BIOLOGICAL OPINION

AGENCY: National Marine Fisheries Service

ACTION: National Marine Fisheries Service's annual approval of a 4(d) research limit (salmonids) and 4(d) research exemption (green sturgeon) to the Endangered Species Act (ESA) take prohibitions for California Department of Fish and Game's Research Program for the next five years (2012-2016), under the authority of section 4(d) of the ESA

CONSULTATION CONDUCTED BY: National Marine Fisheries Service, Southwest Region

FILE NUMBERS: AR #: 151422SWR2012SR_____
PCTS Tracking #: F/SWR/2012/00759

DATE ISSUED: **March 20, 2012**

I. CONSULTATION HISTORY

In 1997, 2000, and 2002, NOAA's National Marine Fisheries Service (NMFS) established protective regulations for listed threatened anadromous salmonids in California through promulgation of three separate Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1538(a)(1)), section 4(d) rules (62 Federal Register (FR) 38479, 65 FR 42422, and 67 FR 1116). On June 28, 2005, NMFS issued *Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs* (70 FR 37160) that amended all existing 4(d) protective regulations for all west coast threatened salmon and steelhead including California, making the regulations consistent for each threatened salmon Evolutionarily Significant Unit (ESU) and each threatened steelhead Distinct Population Segment (DPS).

Consistent with the previous 4(d) rules, the protective regulations in the June 2005 4(d) rule allows an annual limit to the take prohibitions for research and monitoring activities. *Limit Number 7: Scientific Research Conducted by the States,* provides that the prohibitions of section 9(a)(1) of the ESA do not apply to scientific research and monitoring activities submitted by a state fishery agency that meet the criteria specified in the limit.

In June 2002, the California Department of Fish and Game (CDFG) requested that NMFS provide a 4(d) research limit to exempt take for research and monitoring activities conducted by

CDFG employees and researchers that receive a CDFG Scientific Collector Permit (SCP). CDFG submitted project descriptions and estimated take for each project to NMFS. CDFG and NMFS then developed a research program that meets the criteria specified in the 4(d) limit.

Since NMFS' annual approval of a 4(d) research limit (granting an exemption to the ESA take prohibitions) for CDFG research activities is a Federal action, NMFS must conduct an intra-agency section 7 formal consultation. In December 2003, 2004, and 2005, NMFS issued separate biological opinions (BO) annually to approved the 4(d) research limit (granting take exemption) for CDFG research activities conducted in 2004, 2005, and 2006. The CDFG research activities, collectively known as the 4(d) Research Program (Program), are research and monitoring projects conducted by CDFG biologists and by researchers permitted by CDFG that have applied and been approved for inclusion in the annual Program. During 2005 and 2006, NMFS also issued supplemental BO's to approve a modification to the research limit, due to minor modifications to existing projects and to approve additional research projects. In 2007, NMFS issued a five-year programmatic BO for the 2007 through 2011 annual programs. NMFS then annually issued a BO that tiered from the programmatic opinion.

On March 18, 2010, NMFS issued a final listing determination of threatened for the Southern DPS of Pacific eulachon smelt (*Thaleichthys pacificus*) (75 FR 13012). Section 4(d) rules for the Southern DPS of eulachon have not been issued.

On June 2, 2010, NMFS issued the final 4(d) rule that established protected regulations for listed threatened Southern DPS of North America green sturgeon (*Acipenser medirostris*) in California, Oregon and Washington (75 FR 30714). In addition to establishing take prohibitions, this rule also includes an exemption to those prohibitions for state coordinated research activities for scientific research activities included in a state-sponsored, ESA compliant, scientific research program between state fishery agencies and NMFS. Since there is already an established research program for salmonids, NMFS and CDFG agreed to incorporate green sturgeon research projects into the annual CDFG 4(d) Research Program. Similar to the salmonid 4(d) rule limit, the prohibitions of section 9(a)(1) of the ESA do not apply to green sturgeon research projects included in the approved program.

CDFG and NMFS coordination on the 2012 Program began on July 13, 2011. NMFS hosted a teleconference to discuss review and approval of 2010 annual reports, CDFG personnel updates, discuss the open application submittal dates (September 14 through October 14) and the creation of a timeline to facilitate a more efficient review of the submitted applications. The teleconference concluded with the necessity that NMFS and CDFG would meet in person to further discuss the timeline for application review.

On August 25, 2011, CDFG met with NMFS in the North Central Coast Office in Santa Rosa, California. NMFS discussed the timeline that was developed after the previous teleconference and requested any feedback. CDFG concurred that the timeline was reasonable and feasible. The meeting also served as an informative seminar for the newly acquired personnel on the CDFG team. Further discussion entailed updates on the status of CDFG's Scientific Collecting Permit Program, and in what ways the process can be streamlined for researchers in the 4(d)

program. Also mentioned was phasing out the CDFG biologist comments requirement on the submitted applications, due to unforeseen delays the previous year, CDFG concurred that this was no longer a necessity of the application and that this could be phased out.

On September 14, 2011, the open submittal season began for the 2012 4(d) Research Program, allowing applications to be submitted online at the NMFS Authorizations and Permits for Protected Species (APPS) website.

On October 14, 2011, the submittal season closed at midnight, a total of 82 applications were submitted by the deadline.

On October 17, 2011, five additional projects were submitted by researchers that missed the original deadline due to unforeseen circumstances.

From October 21-24, 2011, the 2012 4(d) application review instructions and review tracking worksheet were submitted to the NMFS area offices (Central Valley Office, Southern California Office, and Northern California Office), NMFS North Central Coast Office Branches, CDFG Fisheries Branch, and Green Sturgeon Review Team). All reviewers were asked to meet the deadline of November 4, 2011. The NMFS Area Offices and the Green Sturgeon Review Team all met this timeline. Due to the lack of state resources the CDFG Fisheries Branch did not complete their review until mid-November.

On November 16, 2011, CDFG and NMFS met again at the NMFS North Central Coast Office to discuss the comments and concerns of the respective agency reviewers. All projects were discussed. Follow up tasks were assigned to CDFG and NMFS including requesting additional details from applicants and which applications could not be considered for the program due to increased concerns of impacts to the ESU or DPS.

On January 26, 2012, NMFS and CDFG had their final status meeting to determine if CDFG completed their tasks, to discuss the final applications that will be approved and the letter CDFG has to submit to NMFS requesting continuation of the 4(d) Research Program for 2012.

NMFS received the 2012 4(d) Research Program request letter from CDFG on February 10, 2012, accompanying this letter was the list of projects for consideration in the 2012 4(d) Research Program.

Based on the minor impacts and limited amount mortality of listed species resulting from the last eight years of the 4(d) Research Program, NMFS has decided to consult programmatically, without tiering biological opinions, on the program for the next five years (2012-2016). This document transmits NMFS' programmatic BO, which analyzes the effects of the proposed research on threatened salmonids, threatened Southern DPS of North American green sturgeon (*Acipenser medirostris*), and threatened Southern DPS of Eulachon Smelt associated with authorizing the 4(d) research limit (salmonids) and 4(d) research exemption (green sturgeon) annually for the next five years. This programmatic BO is based on information from the last eight years of the 4(d) Research Program, and from information provided in individual 4(d)

research project applications and reports submitted annually by researchers in the annual program.

A complete administrative record of this consultation is on file at the NMFS North Central Coast Office.

II. ANALYTICAL FRAMEWORK

A. Jeopardy Analysis

In accordance with policy and regulation, the jeopardy analysis in this BO relies on four components: (1) the Status of the Species, which evaluates the various ESU and DPSs range-wide conditions, the factors responsible for the condition, and the species' likelihood of both survival and recovery; (2) the Environmental Baseline, which evaluates the condition of the listed species in the action area, the factors responsible for that condition, and the relationship of the action area to the likelihood of both survival and recovery of the listed species; (3) the Effects of the Action, which determines the direct and indirect effects of the proposed Federal action and the effects of any interrelated or interdependent activities on this species in the action area; and (4) Cumulative Effects, which evaluates the effects of future, non-Federal activities in the action area on this species.

The jeopardy determination is made by adding the effects of the proposed Federal action and any Cumulative Effects to the Environmental Baseline and then determining if the resulting changes in species status in the action area are likely to cause an appreciable reduction in the likelihood of both the survival and recovery of the listed species in the wild.

The jeopardy analysis in this BO places an emphasis on the range-wide likelihood of both survival and recovery of the listed species and the role of the action area in the survival and recovery of the listed species. The significance of the effects of the proposed Federal action is considered in this context, taken together with cumulative effects, for purposes of making the jeopardy determination. We use a hierarchical approach that focuses first on whether or not the effects on salmonids in the action area will impact their respective population. If the population will be impacted, we assess whether this impact is likely to affect the ability of the population to support the survival and recovery of the DPS or ESU.

B. Adverse Modification Determination

The proposed actions considered in this BO for the annual approval of the Program are not likely to adversely affect designated and proposed critical habitat. Any effects to critical habitat that occur are temporary and specifically designed to capture listed salmonids and/or green sturgeon for scientific research. Effects to critical habitat will not continue into the future after research efforts cease, and are not considered further in this BO.

C. Use of Best Available Scientific and Commercial Information

To conduct the assessment, NMFS examined an extensive amount of information from a variety of sources. Detailed background information on the biology and status of the listed species has been published in a number of documents including peer reviewed scientific journals, primary reference materials, and governmental and non-governmental reports. Additional information regarding the effects of the project's actions on the listed species in question, their anticipated response to these actions, and the environmental consequences of the actions as a whole was formulated from the aforementioned resources, and reports summarizing the results of the research activities conducted under previous 4(d) Programs, and project meeting notes if applicable. For information that has been taken directly from published, citable documents, those citations have been referenced in the text and listed at the end of this document.

III. DESCRIPTION OF THE PROPOSED ACTION

NMFS proposes to limit ESA take prohibitions annually for the next five years, under the authority of section 4(d) of the ESA, consistent with the June 2005 4(d) rule (70 FR 37160) and previous 4(d) rules (62 FR 38479, 65 FR 42422, and 67 FR 1116) for threatened juvenile and adult Southern Oregon/Northern California Coast (SONCC) coho salmon (*Oncorhynchus kisutch*), California Coastal (CC) and Central Valley spring-run (CVSR) Chinook salmon (*O. tshawytscha*), Northern California (NC), Central California Coast (CCC), South-Central California Coast (S-CCC), and Central Valley (CV) steelhead (*O. mykiss*) related to scientific research and monitoring projects throughout California. NMFS also proposes to exempt take of Southern DPS green sturgeon associated with state coordinated research activities in California via the exemption for state coordinated research under the authority of the June 5, 2010 4(d) rule (75 FR 30714).

