect' listed fish are not completed. In many cases, USFS biologists or hydrologists are able to be on site within several hours of the misapplication to analyze for effects. NMFS is unaware of what analyses are conducted and length of stream analyzed for impacts, as extensive downstream exposure is likely through drift during this time. NMFS also believes that relying on dead fish as a means of determining effects is not a sufficiently reliable means of evaluating potential adverse effects. While the USFS maintains that all identified misapplications have been considered to have an effect and were reported and consulted on, NMFS questions the reliability of this analysis particularly since NMFS found four completed emergency Opinions on misapplications between 2001 and 2005, while the four non-USFS monitoring reports in Appendix C identify fish kills of over 30,000 fish and 10 miles of lethally affected spawning habitat. Of the eight other retardant misapplications to USFS streams, no mortalities were reported from long-term fire retardant, while one spill occurred on land and was reported to have killed 263 fish, despite emergency consultations authorizing lethal take of approximately 6,500 listed steelhead and Chinook salmon. All 14 misapplications were using the same retardants since the USFS purchases and distributes long-term fire retardants to all state and Federal agencies that fight fires.

The disconnect between the outcome of the emergency consultation, monitoring practices, and the fact that the USFS has not assessed the cumulative impact of fire retardant use in a watershed or ESU is disconcerting to NMFS. Our evaluation of these misapplication instances, however, did not reveal any information to suggest whether USFS personnel are more likely than not to detect misapplications when they occur, nor did our evaluation indicate why in some instance the USFS is choosing not to consult on their emergency actions, when (among other effects of fire suppression) fire retardants are observed entering waterways containing listed species. With better monitoring and evaluation, NMFS believes that the Services and the USFS may identify alterations or amendments to the 2000 Guidelines that would provide additional protection to listed resources.

Based on the general linear trend between 1977 and 2006 (Figure 10), there has been an increase in use of retardants by 16.75 million gallons over 29 years. This amount comes to an annual increase of 578,000 gallons of fire retardant used. The USFS recently stated that in the coming years they anticipate more fires and larger fires across much of the western landscape. As a result, NMFS anticipates that, as in the past, the usage of fire retardants will increase over the coming years. NMFS expects that over the short term, large fluctuations in use, like those seen between 2000 and 2006 will be apparent. Since the USFS expects more and larger fires and based on past trends of aerial fire retardant use, NMFS expects a continual increase of 578,000 gallons of retardant per year and as a result more exposure of listed species to fire retardants in future years.

Five of the eight long-term fire retardants that the USFS has requested consultation on have never been studied and there is no information on their acute toxicities or sub-lethal effects. The toxicities of Phos Chek D75-F, D75-R, and 259-F are known, while the USFS contends that the toxicities of 259-R, G75-W, G75-F, LV-R, and LC-95A-R are variations of the other retardants and therefore have similar toxicities. However, as was shown in the Labat (2007) paper, the assumptions put forward by the USFS are not in agreement with the toxicity values available in peer reviewed literature. NMFS cannot assume that toxicities to fish will be similar due to similarities in the retardants and disagrees with the USFS contention that it would be appropriate. Given the toxicity information of the three formulations for which data exist, and the already impaired baseline from anthropogenic impacts, along with the further impairment of the baseline caused by the fire, NMFS believes that the risk to individuals is even greater than what the laboratory tests indicate. Several studies have shown that when background stressors are elevated, fish are not as resistant to introduced contaminants as they would be under pristine conditions. Even if NMFS assumed the response of fish would be no worse than seen in laboratory studies, there would still be stretches of river up to 6.2 miles long that would be exposed to lethal concentrations of long-term retardant and unmeasured stretches of stream farther downstream that would be exposed to sub-lethal levels of long-term fire retardants.

There is very little information on the sub-lethal response of salmonids, green 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. Sub-lethal levels can persist for more than 6.2 miles downstream and for more than 15 months. All of these effects can have an adverse, long-term impact to listed fish, which is very difficult to measure without extensive long-term monitoring.