This BO programmatically analyzes NMFS' annual approval of a 4(d) research limit (salmonids) and 4(d) research exemption (green sturgeon) for the CDFG 4(d) Research Program for the next five years (2012-2016) through March 31, 2017, (in the event the submission and approval of the 2017 Program is delayed (unless it is modified, suspended or revoked sooner)), and would be subject to the limitations of the ESA and the regulations in 50 CFR parts 222, 223, and 224. NMFS proposes that the number of research and monitoring projects will not exceed 105 projects per year and the amount of salmonid take approved annually will not exceed amount specified in Appendix B: Table 1 and the amount of green sturgeon take approved annually will not exceed the amount specified in Appendix B: Table 2. If the amount requested is higher than the amounts indentified in Appendix B: Tables 1 or 2, then NMFS proposes to supplement this programmattic opinion to analyze the additonal effects associated with the increased take. NMFS has decided to limit the programmatic consultation to cover the next five years of the Program to ensure our assumptions about the amount of take remain valid. In longer time periodsspecies listing status is more likely to change, new species and/or experimental populations might become listed, andresearch activities may increase due to issuance of recovery plans..

A. Description of the Annual Research and Monitoring Program

The salmonid 4(d) rule *Limit Number 7: Scientific Research Conducted by the States,* provides an annual limit to the take prohibitions for research and monitoring activities submitted by a state fishery agency that meet the criteria specified in the limit. In 2003, NMFS and CDFG developed a program that meets the criteria specified in the 4(d) rule limit. The Program annually includes research and monitoring projects conducted by CDFG biologists and by researchers permitted by CDFG that have also applied and been approved for inclusion in the annual Program. The NMFS North Central Coast Office and the Sacramento CDFG Fisheries Branch Office coordinate and manage the Program annually. Similar to the salmonid 4(d) rule, the 4(d) rule for Southern DPS green sturgeon provides an exemption to the take prohibitions for scientific research activities included in a state-sponsored, ESA compliant, scientific research program between state fishery agencies and NMFS. The prohibitions of section 9(a)(1) of the ESA do not apply to salmonid and green sturgeon research projects approved for inclusion in the annual program. The Program is approved by NMFS annually, exempting take for projects included in the Program from January 1 through December 31 (or through March 31 of the subsequent year in the event the submission and approval for the Program is delayed (unless it is modified, suspended or revoked sooner)).

In August annually, NMFS and CDFG coordinate on the next research application cycle, and then in late August or early September either NMFS or CDFG transmit the annual 4(d) open submission notification and instructions to CDFG researchers and to CDFG permitted researchers. The 4(d) research application notification and instructions are also distributed to researchers that have inquired about an ESA approval for research on threatened salmon, steelhead and/or green sturgeon.

Beginning with the 2009 Program, project applications are submitted online at the NMFS online application website Authorizations and Permits for Protected Species (APPS) located at https://apps.nmfs.noaa.gov. Researchers are required to submit the 4(d) research applications on APPS by the mid-October deadline annually. CDFG and NMFS have access to the submitted applications on APPS for the review and approval process. CDFG reviews and approves the applications, and then transmits them to the NMFS North Central Coast Office for individual project review and approval. Once CDFG completes the review of individual project applications, they notify NMFS of the project applications they approve and the ones they deny for NMFS consideration for inclusion in the program. Annual reports and applications for subsequent annual Programs will be submitted online at APPS.

APPS has allowed for improved tracking of take requested, approved and reported. For example, prior to the 2009 Program, natural origin and listed hatchery origin fish were not separated out for the approval or the reporting, and smolts were combined with juveniles. Since the 2009 Program, the amount of take requested, approved and reported has included both natural and listed hatchery origin and includes smolts and juveniles. Also, prior to the 2009 Program, the amount of take requested, approved and reported lumped capture take and observation together. Since the 2009 Program, capture take and observation are requested, approved and reported annually. Take of hatchery fish (with take prohibitions and without) are

also requested, approved, and reported annually. Although ESA take prohibitions do not apply to threatened hatchery produced salmon and steelhead with an adipose fin clip, these fish are still part of the listed salmon ESU or steelhead DPS. NMFS will track the amount of listed hatchery fish (with or without an adipose fin) encountered during research annually to get more information on the proportion of natural origin versus hatchery origin fish within populations, ESUs or DPSs.

The NMFS North Central Coast Office annually coordinates with each branch within the office and with each NMFS office for review, comments, and approval of applications for projects within each office area. The NMFS North Central Coast Office also annually reviews and analyzes individual and additive project effects for all projects and impacts to populations, salmon ESUs, steelhead DPSs and southern DPS green sturgeon within each office area. In some cases, NMFS or CDFG requests modifications to project activities to minimize impacts and/or to reduce requested take levels, requiring the researcher to resubmit the 4(d) application to NMFS and CDFG once modified. Some 4(d) applications are denied for inclusion in the Program due to late application submittals, incomplete or inadequate project design, potential impacts that could not be minimized, inclusion of activities that are inconsistent with established protocols, and some are not considered for inclusion in the Program because NMFS is already processing a section 10(a)(1)(A) research permit to authorize the activities. The annual review, updates to applications, and assessment of the individual and additive project effects will occur from October through early December annually.

NMFS also annually evaluates project activities to confirm that the Program meets the criteria described in the 4(d) rule research limit for salmonids and 4(d) rule research exemption for green sturgeon. NMFS evaluation of the Program is described in a memorandum annually. The title for the 2012 Program memorandum is *Determination for California Department of Fish and Game request for take prohibition limit and take prohibition exemption for research and monitoring activities in 2012.* NMFS has determined that the annual approval of the 4(d) research limit (salmonids) and 4(d) research exemption (green sturgeon) is Categorically Excluded from the National Environmental Policy Act (NEPA), as described in the March 2012 document titled *Categorical Exclusion for approval of a limit (salmonids) and an exemption (green sturgeon) to the Endangered Species Act (ESA) take prohibitions for California Department of Fish and Game's Research Program, under the authority of section 4(d) of the ESA.*

NMFS' Program approval is expected to occur annually in late December or early January. In some years, CDFG may delay their review, so the program approval would occur after CDFG completes their review and submits the written request to NMFS. In the event Program approval is delayed, ongoing projects in the previous year's Program will continue as approved until the current Program is approved. All take that occurs in the calendar year will be reported in that year's Program. Prior to approving the Program annually NMFS will: conduct the analyses described above, evaluate the Program to determine that the Program is consistent with the 4(d) rules, and will confirm that the Program is consistent with the NEPA document. If the Program is not consistent, then NMFS will complete the necessary NEPA assessment and documentation prior to approval of the Program.

Once the annual research request for the Program is confirmed to meet the above, the Regional Administrator will approve the Program's annual research by letter to the CDFG. This letter includes the required general conditions and operating requirements for the Program and the list of projects that were included in the approved Program. The NMFS North Central Coast Office will then update the status of each approved 4(d) project application in APPS to "Approved" and CDFG will transmit the NMFS approval letter to all researchers in the Program. The researchers are then required to have a copy of that year's NMFS approval letter along with a copy of the approved application in their possession while sampling that year to confirm ESA approval to a CDFG warden or NMFS enforcement officer.

Project specific information for all projects in the annual Program(s) including; project description, objectives, methods, locations, and amount of estimated take of listed fish are available on APPS. In addition, an electronic excel workbook with data queried from the APPS database includes project specific information and several worksheets that compiles information from each project. This excel database is maintained in the NMFS North Central Coast Office

As part of the required general conditions, if a researcher will *exceed the anticipated level of take, or if circumstances indicate that such an event is imminent*, the activities must cease. The researcher is then required to contact NMFS and CDFG to provide details about exceeding take and to re-evaluate the techniques used. NMFS and CDFG evaluate the situation, and in some cases will revise the protocols and/or techniques accordingly to prevent or minimize further injury or death of listed species. NMFS may either suspend research activities or allow research activities to continue.

In the event that CDFG requests a modification to existing projects or requests addition of projects to the Program during the year, the researcher will submit a 4(d) Modification Request via the APPS website. NMFS will then analyzes the effects of the modified and/or new research and monitoring projects, and if these analyses confirm that the proposed activities are consistent with the impacts to listed species described in this programmatic opinion, then NMFS will approve the request in APPS and will update the Program excel database.

The research projects included in the 2012 to 2016 Programs will utilize the methods described and evaluated in this programmatic. The annual Program encompasses a diverse set of research objectives, including: (1) determining the abundance, distribution, and condition of adult and juvenile fish, (2) surveying spawning and rearing of adult and juvenile listed and unlisted fish, (3) conducting genetic and age studies using tissue and scale samples, (4) investigating upstream and downstream migration timing, (5) studying estuarine and lagoon ecology, (6) classifying and monitoring salmonid habitats, (7) determining habitat use by adult and juvenile fish, (8) prioritizing inventoried streams for restoration work and assessing effectiveness of restoration efforts, (9) evaluating effect of contaminated water on fish species, (10) examining salmonids for the presence of pathogens, (11) evaluating fish entrainment, survival, and movement through dams and diversions, (12) developing population models and estimates of listed salmonids, (13) studying estuarine and lagoon ecology, (14) examining size of various age classes of fish and growth rate (15) assessing green sturgeon spawning habitat and larval drift, (16) assessing

temporary barriers and associated fish behavior and survival study, and (17) surveying green sturgeon spawning. Many of these research projects focus on monitoring and evaluating management actions and tasks that are recommended for the conservation of listed salmon, steelhead and green sturgeon.

The projects in the annual Program are very similar to research and monitoring activities implemented in the 2004 through 2011 Programs. The Program has included an average of 91 projects throughout California: with approximately half of the projects conducted by CDFG researchers and the other half conducted by non-CDFG researchers that have been issued a CDFG scientific collectors permit and have been approved for inclusion in the Program. Many of these projects are ongoing multi-year efforts that are reapproved annually. Some are new projects, and some are modifications to previously approved projects. The projects within the Program may affect salmonids in three ESA-listed salmon ESUs, and four ESA-listed steelhead DPSs throughout California (Appendix A: Figure 1). Approximately half of the annual projects have research and monitoring activities within coastal watersheds, and the other half of the annual projects have research and monitoring activities within Central Valley watersheds (Appendix A: Figure 2). Some of the projects in the Central Valley may also affect green sturgeon from the ESA-listed Southern DPS of North American green sturgeon**.** A few projects in Northern California may also affect eulachon smelt from the ESA-listed Southern DPS of Pacific eulachon. However, the majority of the effects will be non-lethal effects to individual fish with potential injury or mortality to a few individual fish.

The annual average number of projects in the 4(d) program is 91 and the number has declined since a peak of 108 projects in 2008 (Appendix B: Table 3). This is due to a variety of factors including the issuance of section 10(a)(1)(A) research permits to researchers previously in the program, a downturn in California's economy, and in the amount of Federal and state funding for research and monitoring projects. However, NMFS anticipates that the number of Program research and monitoring projects approved may increase over the next five years as both state and Federal recovery actions are implemented and the economy improves.

NMFS requires detailed annual reports from CDFG and researchers that document research or monitoring-related take and results from each research project under this approval. Each approved application in APPS contains a link to create an annual report for the annual reporting period. Once the researcher enters the take information, answers the questions in the report, and attaches related reports, the report is submitted online at the APPS website. Researchers are required to submit the 4(d) research annual reports on APPS by January 31 each year. NMFS North Central Coast Office and CDFG review each annual report for accuracy and completeness, including comparing the amount of take requested with the reported actual amount of take to confirm that the approved amount was not exceeded. If the actual amount of take exceeds the amount approved for any approved project, the researcher is required to explain the rational as to why take was exceeded, confirm that they notified NMFS and CDFG at the time of the event, and to describe measures taken to reduce the numbers. If non-lethal take is exceeded, typically researchers will adjust the take numbers for the next year of sampling upward. Once the annual reports are approved, each report is searchable and accessible on the APPS website. In addition,

each NMFS area office creates copies of each approved annual report so that the reports and information is readily available to NMFS biologists in each office.

The annual reports for the 2011 Program (January 1, 2011 through December 31, 2011) were submitted by January 31, 2012, and the annual reports for the 2012 Program (January 1, 2012 through December 31, 2012) will be submitted by January 31, 2013. Annual reports for subsequent annual Programs will be submitted by January 31 of the year following the activities.

Approximately, one-third of the annual research projects request observations of spawned adult carcasses, adult, smolt, and juvenile salmonids, and adult green sturgeon. These projects will not capture or handle live fish, but will observe them via snorkel surveys, adult spawner/carcass surveys, weirs, fish ladders, and video, etc. Since the impacts to listed species associated with observation are negligible to minimal, NMFS will not put a limit on the annual amount for observation only impacts. NMFS will continue to annually assess impacts and track the amount of fish observed annually, as this data is beneficial to species conservation and recovery.

The present body of scientific information relative to the abundance, distribution, and genetic composition of anadromous salmonid populations in California is incomplete (Good *et al.* 2005, Spence *et al.* 2008, Williams *et al.* 2011). In order to obtain data on the abundance, distribution, and genetic composition of anadromous salmonid populations vital to species conservation and recovery, researchers need to temporarily capture thousands of juvenile fish, smolts, and a smaller number of adult fish annually. Similarly, the lack of reliable long term data for the Southern DPS green sturgeon abundance, distribution, and genetic composition limits the ability of NMFS and CDFG to understand the effectiveness of recent and ongoing conservation efforts. In order to obtain data on the abundance, distribution, and genetic composition of Southern DPS green sturgeon populations vital to species conservation and recovery, researchers need to temporarily capture hundreds of eggs, larvae, juvenile, and a small number of adult sturgeon annually. In nearly all cases these Southern DPS green sturgeon will be captured, enumerated, handled, sampled, and then released unharmed. Salmon, steelhead and green sturgeon are captured with various standard sampling methods including: nets, seines, trawls, hook and line, electrofishing, weirs, and traps. In addition, a small portion of fish captured may undergo tagging or marking procedures and/or may be tissue sampled for genetic analysis. A more detailed description of the methods and procedures utilized by projects in the Program and associated impacts are described in more detail in the Effects section of this programmatic opinion.

1. <u>Description of the Action Area</u>

The action area includes all coastal streams from the Oregon/California border, south to, but not including, the Santa Maria River (San Luis Obispo County, California), and all anadromous streams of the Sacramento-San Joaquin River Basin of the Central Valley of California (Appendix A: Figures 2-8).

2. <u>Measures to Reduce the Impacts of the Program</u>

To minimize the effect of take on listed fish during the research and monitoring activities implemented in each annual Program, NMFS reviews each application to ensure that the amount of take proposed by individual projects, groups of projects within a watershed, or the Program as a whole is commensurate with the status of the populations of salmon, steelhead, and green sturgeon affected by the Program. In some cases, NMFS requests modifications to the activities to further minimize take, requiring the 4(d) application to be resubmitted once modified. All of the scientific research and monitoring projects will be conducted by CDFG staff or by researchers coordinating with CDFG that have been issued CDFG Scientific Collector Permits. Each researcher in the Program must comply with NMFS conditions and requirements to insure responsible treatment and handling of listed species and to minimize take and the effects of take on the species. Researchers will insure that all persons operating under the Program will be properly trained and have access to properly maintained state-of-the-art equipment. Most of the projects in the annual Program are only authorized for unintentional lethal take (indirect mortalities), in some years a few projects that have justified the need to kill fish for their research have been approved for low numbers of intentional lethal take (direct sacrifice). Researchers are required to coordinate with other co-managers and researchers to ensure that no unnecessary duplication or adverse cumulative effects to ESA-listed species occur as a result of his/her activities.

All electrofishing activities will be conducted according to the NMFS Electrofishing Guidelines published in June 2000. The CDFG has provided assurances that research activities undertaken by CDFG will obtain and comply with conditions specified in applicable Federal, State, tribal, local licenses, permits, and authorizations necessary for the conduct of activities provided for in this authorization. All green sturgeon researchers will follow the NMFS *A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons* published in March 2010. The CDFG has provided assurance that all green sturgeon researchers will follow these protocols, or has provided sufficient justification for those protocols they do not propose to follow.

III. DESCRIPTION AND STATUS OF THE SPECIES AND CRITICAL HABITAT

A. Species and Critical Habitat Listing Status

Although some of the projects discussed in this biological opinion are located within the endangered Sacramento River winter-run (SRWR) Chinook salmon ESU and endangered Central California Coast (CCC) coho salmon ESU, the projects either will not affect these endangered species because the species will not be in the project area, or the project's effects have already been analyzed and/or permitted through section 7 or section 10(a)(1)(A) of the ESA. Therefore, the Program's effects on the SRWR Chinook salmon ESU and CCC coho salmon ESU are not considered in this consultation.

This programmatic BO analyzes the effect of the proposed action on three salmon ESUs, four steelhead DPSs, one sturgeon DPS, and one eulachon DPS listed below:

- SONCC coho salmon ESU, listed as threatened under the ESA (70 FR 37160)

- CC Chinook salmon ESU, listed as threatened under the ESA (70 FR 37160)
- CVSR Chinook salmon ESU, listed as threatened under the ESA (70 FR 37160)
- NC steelhead DPS, listed as threatened under the ESA (71 FR 834)
- CCC steelhead DPS, listed as threatened under the ESA (71 FR 834)
- S-CCC steelhead DPS, listed as threatened under the ESA (71 FR 834)
- CV steelhead DPS, listed as threatened under the ESA (71 FR 834)
- Southern population DPS of North American green sturgeon**,** listed as threatened under the ESA (71 FR 17757)
- Southern population DPS of Pacific eulachon smelt, listed as threatened under the ESA (75 FR 13012)

On June 28, 2005, as part of the final listing determinations for 16 West Coast salmon ESUs, NMFS amended the previously promulgated 4(d) protective regulations for threatened salmon and steelhead (70 FR 37160). NMFS streamlined the regulations to provide the necessary flexibility to ensure that fisheries and artificial propagation programs are managed consistently with conservation needs of threatened salmon and steelhead. Under this change the section 4(d) take prohibitions apply to natural and hatchery fish with an intact adipose fin, but not do not apply to listed hatchery fish that had their adipose fin removed prior to release into the wild. Currently adipose fins are clipped from all listed hatchery fish, except for SONCC coho salmon produced at Iron Gate and Trinity River hatcheries that are maxillary clipped. Although the take prohibitions do not apply to the adipose fin clipped hatchery fish, the amount of fish will be requested, reported and tracked annually since they are still part of the listed salmon ESU or steelhead DPS.

The action area for the proposed action is within the designated critical habitat listed below:

- SONCC coho salmon critical habitat (64 FR 24049)
- CCC coho salmon critical habitat (64 FR 24049)
- CC Chinook salmon critical habitat (70 FR 52488)
- SRWR Chinook salmon critical habitat (58 FR 33212)
- CVSR Chinook salmon critical habitat (70 FR 52488)

- NC steelhead critical habitat (70 FR 52488)
- CCC steelhead critical habitat (70 FR 52488)
- CV steelhead critical habitat (70 FR 52488)
- S-CCC steelhead critical habitat (70 FR 52488)
- Southern population DPS of North American green sturgeon critical habitat (74 FR 52300)

The proposed action considered in this programmatic opinion are not likely to adversely affect critical habitat because any effects to critical habitat that occur will be temporary and specifically designed to capture listed salmonids and green sturgeon for scientific research. Effects to critical habitat will not continue into the future after research efforts cease, and are not considered further in this programmatic opinion.

B. Species Life History and Population Dynamics

Most salmonids are anadromous fish, living in both fresh and salt water. The older juvenile and adult life stages occur in the ocean, until the adults ascend freshwater streams to spawn. Eggs (laid in gravel nests called redds), alevins (gravel dwelling hatchlings), fry (juveniles newly emerged from stream gravels), and younger juveniles all rear in freshwater until they become large enough to migrate to the ocean to finish rearing and become adults. Juveniles migrating to the ocean are called smolts. Both smolts and adults go through physiological changes as they emigrate from fresh to salt water (smolts) and from salt to freshwater (adults). The timing of migrations, freshwater habitat preferences for spawning and rearing, the duration of freshwater and ocean rearing, distribution in the ocean, age at maturity, and several other traits can all vary by species. Salmon adults die after spawning; steelhead can sometimes survive to spawn again (Bjornn and Reiser 1991, Groot and Margolis 1991, Busby *et al.* 1996).

1. Coho Salmon

a. General Life History

The life history of the coho salmon in California has been well documented by Shapovalov and Taft (1954) and Hassler (1987). In contrast to the life history patterns of other anadromous salmonids, coho salmon in California generally exhibit a relatively simple 3-year life cycle (Shapovalov and Taft 1954, Hassler 1987). Adult salmon typically begin the freshwater migration from the ocean to their natal streams after heavy late-fall or winter rains breach the sand bars at the mouths of coastal streams (Sandercock 1991). Delays in river entry of over a month are not unusual (Salo and Bayliff 1958, Eames *et al.* 1981). Migration continues into March, generally peaking in December and January, with spawning occurring shortly after arrival to the spawning ground (Shapovalov and Taft 1954).