When determining the risk to listed Pacific salmonids, green sturgeon, and shortnose sturgeon, NMFS analyzed the potential misapplications that are allowed while using the 2000 Guidelines, the misapplications that would be considered accidents while using the 2000 Guidelines, and the potentially undiscovered misapplications that were not covered by the 2000 Guidelines (headwater streams, runoff) to establish the level of exposure expected while fighting fires in the future. NMFS also reviewed the 11 reported misapplications and many completed emergency consultations to see which populations were repeatedly affected by fires and misapplications of fire retardants. NMFS also considered the likelihood of a misapplication not being observed and therefore never being investigated. NMFS believes the reported rate of misapplications underestimates the actual number of misapplications and believes there have been and will be more than 3.25 misapplications per year, although as many as eight misapplications have happened in a single year (Forest Service Employees for Environmental Ethics vs. USFS, 2005, CV 03-165-M-DWM) and at least four ESUs/DPSs have been affected multiple times in the same year or over consecutive years. Because this project proposes to use long-term fire retardants indefinitely, at least the same frequency of reported misapplications would be expected to occur each year.

Finally, the sum of the evidence available to NMFS and considered herein, suggests that the USFS is not likely to (a) evaluate the direct, indirect effects, and cumulative impacts of all the fire retardants they authorize for use, (b) evaluate the direct, indirect, or cumulative impacts of their emergency fire suppression actions, and (c) the nature of those effects in the basin in which they would occur. Given the nature of the fire retardant program, the Forest Service does not know how frequently fire retardant enters water bodies containing endangered species, threatened species, or designated critical habitat under NMFS' jurisdiction, much less the precise fire retardant to which listed resources are exposed when a drop is observed entering waters containing listed species. Moreover, the USFS has no established procedures for post emergency monitoring of field conditions when fire retardants knowingly enter a waterway that would provide meaningful information on the direct and indirect effects of the retardant on water quality and listed species within the area, nor will the Forest Service necessarily conduct post emergency (follow-up) consultations.

All of the endangered species, threatened species, and designated critical habitat under NMFS' jurisdiction depend on the health of the aquatic ecosystems they occupy for their survival and recovery. The USFS' fire retardant program is meant to protect NFS and other lands from the devastating effects of wildfires. Endangered and threatened species are among the many things the USFS must consider when making decisions under this program. Degraded water quality has been one of the contributing factors for almost all of the anadromous fish species NMFS listed since the mid-1980s. Although fire retardants used by the USFS have never been the sole cause of any of these listing actions, they likely contribute to a degraded baseline in many areas and have been the cause of some massive fish kills in the past. Consequently, while the 2000 Guidelines may help prevent exposure in some cases, we know that the 2000 Guidelines cannot prevent endangered species, threatened species, and designated critical habitat from being exposed in all instances, and as the number of fires increases across the landscape we would expect that the number of times listed species are likely to be exposed to fire retardants will likely increase in the future. We believe it is reasonable to expect that the exposure is likely to increase commensurate with the USFS use of fire retardants. Therefore, we do not believe the USFS can insure that the 2000 Guidelines and their continued use of fire retardants are not likely to jeopardize the continued existence of endangered species or threatened species or result in the destruction or adverse modification of critical habitat that has been designated for these species.

Conclusion

After reviewing the current status of California coastal Chinook salmon, Central Valley spring-run Chinook salmon, LCR Chinook salmon, Puget Sound Chinook salmon, Sacramento River winter-run Chinook salmon, Snake River fall-run Chinook salmon, Snake River spring/summer-run Chinook salmon, UCR spring-run Chinook salmon, Upper Willamette River Chinook salmon, Columbia River chum salmon, Hood Canal summer run chum salmon, LCR coho salmon, Southern Oregon Northern Coastal California coho salmon, Oregon Coast coho salmon, Snake River sockeye salmon, California Central Valley steelhead, LCR steelhead, MCR steelhead, Northern California steelhead, Puget Sound steelhead, Snake River Basin steelhead, South Central California coast steelhead, Southern California steelhead, UCR steelhead, Upper Willamette River steelhead, green sturgeon and shortnose sturgeon, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' Opinion that the project, as proposed, is likely to jeopardize the continued existence of these endangered or threatened species.