Coho salmon are typically associated with small to moderately-sized coastal streams characterized by heavily forested watersheds; perennially-flowing reaches of cool, high-quality water; dense riparian canopy; deep pools with abundant overhead cover; in stream cover consisting of large, stable woody debris and undercut banks; and gravel or cobble substrates. Female coho salmon choose spawning sites usually near the head of a riffle, just below a pool, where water changes from a laminar to a turbulent flow and small to medium gravel substrate is present. The flow characteristics of the location of redds usually ensure good aeration of eggs and embryos, and flushing of waste products. The water circulation in these areas also facilitates fry emergence from the gravel. Preferred spawning grounds have nearby overhead and submerged cover for holding adults; water depth of 10-54 centimeters (cm); water velocities of 20-80 centimeters per second (cm/sec); clean, loosely compacted gravel (1.3-12.7 cm diameter) with less than 20 percent fine silt or sand content; cool water ranging from 4-10 degrees Celsius (^{o}C) with high dissolved oxygen of 8 milligrams per liter (mg/l)); and intergravel flow sufficient to aerate the eggs. Lack of suitable gravel often limits successful spawning in many streams.

Each female builds a series of redds, moving upstream as she does so, and deposits a few hundred eggs in each. Fecundity of coho salmon is directly proportional to female size; coho salmon may deposit from 1,000-7,600 eggs (reviewed in Sandercock 1991). Briggs (1953) noted a dominant male accompanies a female during spawning, but one or more subordinate males also may engage in spawning. Coho salmon may spawn in more than one redd and with more than one partner (Sandercock 1991). Coho salmon are semelparous, *i.e.*, they die after spawning. The female may guard a nest for up to two weeks (Briggs 1953).

The eggs generally hatch after four to eight weeks, depending on water temperature. Survival and development rates depend on temperature and dissolved oxygen levels within the redd. According to Baker and Reynolds (1986), under optimum conditions, mortality during this period can be as low as 10 percent; under adverse conditions of high scouring flows or heavy siltation, mortality may be close to 100 percent. McMahon (1983) found that egg and fry survival drops sharply when fines make up 15 percent or more of the substrate. The newly-hatched fry remain in the redd from two to seven weeks before emerging from the gravel (Shapovalov and Taft 1954). Upon emergence, fry seek out shallow water, usually along stream margins. As they grow, juvenile coho salmon often occupy habitat at the heads of pools, which generally provide an optimum mix of high food availability and good cover with low swimming cost (Nielsen 1992). Chapman and Bjornn (1969) determined that larger parr tend to occupy the head of pools, with smaller parr found further down the pools. As the fish continue to grow, they move into deeper water and expand their territories until, by July and August; they reside exclusively in deep pool habitat. Juvenile coho salmon prefer well shaded pools at least 1 meter (m) deep with dense overhead cover; abundant submerged cover composed of undercut banks, logs, roots, and other woody debris; preferred water temperatures of 54-59 degrees Fahrenheit (^{o}F) (Brett 1952, Reiser and Bjornn 1979), but not exceeding 73-77 ^{o}F (Brungs and Jones 1977) for extended time periods; dissolved oxygen levels of 4-9 mg/l; and water velocities of 9-24 cm/sec in pools and 31-46 cm/sec in riffles. Water temperatures for good survival and growth of juvenile coho salmon range from 50-59 ^{o}F (Bell 1973, McMahon 1983). Growth is slowed considerably at 64 ^{o}F and ceases at 68°F (Stein *et al.* 1972, Bell 1973).

Preferred rearing habitat has little or no turbidity and high sustained invertebrate forage production. Juvenile coho salmon feed primarily on drifting terrestrial insects, much of which are produced in the riparian canopy, and on aquatic invertebrates growing within the interstices of the substrate and in leaf litter in pools. As water temperatures decrease in the fall and winter months, fish stop or reduce feeding due to lack of food or in response to the colder water, and growth rates slow down. During December-February, winter rains result in increased stream flows and by March, following peak flows, fish again feed heavily on insects and crustaceans, and grow rapidly.

In the spring, as yearlings, juvenile coho salmon undergo a physiological process, or smoltification, which prepares them for living in the marine environment. They begin to migrate downstream to the ocean during late March and early April, and out migration usually peaks in mid-May, if conditions are favorable. Emigration timing is correlated with peak upwelling currents along the coast. Entry into the ocean at this time facilitates more growth and, therefore, greater marine survival (Holtby *et al.* 1990). At this point, the smolts are about 10-13 cm in length. After entering the ocean, the immature salmon initially remain in nearshore waters close to their parent stream. They gradually move northward, staying over the continental shelf (Brown *et al.* 1994). Although they can range widely in the north Pacific, movements of coho salmon from California are poorly known.

b. Population Trend – Southern Oregon/Northern California Coast Coho Salmon

As with most salmonid species in California, SONCC coho salmon populations are in decline. CDFG (1994) summarized most information available at the time, and concluded that "coho salmon in California, including hatchery populations, could be less than 6 percent of their abundance during the 1940s, and have experienced at least a 70 percent decline in the 1960s." They also noted that coho salmon populations have been virtually eliminated in many streams, and that adults are observed only every third year in some streams, suggesting that two of three brood cycles may already have been eliminated. The number of adult SONCC coho salmon collected at Benbow Dam on the South Fork Eel River (California) declined from greater than 25,000 adults in the 1940's to less than 1,000 adults by the early 1970's (NMFS 2007a). Weitkamp *et al.* (1995) estimated that the rivers and tributaries in the California portion of the SONCC coho salmon ESU had "recently" produced 7,080 naturally spawning coho salmon and 17,156 hatchery returns, including 4,480 "native" fish occurring in tributaries having little history of supplementation with nonnative fish. Combining the California run-size estimates with Rogue River (Oregon) estimates, Weitkamp *et al.* (1995) arrived at a rough minimum run-size estimate for the SONCC coho salmon ESU of about 10,000 natural fish and 20,000 hatchery fish.

Good *et al.* (2005) concluded that coho salmon populations across the ESU remain substantially lower than historic levels and that breeding groups had been lost from a significant portion of the ESUs historic range. The Southern Oregon/Northern California Technical Recovery Team (TRT) evaluated the population structure of this ESU was characterized by small to moderate

sized coastal basins where high quality habitat is in the lower portions, middle portions of the basins, provided little habitat, and the largest amount of habitat was located in the upper portions of the sub-basins. Based on its review, the TRT concluded the ESU was historically comprised of: 1) 19 functionally independent populations, 2) 12 potentially independent populations, 3) 17 small dependent populations of coho salmon, and 4) 2 ephemeral populations. The Good *et al.* (2005) review concluded that the SONCC coho salmon ESU was likely to become endangered. Since that review, the apparent negative trends across the ESU are of great concern as is the lack of information necessary to determine if there has been a substantial improvement in freshwater habitat and survival. However, these recent negatives must be considered in the context of the apparent extremely low marine survival rates over the past five years that most likely contributed to the observed declines. Overall, this new information, while cause for concern, does not appear to indicate there has been a change in biological extinction risk since the last status review. However, careful monitoring and evaluation of biological extinction of this ESU is warranted.

Other than the Shasta River and Scott River adult counts, reliable time series of naturally produced adult migrant or spawners are not available for the California portion of the SONCC ESU at the "population unit" scale. As discussed by Good *et al.* (2005), the CDFG has conducated annual spawner surveys on 4.5 miles of Sprowl Creek, a tributary to the Eel River, since 1974 (except of 1976-1977) and on 2 miles of Canon Creek, a tributary to the Mad River, since 1981 (PSFMC 2010). These counts are conducted primarily to generate minimum Chinook salmon counts and the detection of choh salmon is problematic due to conditions during those surveys (Good *et al.* 2005). The number of adult coho salmon observed over the past 29 years has never exceeded 29 fish.

The 2011 status update (Williams *et al.* 2011) states that all available data from shorter-term research and monitoring efforts indicate that conditions have worsened for populations in this ESU since the last formal status review (Good *et al.* 2005). For all available time series (except the counts from the West Branch and East Fork of Mill Creek), recent population trends have been downward. The longest existing time series at the "population unit" scale is for the past ten years in the Shasta River and this series shows a significant negative trend. Many independent populations are well below low-risk abundance targets and several are likely below the high-risk thresholds. Though population-level estimates of abundance for most independent populations are lacking, it does not appear that any of the seven diversity strata currently supports a single viable population (Williams *et al*. 2011) though all diversity strata are occupied. Based on this information, NMFS recommended maintaining the threatened status of this ESU while also recommending monitoring and reassessment within 2-3 years if a positive trend does not become evident. (NMFS 2011a,76 FR 50447).

2. <u>Chinook Salmon</u>

a. General Life History for Chinook salmon

Chinook salmon exhibit two generalized freshwater life history types (Healey 1991). "Stream-Type" Chinook salmon, enter freshwater months before spawning and reside in freshwater for a

year or more following emergence, whereas “ocean-type” Chinook salmon spawn soon after entering freshwater and migrate to the ocean as fry or parr within their first year. Spring-run Chinook salmon can exhibit a stream-type life history. Adults enter freshwater in the spring, hold over summer, spawn in the fall, and some of the juveniles may spend a year or more in freshwater before emigrating. The remaining fraction of the juvenile spring-run population may also emigrate to the ocean as young-of-the-year in the spring. Winter-run Chinook salmon are somewhat anomalous in that they have characteristics of both stream-and ocean-type races (Healey 1991). Adults enter freshwater in winter or early spring, and delay spawning until spring or early summer (stream-type). However, juvenile winter-run Chinook salmon migrate to sea after only 4 to 7 months of river life (ocean-type). Adequate instream flows and cool water temperatures are more critical for the survival of Chinook salmon exhibiting a stream-type life history due to over summering by adults and/or juveniles.

Chinook salmon typically mature between 2 and 6 years of age (Myers *et al.* 1998). Freshwater entry and spawning timing generally are thought to be related to local water temperature and flow regimes. Runs are designated on the basis of adult migration timing; however, distinct runs also differ in the degree of maturation at the time of river entry, thermal regime and flow characteristics of their spawning site, and the actual time of spawning (Myers *et al.* 1998). Both spring-run and winter-run Chinook salmon tend to enter freshwater as immature fish, migrate far upriver, and delay spawning for weeks or months. For comparison, fall-run Chinook salmon enter freshwater at an advanced stage of maturity, move rapidly to their spawning areas on the main stem or lower tributaries of the rivers, and spawn within a few days or weeks of freshwater entry (Healey 1991).

During their upstream migration, adult Chinook salmon require stream flows sufficient to provide olfactory and other orientation cues used to locate their natal streams. Adequate stream flows are necessary to allow adult passage to upstream holding habitat. The preferred temperature range for upstream migration is 38°F to 56°F (Bell 1991, CDFG 1998). Boles (1988) recommend water temperatures below 65°F before they experience an increased susceptibility to disease (Williams 2006).

Information on the migration rates of Chinook salmon in freshwater is scant and primarily comes from the Columbia River basin where information regarding migration behavior is needed to assess the effects of dams on travel times and passage (Matter *et al.* 2003). Keefer *et al.* (2004) found migration rates of Chinook salmon ranging from approximately 10 kilometers (km) per day to greater than 35 km per day and to be primarily correlated with date, and secondarily with discharge, year, and reach, in the Columbia River basin. Matter *et al.* (2003) documented migration rates of adult Chinook salmon ranging from 29 to 32 km per day in the Snake River. Sacramento and San Joaquin rivers were observed exhibiting substantial upstream and downstream movement in a random fashion while migrating upstream over the course of several days (CALFED 2001). Adult salmonids migrating upstream are assumed to make greater use of pool and mid-channel habitat than channel margins (Stillwater Sciences 2004), particularly larger salmon such as Chinook salmon, as described by Hughes (2004). Adults are thought to exhibit crepuscular behavior during their upstream migrations; meaning that they primarily are active during twilight hours. Recent hydroacoustic monitoring showed peak upstream movement adult

Central Valley spring-run Chinook salmon in lower Mill Creek, a tributary to the Sacramento River, occurring in the 4-hour period before sunrise and again after sunset.

Spawning Chinook salmon require clean, loose gravel in swift, relatively shallow riffles or along the margins of deeper runs, and suitable water temperatures, depths, and velocities for red construction and adequate oxygenation of incubating eggs. Chinook salmon spawning typically occurs in gravel beds that are located at the tails of holding pools (USFWS 1995a). The range of water depths and velocities in spawning beds that Chinook salmon find acceptable is very broad. The upper preferred water temperature for spawning Chinook salmon is 55°F to 57°F (Chambers 1956, Smith 1973, Bjornn and Reiser 1991, and Snider 2001).

Incubating eggs are vulnerable to adverse effects from floods, siltation, desiccation, disease, predation, poor gravel percolation, and poor water quality. Studies of Chinook salmon egg survival to hatching conducted by Shelton (1995) indicated 87 percent of fry emerged successfully from large gravel with adequate subgravel flow. The optimal water temperature for egg incubation ranges from 41°F to 56°F (44°F to 54°F [Rich 1997], 46°F to 56°F [NMFS 1997 Winter-run Chinook salmon Recovery Plan], and 41°F to 55.4°F [Moyle 2002]). A significant reduction in egg viability occurs at water temperatures above 57.5°F and total embryo mortality can occur at temperatures above 62°F (NMFS 1997). Alderdice and Velsen (1978) found that the upper and lower temperatures resulting in 50 percent pre-hatch mortality were 61°F and 37°F, respectively, when the incubation temperature was held constant. As water temperatures increase, the rate of embryo malformations also increases, as well as the susceptibility to fungus and bacterial infestations. The length of development for Chinook salmon embryos is dependent on the ambient water temperature surrounding the egg pocket in the red. Colder water necessitates longer development times as metabolic processes are slowed. Within the appropriate water temperature range for embryo incubation, embryos hatch in 40 to 60 days, and the alevins (yolk-sac fry) remain in the gravel for the additional 4 to 6 weeks before emerging from the gravel.

During the 4 to 6 week period when alevins remain in the gravel, they utilize their yolk-sac to nourish their bodies. As their yolk-sac is depleted, fry begin to emerge from the gravel to begin exogenous feeding in their natal stream. The post-emergent fry disperse to the margins of their natal stream, seeking out shallow waters with slower currents, finer sediments, and bank cover such as overhanging and submerged vegetation, root wads, and fallen woody debris, and begin feeding on zooplankton, small insects, and small invertebrates. As they switch from endogenous nourishment to exogenous feeding, the fry's yolk-sac is reabsorbed, and the belly suture closes over the former location of the yolk-sac (button-up fry). Fry typically range from 25 mm to 40 mm during this stage. Some fry may take up residence in their natal stream for several weeks to a year or more, while others are displaced downstream by the stream's current. Once started downstream, fry may continue downstream to the estuary and rear, or may take up residence in river reaches farther downstream for a period of time ranging from weeks to a year (Healey 1991).

Fry then seek nearshore habitats containing beneficial aspects such as riparian vegetation and associated substrates important for providing aquatic and terrestrial invertebrates, predator

avoidance, and slower velocities for resting (NMFS 1996 a). The benefits of shallow water habitats for salmonid rearing also have recently been realized as shallow water habitat has been found to be more productive than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et.al*. 2001).

When juvenile Chinook salmon reach a length of 50 mm to 57 mm, they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures. In the mainstems of larger rivers, juveniles tend to migrate along the margins and avoid the elevated water velocities found in the thalweg of the channel. When the channel of the river is greater than 9 feet to 10 feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1982). Migrational cues, such as increasing turbidity from runoff, increased flows, changes in day length, or intraspecific competition from other fish in their natal streams may spur outmigration of juveniles when they have reached the appropriate stage of maturation (Kjelson *et.al.* 1982, Brandes and McLain 2001).

As fish begin their emigration, they are displaced by the river's current downstream of their natal reaches. Similar to adult movement, juvenile salmonid downstream movement is crepuscular. Documents and data provided to NMFS in support of ESA section 10 research permit applications depicts that daily migration of juveniles passing Red Bluff Diversion Dam (RBDD) is highest in the four hour period prior to sunrise (Martin *et al.* 2001). Juvenile Chinook salmon migration rates vary considerably presumably depending on the physiological stage of the juveniles and the hydrologic conditions. Kjelson *et al.* (1982) found fry Chinook salmon to travel as fast as 30 km per day in the Sacramento River and Sommer *et al.* (2001) found rates ranging from approximately 0.5 miles up to more than 6 miles per day in the Yolo Bypass. As Chinook salmon begin the smoltification stage, they prefer to rear further downstream where ambient salinity is up to 1.5 to 2.5 parts per thousand (Healey 1980, Levy and Northcote 1982).

Fry and parr may rear within riverine and estuarine habitats of the Sacramento River, the Delta, and their tributaries. In addition, Central Valley spring-run Chinook salmon juveniles have been observed rearing in the lower reaches of non-natal tributaries and intermittent streams in the Sacramento Valley during the winter months (Maslin *et al.* 1997, and Snider 2001). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as intertidal and subtidal mudflats, marshes, channels, and sloughs (McDonald 1960, Dunford 1975). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1982, Sommer *et al.* 2001, MacFarlene and Norton 2002). Shallow water habitats are more protective than the main river channels, supporting higher growth rates, partially due to higher prey consumption rates, as well as favorable environmental temperatures (Sommer *et al.* 2001). Optimal water temperatures for the growth of juvenile Chinook salmon in the Delta are between 54°F to 57°F (Brett 1952). In Suison and San Pablo Bays water temperatures can reach 54°F by February in typical year. Other portions of the Delta (i.e. south Delta and cental Delta) can reach 70°F by February in a dry year. However, cooler temperatures are usually the norm until after the spring runoff has ended.

Within the estuarine habitat, juvenile Chinook salmon movements are dictated by the tidal

cycles, following the rising tide into shallow water habitats from the deeper main channels, and returning to the main channels when the tide recedes (Levy and Northcote 1982, Levings 1982, Levings *et al.* 1986, Healey 1991). As juvenile Chinook salmon increase in length, they tend to school in the surface waters of the main and secondary channels and sloughs, following the tides into shallow water habitats to feed (Allen and Hassler 1986). In Suisun Marsh, Moyle *et al.* (1989) reported that Chinook salmon fry tend to remain close to the banks and vegetation, near protective cover, and in dead-end tidal channels. Kjelson *et al.* (1982) reported that juvenile and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column. Available data indicates that juvenile Chinook salmon use Suisun Marsh extensively both as a migratory pathway and rearing area as they move downstream to the Pacific Ocean. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay and grew little in length or weight until they reached the Gulf of the Farallones (MacFarlane and Norton 2002). Based on the mainly ocean-type life history observed (*i.e.*, fall-run Chinook salmon) MacFarlane and Norton (2002) concluded that unlike other salmonid populations in the Pacific Northwest, Central Valley Chinook salmon show little estuarine dependence and may benefit from expedited ocean entry.

b. Population Trend – California Coastal Chinook Salmon

The 2005 BRT concluded that the CC Chinook salmon ESU is likely to become endangered (Good *et al.* 2005). Widespread declines in abundance and the present distribution of small populations with sometimes sporadic occurrences contribute to the risks faced in this ESU. The BRT is concerned about the paucity of information and resultant uncertainty associated with estimates of abundance, natural productivity, and distribution of Chinook salmon in this ESU (Good *et al.* 2005).

The CC Chinook salmon ESU historically supported 16 Independent populations of fall-run Chinook salmon (11 Functionally Independent and five potentially Independent), six populations of spring-run Chinook, and an unknown number of dependent populations. However, based on the data available, 8 of the 16 populations were classified as data deficient, 1 population (Mattole River) was classified as being at a Moderate/High risk of extinction, and 6 populations (Ten Mile River, Noyo River, Big River, Navarro River, Garcia River, and Gualala River) were classified as being at a High risk of extinction (Spence *et al.* 2008). Overall, Spence *et al.* (2008) concluded that the CC Chinook salmon ESU is at an elevated risk of extinction, which was consistent with previous status reviews (Myers *et al.* 1998, Good *et al.* 2005).

The CC Chinook Salmon ESU appears to contain only one population (the Russian River population) that may be trending toward viability. All other populations are substantially reduced from historical levels. Both the North- Central Coastal and Central Coast Diversity Strata are poorly represented in terms of Functionally Independent populations (and dependent populations). Degraded habitat conditions limit the ability of many Chinook salmon populations to increase in abundance, and may foster further declines in some areas. This ESU is at an elevated risk of extinction.

Data from the 2010 and 2011 adult CC Chinook salmon return counts and estimates indicates an increase in returning adults across the range of CC Chinook salmon on the coast of California (Jeffrey Jahn, personal communication 2012), including within the two largest watersheds within the ESU (Russian and Eel rivers). The number of adult CC Chinook salmon returns in the Russian River Watershed increased substantially in 2011 compared to the 2009 and 2010 returns[1]. The number of CC Chinook salmon returns to the Van Arsdale Fisheries Station located on the Upper Eel River also increased substantially in 2010 and 2011, exceeding the number of adult Chinook salmon counted since counts began in 1933 (Jeffrey Jahn, personal communication 2012).