After reviewing the current status of California coastal Chinook salmon, Central Valley spring-run Chinook salmon, LCR Chinook salmon, Puget Sound Chinook salmon, Sacramento River winter-run Chinook salmon, Snake River fall-run Chinook salmon, Snake River spring/summer-run Chinook salmon, UCR spring-run Chinook salmon, Upper Willamette River Chinook salmon, Columbia River chum salmon, Hood Canal summer run chum salmon, Southern Oregon Northern Coastal California coho salmon, Oregon Coast coho salmon, Snake River sockeye salmon, California Central Valley steelhead, LCR steelhead, MCR steelhead, Northern California steelhead, Snake River Basin steelhead, South Central California coast steelhead, Southern California steelhead, UCR steelhead, and Upper Willamette River steelhead, the environmental baseline for the action area, the effects of the proposed action, and the cumulative effects, it is NMFS' Opinion that the project, as proposed, is likely to result in the destruction or adverse modification of critical habitat of these endangered and threatened species.

Reasonable and Prudent Alternatives

This Opinion has concluded that the USFS' proposed continued use of the eight long-term fire retardants, Phos-Chek D75-R, Phos-Chek D75-F, Phos-Chek 259-R, Phos-Chek 259-F, Phos-Chek G75-F, Phos-Chek G75-W, Phos-Chek LV-R, and Phos-Chek LC-95A-R, on National Forest System lands is likely to jeopardize the continued existence of 26 anadromous fish species under the jurisdiction of the NMFS and result in the destruction or adverse modification of critical habitat that has been designated for these species. The clause "jeopardize the continued existence of" means "to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR §402.02).

Regulations implementing section 7 of the ESA (50 CFR §402.02) define reasonable and prudent alternatives as alternative actions, identified during formal consultation, that: (1) can be implemented in a manner consistent with the intended purpose of the action; (2) can be implemented consistent with the scope of the action agency's legal authority and jurisdiction; (3) are economically and technologically feasible; and (4) NMFS' believes would avoid the likelihood of jeopardizing the continued existence of listed species or result in the destruction or adverse modification of critical habitat.

NMFS reached this conclusion because the evidence available suggests that the USFS is not likely to (a) evaluate the direct, indirect effects, and cumulative impacts of the fire retardants they authorize for use, (b) evaluate the direct, indirect, or cumulative impacts of fire retardant misapplications in the basin in which they occur, nor (c) evaluate the consequences of those effects on listed resources under NMFS' jurisdiction. Given the nature of the fire retardant program, the USFS does not know how frequently fire retardant enters water bodies containing endangered species, threatened species, or designated critical habitat under NMFS' jurisdiction, much less the precise fire retardant to which listed resources are exposed when a drop is observed entering waters containing listed species. Moreover, the USFS has no established procedures for post emergency monitoring of field conditions when fire retardants knowingly enter a waterway that would provide meaningful information on the direct and indirect effects of the retardant on water quality and listed species within the area, nor will the USFS necessarily conduct post emergency (follow-up) consultations.

To satisfy its obligation pursuant to section 7(a)(2) of the Endangered Species Act of 1973, as amended, the USFS must put itself in a position to monitor (a) the direct, indirect, and cumulative impacts of the long-term fire retardants they use, (b) evaluate the direct, indirect, or cumulative impacts of their fire retardant misapplications in the basin in which they occur, and (c) the consequences of those effects on listed resources under NMFS' jurisdiction. The purpose of the prescribed monitoring and studies is so that the USFS will be in a position to adaptively modify their program, using the results of their monitoring and studies, to reduce exposure and minimize the effect of exposure where it will occur, and to ensure their actions are not likely to jeopardize the continued existence of 26 anadromous fish species under the jurisdiction of the NMFS, nor result in the destruction or adverse modification of critical habitat that has been designated for these species. What follows is a single reasonable and prudent alternative, consisting of several sub-elements, that must be implemented in its entirety to insure that the USFS' proposed continued use of the long-term fire retardants on NFS lands is not likely to jeopardize endangered or threatened species under the jurisdiction of NMFS or destroy or adversely modify critical habitat that has been designated for these species. The USFS must:

1. Provide evaluations on the two fire retardant formulations, LC 95-A and 259R, for which acute toxicity tests have not been conducted, using standard testing protocols. Although direct fish toxicity tests have not been conducted on three additional formulations, G75-W, G75-F, LV-R, studies are not warranted in light of the fact the USFS intends to phase out their use of these formulations by 2010. All formulations expected to be in use beyond 2010 shall be evaluated using, at a minimum, the established protocols to assess acute mortality to fish. Evaluations must be completed and presented to NMFS no later than two years from the date of this Opinion. Depending on the outcome of these evaluations and after conferring with NMFS, the USFS must make appropriate modifications to the program that would minimize the effects on NMFS' listed resources (e.g., whether a retardant(s) should be withdrawn from use and replaced with an alternative retardant(s)).

2. Engage in toxicological studies on long-term fire retardants approved for current use in fighting fires, to evaluate acute and sublethal effects of the formulations on NMFS' listed resources. The toxicological studies will be developed and approved by both the USFS and NMFS. The studies should be designed to explore the effects of fire retardant use on: unique life stages of anadromous fish such as smolts and buried embryo/alevin life stages ranging in development from spawning to yolk sac absorption and the onset of exogenous feeding (approximately 30 days post-hatch); and anadromous fish exposed to fire retardants under multiple stressor conditions expected during wildfires, such as elevated temperature and low DO. Within 12 months of accepting the terms of this Opinion, USFS provide NMFS with a draft research plan to conduct additional toxicological studies on the acute and sublethal effects of the fire retardant formulations. Depending on the outcome of these studies described per the research plan and after conferring with NMFS, the USFS must make appropriate modifications to the program that would minimize the effects on NMFS' listed resources (e.g., whether a retardant(s) should be withdrawn from use and replaced with an alternative retardant(s)).

3. Develop guidance that directs the US Forest Service to conduct an assessment of site conditions following wildfire where fire retardants have entered waterways, to evaluate the changes to on site water quality and changes in the structure of the biological community. The field guidance shall require monitoring of such parameters as macroinvertebrate communities, soil and water chemistry, or other possible surrogates for examining the direct and indirect effects of fire retardants on the biological community within and downstream of the retardant drop area as supplemental to observations for signs of dead or dying fish. The guidance may establish variable protocols based upon the volume of retardants expected to have entered the waterway, but must require site evaluations commensurate with the volume of fire retardants that entered the waterway.

4. Provide policy and guidance to ensure that USFS local unit resource specialist staff provide the local NMFS Regional Office responsible for section 7 consultations with a summary report of the site assessment that identifies: (a) the retardant that entered the waterway, (b) an estimate of the area affected by the retardant, (c) a description of whether the retardant was accidentally dropped into the waterway or whether an exception to the 2000 Guidelines was invoked and the reasons for the accident or exception, (d) an assessment of the direct and indirect impacts of the fire retardant drop, (e) the nature and results of the field evaluation that was conducted following control and abatement of the fire, and any on site actions that may have been taken to minimize the effects of the retardant on aquatic communities.