Using an updated analysis approach, Williams *et al*. (2011) did not find evidence of a substantial change in conditions since the last status review (Good *et al.* 2005). Williams *et al.* (2011) analysis found that the loss of representation from one diversity stratum, the loss of the spring-run history type in two diversity substrata, and the diminished connectivity between populations in the northern and southern half of the ESU pose a concern regarding viability for this ESU. Based on consideration of this updated information, Williams *et al.* (2011) concluded the extinction risk of the CC Chinook salmon ESU has not changed since the last status review. On August 15, 2011, NMFS affirmed no change to the determination that the CC Chinook salmon ESU is a threatened species, as previously listed (NMFS 2011b, 76 FR 50447).

c. Population Trend - Central Valley spring-run Chinook Salmon

Although protective measures likely have contributed to recent increases in Central Valley 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, run hybridization and genomic homogenization), climatic variation, high water temperatures, predation, and water diversions still persist.

Wild runs of CVSR Chinook salmon persist in a fraction of the streams that they historically occurred in (NMFS 2009a). These include, the upper reaches of the Sacramento River Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFG 1998). Only the Deer, Mill, and Butte creek populations are considered to be independent populations and these three populations are all within the same diversity strata (NMFS 2009a). Because wild CVSR Chinook salmon ESU populations are confined to relatively few remaining watersheds and continue to display broad fluctuations in abundance, the BRT (Good *et al.* 2005) concluded that the ESU is likely to become endangered within the foreseeable future. According to Population Viability Assessment (PVA) models and other population viability criteria, Lindley *et al.* (2007) concluded that the CVSR Chinook salmon populations in Butte and Deer creeks were at a low-risk of extinction. The Mill Creek population was classified as being at a moderate-risk of extinction based on the PVA model, however it met the criteria for a low-risk of extinction for other all other viability criteria.

[1] http://www.scwa.ca.gov/chinook/

Data from the 2009 and 2010 adult CVSR Chinook salmon return counts indicates a decline in returning adults across the range of CVSR Chinook salmon within the Central Valley of California. Poor ocean conditions are suspected as the principal short term cause because of the wide geographic range of declines (Southwest Fisheries Science Center 2008, Lindley *et al.* 2009). Preliminary data from the 2011 adult returns indicate an increase in returning adults across their range (Jeffrey Jahn, personal communication 2012).

Williams *et al.* 2011 conclude that the status of CVSR Chinook salmon ESU has probably deteriorated since the 2005 status review. Improvements, evident in the status of two populations, are certainly not enough to warrant downgrading of the ESU extinction risk. The degradation in status of the three formerly low- or moderate- risk independent populations is cause for concern. New information available since Good *et al.* (2005) indicates an increased extinction risk. Based on this information, NMFS recommended maintaining the threatened status of this ESU while also recommending monitoring and reassessment within 2-3 years if a positive trend does not become evident (NMFS 2011c). On August 15, 2011, NMFS affirmed no change to the determination that the CVSR Chinook salmon ESU is a threatened species, as previously listed (76 FR 50447).

2. Steelhead

a. General Life History

Steelhead are anadromous forms of *O. mykiss*, spending some time in both freshwater and saltwater. Steelhead can be divided into two reproductive ecotypes, based upon their state of sexual maturity at the time of river entry (*i.e.*, winter or summer runs) and the duration of their spawning migration. Winter-run steelhead, the more common form of the two ecotypes, typically migrate upstream during high flow events between November and April. In many streams, the timing of upstream migration begins only after stream flows are high enough to breach the sand bars at the stream mouths. Summer-run steelhead migrate upstream from March through September. In contrast to other species of *Oncorhynchus*, steelhead may spawn more than one season before dying (iteroparity); although one-time spawners represent the majority (Shapovalov and Taft 1954). Steelhead young usually rear in freshwater for one to three years before migrating to the ocean as smolts in the spring. Steelhead may remain in the ocean for one to five years (two to three years is most common) before returning to their natal streams to spawn (Shapovalov and Taft 1954, Busby *et al.* 1996). The distribution of steelhead in the ocean is not well known. Coded wire tag recoveries indicate most steelhead tend to migrate north and south along the continental shelf (Barnhart 1986).

Outmigration appears to be more closely associated with size than age and a decline in the hydrograph (Shapovalov and Taft 1954). In Waddell Creek, Shapovalov and Taft (1954) found steelhead juveniles migrating downstream at all times of the year, with the largest numbers of young-of-year (YOY) and age 1+ steelhead moving downstream during spring and summer. For steelhead embryos, survival to emergence is inversely related to the proportion of fine sediment in the spawning gravels. Steelhead are slightly more tolerant than other salmonids, with significant reductions in survival when particles less than 0.25 inches in diameter comprise

20 to 25 percent of the substrate. Fry typically emerge from the gravel two to three weeks after hatching (Barnhart 1986). Upon emerging from the gravel, fry rear in edge-water habitats and move gradually to deeper and faster habitats as they grow (Chapman and Bjornn 1969, Everest and Chapman 1972, Smith and Li, 1983). Older fry establish territories which they defend. During this period, cover (*i.e.*, overhanging and emergent vegetation, boulders, and woody material) is an important habitat component for juvenile steelhead, both as a velocity refuge and as a means of avoiding predation (Meehan and Bjornn 1991).

As juveniles, steelhead tend to use riffles and other fast water habitats (*i.e.*, runs and heads of 12 pools) during summer where food, in the form of drifting invertebrates, is more abundant (Smith and Li 1983). Young steelhead feed on a wide variety of aquatic and terrestrial insects, and emerging fry are sometimes preyed upon by older juveniles. In winter, juvenile steelhead become less active and hide in available cover, including gravel or woody debris, under cut banks, and dense streamside vegetation. Steelhead typically spend much of their juvenile lifestage in freshwater habitats, particularly inland populations. For most coastal systems, the use of estuaries and seasonal lagoons by juvenile salmonids for rearing is much more extensive. Studies have confirmed estuaries (including seasonal, bar-built lagoons) play an important role in the lifecycle of salmonids because they are typically more productive than upstream riverine habitats, and because size at ocean entry can affect ocean survival substantially (Smith 1990, Bond 2006, Hayes *et al.* 2008).

In riverine habitats, adequate flow, temperature, and food availability are important factors for survival and growth. Water temperature can influence the metabolic rate, distribution, abundance, and habitat use of rearing juvenile steelhead (Barnhart 1986, Bjornn and Reiser 1991, Myrick and Cech 2005, Casagrande 2010). Optimal temperatures for steelhead growth range between 10 and 20 °C (Hokanson *et al.* 1977, Wurtsbaugh and Davis 1977, Myrick and Cech 2005). Variability in the diurnal water temperature range is also important for the survivability and growth of salmonids (Busby *et al.* 1996, Casagrande 2010).
Stream water temperature is regulated by multiple factors including air temperature, stream channel dimension and orientation, and the presence and abundance of riparian vegetation (Poole and Berman 2001).

Suspended sediment concentrations, or turbidity, also can influence the distribution and growth of steelhead (Bell 1973, Sigler et al. 1984, Newcombe and Jensen 1996). Bell (1973) found suspended sediment loads of less than 25 milligrams per liter (mg/L) were typically suitable for rearing juvenile steelhead.

b. Population Trend- Northern California steelhead

Historically, the NC steelhead DPS was comprised of 41 independent populations (19 functionally and 22 potentially independent) of winter run steelhead and 10 functionally independent populations of summer run steelhead (Bjorkstedt *et al.* 2005). Based on the limited data available (dam counts of portions of stocks in several rivers), NMFS' initial status review of NC steelhead (Busby *et al*. 1996) determined that population abundance was very low relative to historical estimates (1930s and 1960s dam counts), and recent trends were downward in most

stocks. Overall, population numbers are severely reduced from pre-1960s levels, when approximately 198,000 adult steelhead migrated upstream to spawn in the major rivers of this DPS (Busby *et al*. 1996, 65 FR 36074).

Updated status reviews reach the same conclusion, and noted the poor amount of data available, especially for winter run steelhead (NMFS 1997, Adams 2000, Good *et al*. 2005). The information available suggests that the DPS population growth rate is negative. Comprehensive geographic distribution information is not available for this DPS, but steelhead are considered to remain widely distributed (NMFS 1997). It is known that dams on the Mad River and Eel River block large amounts of habitat historically used by NC steelhead (Busby *et al*. 1996, Spence *et al.* 2008). Also, hatchery practices in this DPS have exposed the wild population to genetic introgression and the potential for deleterious interactions between native stock and introduced steelhead. Historical hatchery practices at the Mad River hatchery are of particular concern, and included out-planting of non-native Mad River hatchery fish to other streams in the DPS and the production of non-native summer steelhead (65 FR 36074). The conclusion of the 2005 status review (Good *et al*. 2005) echoes that of previous reviews. Abundance and productivity in this DPS are of most concern, relative to NC steelhead spatial structure (distribution on the landscape) and diversity (level of genetic introgression). The lack of data available also remains a risk because of uncertainty regarding the condition of some stream populations.

Adult returns of NC steelhead during 2007/08 were considered average for the last decade, data from the 2008/09 adult NC steelhead were lower and indicate populations remained suppressed across much of their range compared to historic amounts. However, returns during the 2009/10 and preliminary data on the 2010/11 returns indicate increases in many populations of NC steelhead compared to the previous two years (Jeffrey Jahn, personal communication, 2011). The most recent status review update by Williams *et al.* (2011) reports a mixture of patterns in population trend information, with more populations showing declines than increases. Although little information is available to assess the status for most population in the NC steelhead DPS, overall Williams *et al.* (2011) found little evidence to suggest a change in status compared to the last status review by Goode *et al.* (2005). Based on this information, NMFS chose to make no change to the listing status of threatened for NC steelhead (NMFS 2011d, 76 FR 76386).

c. Population Trend- Central California Coast steelhead

On January 5, 2006, NMFS issued a final determination that the CCC steelhead DPS is a threatened species, as previously listed (71 FR 834). CCC steelhead have experienced serious declines in abundance, and long-term population trends suggest a negative growth rate (Good *et al.* 2005). This indicates the DPS may not be viable in the long term. DPS populations that historically provided enough steelhead strays to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead have maintained a wide distribution throughout the DPS, roughly approximating the known historical distribution, CCC steelhead likely possess a resilience that is likely to slow their decline relative to other salmonid species in worse condition (*e.g.*, CCC coho salmon).

The most recent status review concluded that the CCC steelhead DPS is “likely to become

endangered in the foreseeable future," and they cite a lack of population data as a contributing risk (Good *et al.* 2005). Their conclusion was consistent with the previous status review's determination (Busby *et al.* 1996).

The CCC steelhead DPS historically supported 37 Independent populations (14 Functionally Independent and 23 potentially Independent). Spence *et al.* (2008) concluded that data on spawner abundance was insufficient to rigorously assess the viability of these independent populations of CCC steelhead, particularly for the North Coastal, Interior, and Santa Cruz Mountain diversity strata. However, they did suggested that, based on degraded habitat conditions and the extensive loss of historic spawning habitat due to dams and other ancillary data, CCC steelhead populations in six watersheds that drain to San Francisco Bay are all unviable and at a high risk of extinction.

Although there were average returns of adult CCC steelhead during 2007/08, data from the 2008/09 and 2009/10 adult CCC steelhead returns indicate a decline in returning adults across their range compared to recent returns (Jeffrey Jahn, personal communication 2010). Preliminary data from the 2010/11 adult CCC steelhead returns indicate an increase in return compared to the previous two years, but still remain below average (Jeffrey Jahn, personal communication 2011).

The most recent status review by the Williams *et al.* (2011) concludes that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future" (Williams *et al.* 2011), as new and additional information available since Good *et al.* (2005) does not appear to suggest a change in extinction risk. On December 7, 2011, NMFS affirmed no change to the determination that the CCC steelhead DPS is a threatened species, as previously listed (NMFS 2011d, 76 FR 76386).

d. Population Trend- South Central California Coast steelhead

Populations of S-CCC steelhead throughout the DPS have exhibited a long-term negative trend since the mid-1960s. In the mid-1960s, total spawning populations were estimated at 17,750 individuals (Good *et al.* 2005). Available information shows S-CCC steelhead population abundance continued to decline from the 1970s to the 1990s (Busby *et al.* 1996) and more recent data indicate this trend continues (Good *et al.* 2005). Current S-CCC steelhead run-sizes in the five largest systems in the DPS (Pajaro River, Salinas River, Carmel River, Little Sur River, and Big Sur River) are likely greatly reduced from 4,750 adults in 1965 (CDFG 1965) to less than 500 returning adult fish in 1996. More recent estimates for total run-size do not exist for the S-CCC steelhead DPS (Good *et al.* 2005).

Recent analyses conducted by NMFS (NMFS 2006, Boughton *et al.* 2007) indicate the S-CCC steelhead DPS consists of 12 discrete sub-populations which represent localized groups of 13 interbreeding individuals, and none of these sub-populations currently meet the definition of viable. Most of these sub-populations can be characterized by low population abundance, variable or negative population growth rates, and reduced spatial structure and diversity. The sub-populations in the Pajaro River and Salinas River watersheds are in particularly poor

condition (relative to watershed size) and exhibit a greater lack of viability than many of the coastal subpopulations.

Steelhead populations are present in most streams in the S-CCC DPS (Good *et al.* 2005), however, these populations are fragmented and unstable (NMFS 2006a). In addition, severe habitat degradation and compromised genetic integrity of some populations pose a serious risk to the survival and recovery of the S-CCC steelhead DPS (Good *et al.* 2005). NMFS' most recent status review concluded S-CCC steelhead remains "likely to become endangered in the foreseeable future" (Good *et al.* 2005). NMFS confirmed the listing of S-CCC steelhead as threatened under the ESA on January 5, 2006 (71 FR 834). In the 2008/09 and 2009/10 winters, adult returns in many streams within the DPS were considerably reduced relative to higher returns at the beginning of the decade. This was likely attributed largely to poor ocean conditions along the eastern Pacifica Ocean (Lindley *et al.* 2009). However, during the winter of 2010/11, adult returns appeared to rebound toward numbers seen at the beginning of the decade, based on a significant increase in adult returns counted at San Clemente Dam on the Carmel River[4], and a notable increase in the number of observed adults in Uvas Creek of the Pajaro Watershed (Jon Ambrose, NMFS, personal communication, May 2011).

Williams *et al.* 2011 concluded that while the to the scarcity of information on S-CCC abundance assessing whether conditions have changed appreciably since the previous status review of Good *et al.* (2005) is difficult there was no evidence of a substantial change in conditions since the Good *et al.* 2005 status review. On December 7, 2011, NMFS affirmed no change to the determination that the S-CCC steelhead DPS is a threatened species, as previously listed (NMFS, 2011e, 76 FR 76386).

e. Population Trend- Central Valley steelhead

Popluaiton trend data remain extremely limited for CV steelhead (Williams *et al.* 2011). Historic CV steelhead run sizes are 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 through the 1960s in the Sacramento River, upstream of the Feather River. Steelhead counts at Red Bluff Diversion Dam (RBDD) 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 totoal annual run size for the entire Sacramento-San Joaquin system, based on RBDD counts, to be no more than 10,000 adults (McEwan and Jackson 1996, McEwan 2001). Steelhead escapement surveys at RBDD ended in 1993 due to changes in dam operations.

The best best poplation-level data come from Battle Creek where Coleman National Fish Hatchery (NFH) operates a weir that blocks upstream movement of fish (Williams et al. 2011). However, changes in hatcheries policies and transfer of fish over the years complicate the interpretation of these data (CVP PRD staff). For example, starting in 2005, Coleman NFH stopped transferring all adipose fin clipped (hatchery-origin) steelhead above the weir resulting

in a large decrease in the overall numbers of fish passing the weir in subsequent years. As a result, the only unbaised time series for Battle Creek is the number of unclipped (wild) steelhead returning since 2001. These data show a slight decline over the last ten years mostly because of the high returns observed in 2002 and 2003. Williams *et al.* (2011) indicate that the Battle Creek population declined significantly since the early 2000s, but their analysis did not take into account the fact that hatchery fish were not transferred above the barrier weir after 2005. Prior to halting the transfer of adipose fin-clipped steelhead above the weir in 2005, the majority of fish transferred were of hatchery origin in the early 2000s.

Steelhead returns to Coleman NFH have varied considerably over the past five years. Since 2003, adults returning to the hatchery have been classified as wild (unclipped) or hatchery produced (adipose fin-clipped). Wild adults counted at the hatchery each year represent a small fraction of overall returns, but their numbers have remained relative stable in the range of 200-300 fish each year. Numbers of hatchery origin fish have flucuated much more; however, ranging from 624 to 2,968 fish.

Steelhead redd counts are made in Clear Creek and the American River, but the data are currently insufficient data to compute population metrics (Williams *et al.* 2011). An average of 151 steelhead redds have been counted annually in Clear Creek from 2001 to 2010 and the total number of observed redds has steadily increased since Saeltzer Dam was removed in 2000 (Matt Brown, USFWS, personal Communication). The vast majority of steelhead in Clear Creek are likely of natural origin since hatchery fish are not stocked there and no hatchery origin fish were found during monitoring through at least 2008 (Matt Brown, USFWS, personal Communication).

In the American River an average of 154 redds were counted annually between 2002-2010 and the available data suggests a declining trend (Hannon and Deason 2008). The East Bay Municipal Utilities District (EBMUD) has included steelhead in their redd surveys on the lower Mokelumne River since the 1999-2000 spawning season. Based on data from these surveys, the overall trend suggests that redd number have slightly increased over the years. According to Satterthwaite *et al.* (2010), it is likely that most of the O. Mykiss spawning in the Mokelumne River are non-anadromous (or resident) fish rather than steelhead.

Steelhead returns to the Feather River Hatchery have decreased substantially in the last several years with only 679 in 2008, 312 in 2009 and 86 in 2010. Because almost all of the returning fish are of hatchery origin and stocking levels have remained fairly constant over the years, the data suggest that adverse freshewater and/ or ocean survival conditions have caused or at least contribute to these declining hatchery returns. The Central Valley experienced three consecutive years of drought (2007-2009) which would likely have impacted parr and smolt growth and survival and poor conditions are known to have occurred in at least 2005 and 2006 which impacted Chinook populations in the Central Valley and may welll have also impacted steelhead populations. Preliminary return data for 2011 from CDFG suggest a strong rebound in return numbers for 2011, with 712 adults returning to the hatchery through April 5. Based on steelhead returns to the hatcheries and the redd counts on Clear Creek, the American River, and the Mokelumne River, it appears that wild fish may not have been impacted by poor freshwater and marine rearing conditions as much as hatchery origin fish over the last several years. This may

reflect greater fitness of naturally produced steelhead relative to hatchery fish, and certainly merits further study.

The Chipps Island midwater trawl dataset from the USFWS provides information on the trend in the overal abundace of the CV steelhead DPS (Williams *et al.* 2011). Updated through 2010, the trawl data indicate that the apparent decline in natural production of steelhead has continued since the 2005 status review. Catch per-unit-effort has fluctuated over the past decade, but the proportion of the catch that is ad-clipped (100 percent of all hatchery produced steelhead have been adipose fin clipped since 1998) has steadily increased, exceeding 90 percent in recent years and reaching 95 percent in 2010 (Williams *et al.* 2011). Because hatchery releases have been fairly constant over the years, these data suggest that natural producation of steelhead has been declining.

Steelhead salvage data from the fish collection facilities at the Federal and State pumping plants in the southern Delta are another source of information on the relative to hatchery steelhead fluctuated dramatically since 1993, but there has been a marked decline in the number of salvaged hatchery orign. The percentage of salvaged fish that are wild has also fluctuated over the past decade, but also has declined in the past several years.

Until recently, CV 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, and Calaveras rivers, and other streams previously thought to be devoid 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 (Demko 2000, 2001). It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and merced rivers during fall-run Chinook salmon monitoring acutivities, indicating that steelhead are widespread throughout accessible streams and rivers in the CV (Good *et al.* 2005). CDFG staff has prepared juvenile migrant CV steelhead catch summaries on the san Joaquin river near Mossdale representing migrants from the Stanislaus, Tuolumne, and Merced rivers. Based on trawl recoveries at mossdale between 1988 and 2002, as well as rotary screw trap efforts in all three tributaries, CDFG staff stated that it is "clear from this data that rainbow trout do occur in all the tributaries as migrants and that the vast majority of them occur on the Stanisslaus River" (Letter from Dean Marston, CDFG, to Madelyn Martinez, NMFS, January 9, 2003). The documented returns on the order of single fish in these tributaries suggest that existing populations of CV steelhead on the Tuolumne, Merced, and lower San Joaquin rivers are severely depressed.