5. Provide NMFS Headquarter's Office of Protected Resources with a biannual summary (every two years) that evaluates the cumulative impacts (as the Council on Environmental Quality has defined that term pursuant to the National Environmental Policy Act of 1969) of their continued use of long-term fire retardants including: (a) the number of observed retardant drops entering a waterway, in any subwatershed and watershed, (b) whether the observed drops occurred in a watershed inhabited by NMFS' listed resources, (c) an assessment as to whether listed resources were affected by the misapplication of fire retardants within the waterway, and (d) the USFS' assessment of cumulative impacts of the fire retardant drops within the subwatershed and watershed and the consequences of those effects on NMFS' listed resources. The evidence the USFS shall use for this evaluation would include, but is not limited to: (i) the results of consultation with NMFS' Regional Offices and the outcome of the site assessment described in detail in the previous element of this RPA (Element 4) and (ii) the results of new fish toxicity studies identified within Element 2; and (d) any actions the USFS took or intends to take to supplement the 2000 Guidelines to minimize the exposure of listed fish species to fire retardants, and reduce the severity of their exposure.

Because this Opinion has concluded that the USFS' proposed continued use of its long-term fire retardants is likely to jeopardize the continued existence of endangered species and threatened species under the jurisdiction of the NMFS and is likely to result in the destruction or adverse modification of critical habitat that has been designated for these species, the USFS is required to notify NMFS' Office of Protected Resources of its final decision on implementation of the reasonable and prudent alternatives.

INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibits the take of endangered and threatened species, respectively, without 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 NMFS to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the Act provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

Amount or Extent of Take

As described earlier in this Opinion, this is a programmatic consultation on the USFS' aerially application of long-term fire retardants. The USFS applies long-term fire retardants in response to emergency circumstances. The goal of this program-level Opinion is to evaluate the impacts to NMFS' listed resources from the USFS' broad use of aerially applied fire retardants. Since specific emergency actions and the scope of USFS' response to those emergencies cannot be predicted, it is not possible to identify specific take that would occur. Instead, this Opinion anticipates the general effects that would occur from the USFS' use of aerially applied long-term fire retardants across the landscape. This Opinion does not exempt incidental take of listed fish or wildlife species from the prohibitions of section 9 of the ESA for the USFS' use of aerially applied long-term fire retardants.

According to the implementing regulations of section 7 of the ESA, section 402.05, where emergency circumstances mandate the need to consult in an expedited manner, consultation may be conducted informally through alternative procedures that the Director determines to be consistent with the requirement of section 7(a)-(d). Formal consultation shall be initiated as soon as practicable after the emergency is under control. At which time the USFS must submit to NMFS' Regional Office: (a) information on the nature of the emergency action(s), (b) the justification for the expedited consultation, and (c) the impacts to endangered or threatened species and their habitats (CFR 402.05). The purpose of these consultations is to allow action agencies to incorporate listed resources into their actions during and following the response to an emergency. In the event incidental take is anticipated during the emergency response, NMFS' Regional Office can advise the USFS of ways to minimize the take. Generally, however, an incidental take statement in an emergency consultation does not include reasonable and prudent measures or terms and conditions to minimize take, except where an agency has an ongoing action related to the emergency. The incidental take statement, however, would document the recommendations given to the USFS to minimize take during information consultation, the success of the agency in carrying out these recommendations and the effects of the emergency on the listed resources, and determine whether the emergency action "is not likely to jeopardize the continued existence of a threatened or endangered species or a species proposed for such designation, or is not likely destroy or adversely modify the critical habitat of such species.

CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the Act directs Federal agencies to utilize their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

1. *Accuracy of drops*. Employ available flight navigation and guidance technologies that reduce the exposure of fish to fire retardants by increasing the precision and accuracy of retardant drops and the ability of pilots to avoid misapplication of fire retardants in streams.

In order for NMFS to be kept informed of actions minimizing or avoiding adverse effects or benefiting listed species or their habitats, the USFS should notify NMFS of any conservation recommendations they implement in their final action.

REINITIATION NOTICE

This concludes formal consultation on the USFS' National Fire Retardant Programmatic Consultation. As provided in 50 CFR '402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this opinion; (2) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this opinion; or (3) a new species is listed or critical habitat designated that may be affected by the action. No incidental take is authorized at the programmatic level of this consultation. Any new information developed through the toxicity studies required as part of the RPA or new fire retardants added to the QPL, would not have been considered in this Opinion, and would be sufficient to trigger reinitiation of this consultation.

MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Fishery Conservation and Management Act 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 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 C.F.R. § 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 C.F.R. § 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 C.F.R. § 600.920(i)).

Promulgating regulations and implementing the 2000 Guidelines 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. USFS is using the draft Aquatics Report to generally describe impacts that may be associated with future, site-specific proposals authorized, or proposed to be authorized, by USFS. The analysis provided in the Aquatics Report 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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APPENDIX A

LONG-TERM RETARDANT

Qualified by USDA Forest Service In Accordance with Forest Service Specification 5100-304b, As Amended.

The listed products are qualified and approved for use, only at the specified mix ratio, and only with the indicated application equipment. Consult individual agencies for specific policies relating to long-term retardant use.

Chemical	Mix Ratio (Pounds concentrate per gallon water)	Qualified / Approved Applications[1] Fixed-Wing Airtanker	SEATS	Fixed-Tank Helicopter	Helicopter Bucket	Ground Engine
Dry Concentrate - Gum-thickened; Permanent or Temporary Base						
Phos-Chek D75-R	1.20 lb/gal	•	•		•	
Phos-Chek D75-F	1.20 lb/gal	•	•		•	
Dry Concentrate - Gum-thickened; Temporary Base						
Phos-Chek 259-R	1.14 – 1.60 lb/gal	•	•	•	•	•
Phos-Chek 259-F	1.14 – 1.60 lb/gal	•	•	•	•	•
Phos-Chek G75-F	1.12 lb/gal	•	•		•	•
Phos-Chek G75-W	1.12 lb/gal				•	•
Wet Concentrate - Gum-thickened; Permanent or Temporary Base						
Phos-Chek LV-R	3.6:1	•	•		•	•
Phos-Chek LC-95A-R	5.5:1	•	•		•	•

[1] • Fully Qualified (Product complies with all requirements of a formal specification.)

APPENDIX B

SUMMARY OF ALL KNOWN RETARDANT APPLICATION IN WATERWAYS
AUGUST 2001 THROUGH DECEMBER 2005

#	FIRE NAME, SIZE, and DATE	LOCATION	MAGNITUDE (SPECIES AND MORTALITY)	EFFECTS DETER-MINATION*	MAGNITUDE - RESOURCES AT RISK OR LOST	PRODUCT APPLIED
1	Biscuit 499,570 ac., July-Nov 2002	Siskiyou NF	SOCC Chinook, SONC Coho - No mortality	LAA (all suppression action)	Not identified in BA Towns of Galice, Cave Junction, Kerby, Selmac, O'Brian, Agness, Brooking, Power line serving Gasquet, Hiouchi, Cresent City, and Klamath, Industrial timberlands, Late-success ional Reserve, T,E&S fish, plant and animals, Illinois, Rogue and Smith Nat. Wild and Scenic River, N. Fk. Smith Botanical Area, Port Orford Cedars	Not identified
2	Eyerly 23,573 ac., and Cache 4200 ac., July-Aug 02	Deschutes NF, Street Cr.	Interior Redband Trout, Columbia River Bull Trout - 260 red band, 1 bull trout, 2 kokanee mortality	LAA, NLAA, WIFV (all suppression actions)	20 homes lost, timber, private timber, Black Butte Ranch subdivision and resort community; 1,300 residents, 15 commercial properties, 2 golf courses.	Astaris, Phos Chek
3	Forks Fire 1387 ac. June 2002	Klamath NF	SONCC Coho salmon – No mortality	NLAA (all suppression actions)	Timber, mining, recreation, private land and structures, plantations, Spotted Owl Habitat	Phos Chek D75R
4	Bowl Fire 339 ac., Sept. 2002	Mt. Hood NF Clackamas River	Lower Columbia River steelhead, Upper Willamette Rive Chinook and Lower Columbia River/SW Washington Coho salmon –No mortality	LAA (all suppression action)	Not identified in BA info received, Fisheries including T&E species, Wild and Scenic River values, PGE Power lines, Hwy 224, and Cultural Sites. The Clackamas River is the municipal water supply for communities downstream (Estacada, Oregon City, Lake Oswego, and others)	Fire Trol LCG-R
5	East Fork Size not listed, 2002	Wasatch Cache NF	Not specified, No mortality	No BA known	Not identified in info received	Not identified
6	St Mary's Mission 8112 ac., Aug. 2001	Omak Creek Colville Confederated Tribes	10,040 rainbow and brook trout plus all natural reproduction of summer steelhead for 7.2 miles, spring Chinook	No BA known	Not identified in info received	Fire Trol
7	Fall River, 1 ac., Aug. 2002	Oregon State, Oregon Dept of Forestry	21,000 total fish (no info on species)	No BA known, Assessment by Ed Little, USGS	Hundreds of homes	Fire Trol LCA
8	Cannon Fire, 23,013 ac. June-July 2002	Humboldt-Toiyabe NF. Walker River	Lahontan Cutthroat Trout, Bald Eagle Mortality not known	LAA, (all suppression activities, and implementation of emergency rehabilitation)	Evacuation of the Camp Antelope sub-division. Air Tanker crash (3 fatalities). Approximately 1200 people were affected by the evacuation.	Not identified

#	FIRE NAME, SIZE, and DATE	LOCATION	MAGNITUDE (SPECIES AND MORTALITY)	EFFECTS DETER-MINATION*	MAGNITUDE - RESOURCES AT RISK OR LOST	PRODUCT APPLIED
1	ELK HEIGHTS FIRE	Washington State DNR	Unknown, but based on what little information there was no mortality			Fire Trol LCG-R
2	CANYON FIRE, July 2004	Cascade Reservoir area, jurisdiction?	No known mortality encountered	Monitoring showed no impacts		Not identified
3	NICK FIRE, 5 acres, August 2004	Nick Creek, Payette NF	No mortality observed, Chinook salmon, steelhead, bull trout	LAA	Timber, recreation, watershed	Fire Trol LCG

***Effects Determinations**

Threatened and Endangered Species **under** Section 7 of the Endangered Species Act

NE	No Effect
NLAA	May Effect, Not Likely to Adversely Affect
LAA	May Effect, Likely to Adversely Affect
BE	Beneficial Effect

Sensitive Species

NI	No Impact
MIIH	May Impact Individuals or Habitat, but Will Not Likely Contribute to a Trend Towards Federal Listing or Cause a Loss of Viability to the Population or Species
WIFV	Will Impact Individuals or Habitat with a Consequence that the Action May Contribute to a Trend Towards Federal Listing or Cause a Loss of Viability to the Population or Species

APPENDIX C

NMFS' REVISION OF USFS' SUMMARY OF ALL KNOWN RETARDANT APPLICATION IN WATERWAYS
AUGUST 2001 THROUGH DECEMBER 2005

#	FIRE NAME, SIZE, and DATE	LOCATION	MAGNITUDE (SPECIES AND MORTALITY)	EFFECTS DETER-MINATION*	MAGNITUDE - RESOURCES AT RISK OR LOST	PRODUCT APPLIED
1	Biscuit 499,570 ac., July-Nov 2002	Siskiyou NF, OR.	SOCC Chinook, SONCC Coho – No analysis conducted	No BA	Not identified in BA Towns of Galice, Cave Junction, Kerby, Selmac, O'Brian, Agness, Brooking, Power line serving Gasquet, Hiouchi, Cresent City, and Klamath, Industrial timberlands, Late-success ional Reserve, T,E&S fish, plant and animals, Illinois, Rogue and Smith Nat. Wild and Scenic River, N. Fk. Smith Botanical Area, Port Orford Cedars	Not identified
2	Eyerly 23,573 ac., and Cache 4200 ac., July-Aug 02	Deschutes NF, OR., Street Creek	Interior Redband Trout, Columbia River Bull Trout - 260 red band, 1 bull trout, 2 kokanee mortality	No NMFS species present	20 homes lost, timber, private timber, Black Butte Ranch subdivision and resort community; 1,300 residents, 15 commercial properties, 2 golf courses.	Astaris, Phos Chek
3	Forks Fire 1387 ac. June 2002	Klamath NF, CA.	SONCC Coho salmon – No observed mortality	NLAA (No BA)	Timber, mining, recreation, private land and structures, plantations, Spotted Owl Habitat	Phos Chek D75R
4	Bowl Fire 339 ac., Sept. 2002	Mt. Hood NF, OR., Clackamas River	Lower Columbia River steelhead, Upper Willamette River Chinook, and Lower Columbia Coho salmon – some steelhead and Chinook mortality	LAA (BA completed)	Not identified in BA info received, Fisheries including T&E species, Wild and Scenic River values, PGE Power lines, Hwy 224, and Cultural Sites. The Clackamas River is the municipal water supply for communities downstream (Estacada, Oregon City, Lake Oswego, and others)	Fire Trol LCG-R
5	East Fork Size not listed, 2002	Wasatch Cache NF, UTAH	Not specified, No mortality	No NMFS species present	Not identified in info received	Not identified
6	St Mary's Mission 8112 ac., Aug. 2001	Colville Confederated Tribes, Omak Creek	10,040 Upper Columbia River steelhead and brook trout plus all natural reproduction of steelhead for 7.2 miles, complete fish mortality for 5.5 miles, partial mortality to Okanogan R.	No BA	Not identified in info received	Fire Trol
7	Fall River, 1 ac., Aug. 2002	Deschutes NF, OR., Fall River	21,000 total dead fish. All fish in a 4 mile stretch of river killed. Likely affected Deschutes River	No BA – monitoring conducted by Ed Little, USGS	Hundreds of homes	Fire Trol LCA
8	Cannon Fire, 23,013 ac. June-July 2002	Humboldt-Toiyabe NF. Walker River	Lahontan Cutthroat Trout, Bald Eagle Mortality not known	No NMFS species present	Evacuation of the Camp Antelope sub-division. Air Tanker crash (3 fatalities). Approximately 1200 people were affected by the evacuation.	Not identified
9	Rattlesnake Canyon Fire, 10,600 acres, July 2003	Colville Confederated Tribes, Omak Creek, Salmon Creek	Upper Columbia River steelhead	No BA	11 structures destroyed, 22 threatened	Unknown

#	FIRE NAME, SIZE, and DATE	LOCATION	MAGNITUDE (SPECIES AND MORTALITY)	EFFECTS DETER-MINATION*	MAGNITUDE - RESOURCES AT RISK OR LOST	PRODUCT APPLIED
10	ELK HEIGHTS FIRE, 370 acres	WA. state and private lands, Yakima River	Unknown		197 structures	Fire Trol LCG-R
11	CANYON FIRE, 95 acres, July 2004	Cascade Reservoir, Boise NF	No known mortality encountered	No NMFS species present		Not identified
12	NICK FIRE, 5 acres, August 2004	Nick Creek, Payette NF	2,606 dead Snake River Spring/Summer Chinook and 2,978 dead Snake River steelhead	LAA (BA completed)	Timber, recreation, watershed	Fire Trol LCG
13	Desolation Fire, 20.5 acres, August 2005	Umatilla NF, OR., Desolation Creek	950 Middle Columbia River steelhead smolts of two age classes	LAA (BA completed)		Fire Trol LCG-R
14	Fly Creek Fire, 609 acres on NFS land, 229 on private land	Wallowa-Whitman NF, WA, Fly Creek	15 Snake River steelhead	LAA (BA completed)		Fire Trol LCG

***Effects Determinations**

Threatened and Endangered Species **under** Section 7 of the Endangered Species Act

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