Williams *et al.* 2011 have concluded that the status of CV steelhead has worsened since the 2005 status review (Good *et al.* 2005), when the BRT concluded that the DPS was in danger of extinction. Based on this information, NMFS recommended maintaining the threatened status of this ESU while also recommending monitoring and reassessment within 2-3 years if a positive trend does not become evident (NMFS 2011f). On August 15, 2011, NMFS affirmed no change to the determination that the CV steelhead DPS is a threatened species, as previously listed (76

FR 50447).

3. Green Sturgeon

a. General Life History

The North American green sturgeon ranges from the Bering Sea, Alaska, to Ensenada, Mexico. Presently, spawning has been confirmed to occur in the Klamath and Rogue Rivers (Northern DPS) and the Sacramento and Feather Rivers[2] (Southern DPS). Adults spawn in large rivers during the spring and early summer and eggs are laid in turbulent areas on the river bottom and settle into the interstitial spaces between cobble and gravel (Adams *et al*. 2007). Like salmonids, green sturgeon require cool water temperatures for egg and larval development, with optimal temperatures ranging from 11 to 17˚C (Van Eenennaam *et al*. 2005). Eggs hatch after 6–8 days, and larval feeding begins 10–15 days post-hatch; metamorphosis of larvae into juveniles typically occurs after a minimum of 45 days (post-hatch) when fish have reached 60–80 mm total length (TL) (Beamesderfer *et al*. 2007). After rearing in freshwater or the estuary of their natal river for one to four years, young green sturgeon move into coastal waters (Nakamoto *et al*. 1995, Adams *et al*. 2002). Juvenile green sturgeon captured in the Klamath River estuary ranged from 320 to 660 mm TL (Nakamoto *et al.* 1995). Records of juvenile green sturgeon in San Francisco estuary are limited, but juveniles captured in the Delta are typically greater than 200 mm TL (Adams *et al.* 2002), suggesting Southern DPS green sturgeon also spend several months rearing in freshwater before entering the estuary. Laboratory studies, conducted by Allen and Cech, Jr. (2007), indicated juveniles approximately 6 months old (approximately 34 cm TL) were tolerant of saltwater, but approximately 1.5 year old (approximately 75 cm TL) green sturgeon appeared more capable of successful osmoregulation in salt water. Furthermore, green sturgeon observed from coastal marine waters in limited entry groundfish bottom trawl and California halibut commercial fisheries between 2007 and December 2010 (n=88) were greater than 60 cm fork length (or greater than approximately 65 cm TL) (WCGOP 2011, unpublished data). Green sturgeon are one of the most marine-oriented and widely distributed of the sturgeons; sexually immature fish that have entered coastal marine waters ("subadults ") spend several years at sea before reaching reproductive maturity and returning to freshwater to spawn for the first time (Nakamoto *et al*. 1995).

Green sturgeon do not mature until they are at least 15–17 years of age at a size of 1.4–2.2 m in length (Beamesderfer *et al*. 2007). The length at first maturity is estimated to be 152 cm TL (14-16 years) for males and 162 cm TL (16-20 years) for females in the Klamath River (Van Eenennaam *et al*. 2006), and 145 cm TL for males and 166 cm TL for females in the Rogue River (Erickson and Webb 2007). Adult green sturgeon are iteroparous and believed to spawn every 2-4 years (Moyle 2002, Erickson and Webb 2007). Although males are capable of spawning annually, female sturgeon typically require two years to complete vitellogenesis (process of yolk formation necessary prior to spawning). Green sturgeon fecundity (50,000–

[2] Spawning was recently confirmed in the Feather River downstream of Oroville Dam (Findings reported in annual report for 2011 4(d) project 16073: Lower Feather River Green Sturgeon Spawning Survey by A. Seesholtz, DWR)

115,000 eggs; Van Eenennaam *et al*. 2008) is reportedly lower than other sturgeons, but the egg size is larger.

Mature green sturgeon enter their natal river in the spring and, in the Northern DPS, typically leave the river during the subsequent autumn when water temperatures drop below 10°C and flows increase (Erickson and Webb 2007). Recent telemetry studies by Heublein *et al.* (2009) revealed adults typically enter the Bay and begin their upstream spawning migrations between late February and early May. Based on egg capture and upstream migration of tagged fish, peak spawning is estimated to occur in deep turbulent sections of the Sacramento River between April and mid-June (Poytress *et al*. 2011, Heublein *et al.* 2009). CDFG (2002) report Southern DPS green sturgeon spawning occurs above Hamilton City and possibly as far upstream as Keswick Dam on the Sacramento River. Incidental capture of green sturgeon post-larvae in salmon out-migrant traps indicates successful spawning can occur in the Sacramento River both upstream and downstream of Red Bluff Diversion Dam (Rkm 391) (Israel and Klimley 2008). More specifically, green sturgeon eggs have been captured in egg mats in the Sacramento River from below the confluence of Antelope Creek (Rkm 377) up to the confluence of Ink's Creek (Rkm 426) (Poytress *et al*. 2011). In the Southern DPS, tagged adult green sturgeon displayed two outmigration strategies; presumably after spawning, green sturgeon emigrated from Sacramento River during summer months, or remained in the river until the onset of winter flows (Heublein *et al.* 2009).

Subadult and adult green sturgeon move between coastal waters and various estuaries along the U.S. West Coast between San Francisco Bay, California, and Grays Harbor, Washington (Lindley *et al*. 2008, Lindley *et al*. 2011). Multiple rivers and estuaries are visited by dense aggregations of green sturgeon in summer months (Moser and Lindley 2007, Lindley *et al*. 2011). Notably, capture of green sturgeon in San Pablo Bay and detections of tagged green sturgeon indicated adult and subadult green sturgeon can be present in the Bay during all months of the year (Kelly *et al*. 2007, Heublein *et al.* 2009, Lindley *et al.* 2011). Relatively little is known about how green sturgeon use habitats in the coastal ocean and in estuaries, or the purpose of their episodic aggregations there at certain times (Lindley *et al*. 2008, Lindley *et al*. 2011). Genetic studies examining the stock composition of estuarine aggregations (Israel *et al*. 2009) indicate that almost all green sturgeon in the San Francisco Bay system belong to the Southern DPS. This is corroborated by tagging and tracking studies which found that no green sturgeon tagged in the Klamath or Rogue rivers (i.e., Northern DPS spawning rivers) were detected in San Francisco Bay (Lindley *et al*. 2011). However, green sturgeon in coastal waters adjacent to San Francisco Bay may include Northern DPS green sturgeon. Genetic analysis of tissue samples collected from observed green sturgeon bycatch in coastal waters adjacent to San Francisco Bay indicated that approximately 17 percent (i.e., 3 out of 18) of the green sturgeon encountered and sampled belonged to the Northern DPS and approximately 83 percent (i.e., 15 out of 18) belonged to the Southern DPS (Israel 2010).

Green sturgeon feed on benthic invertebrates and fish (Adams *et al.* 2002). Radtke (1966) analysed stomach contents of juvenile green sturgeon captured in the Delta and found the majority of their diet was benthic invertebrates such as mysid shrimp and amphipods (*Corophium spp*). Manual tracking of acoustically-tagged green sturgeon in the San Francisco

Bay estuary indicates they are generally demersal but make occasional forays to surface waters, perhaps to assist their migration (Kelly *et al*. 2007). Recent telemetry data in coastal ocean habitats suggest that green sturgeon spent a longer duration in areas with high seafloor complexity, especially where a greater proportion of the substrate consists of boulders (Huff *et al*. 2011). However, while presumably feeding on benthic invertebrates in estuaries green sturgeon do not appear to utilize hard substrates (Dumbauld *et al*. 2008). Preliminary data from mapping surveys conducted in Willapa Bay, Washington, showed densities of "feeding pits" (depressions in the substrate believed to be formed when green sturgeon feed) were highest over shallow intertidal mud flats, while harder substrates (e.g., gravel) had no pits (M. Moser, unpublished data). In their natal rivers, telemetry data indicates mature green sturgeon prefer deep pools, presumably for the purposes of spawning and conserving/restoring energy (Erickson and Webb 2007, Heublein *et al*. 2009). Similar tracking studies involving juvenile green sturgeon have not been conducted, and their behavior and habitat preferences in rivers and estuaries are largely unknown.

b. Population Trend- Southern DPS Green Sturgeon

To date, little population-level data have been collected for green sturgeon. In particular, there are no published abundance estimates for either Northern DPS or Southern DPS green sturgeon in any of the natal rivers based on survey data (Israel *et al*. in prep). As a result, efforts to estimate green sturgeon population size have had to rely on sub-optimal data with known potential biases, including monitoring designed for white sturgeon (*Acipenser transmontanus*) populations, harvest time series, or entrainment from water diversion and export facilities (Adams *et al*. 2007). Of these sources, only the water diversion data indicate a possible trend, suggesting Southern DPS green sturgeon abundance or recruitment has declined since 1986 in the Sacramento River (Adams *et al*. 2007).

More recent genetic techniques and monitoring surveys are beginning to clarify questions about green sturgeon population size. Genetic data collected from incidental captured larval green sturgeon in salmon out-migrant traps suggest that the number of adult green sturgeon in the upper Sacramento River (Southern DPS green sturgeon) remained roughly constant between 2002 and 2006 in river reaches above Red Bluff (Israel and May 2010). Recently developed surveys using dual-frequency identification sonar (DIDSON) have estimated 175 to 250 sturgeon (±50) in the mainstem Sacramento River during the spawning season in 2010 and 2011 (personal communication. with Ethan Mora, UC Davis, on January 10, 2012). However, this estimate includes considerable uncertainty; all sturgeon detections were assumed to be green sturgeon and a small number of white sturgeon were potentially misidentified as green sturgeon. Furthermore, spawning population estimates assumed individual fish did not move in and out of survey areas throughout the season (*i.e.* observations of multiple individuals moving in and out of an area could be recorded as one individual). Given these uncertainties, caution must be taken in using these estimates to infer the spawning run size for the Sacramento River, until further analyses are completed.

Recruitment data for Southern DPS green sturgeon are essentially nonexistent. Incidental catches of larval green sturgeon in the mainstem Sacramento River and of juvenile green

sturgeon at the state and Federal pumping facilities in the South Delta suggest that green sturgeon are successful at spawning, but that annual year class strength may be highly variable (Beamesderfer *et al*. 2007, Adams *et al*. 2007). Successful recruitment into the population is unclear. Because green sturgeon are long-lived and spawn multiple times throughout their lifetime, spawning failure in one year can be made up for in another spawning year. In general, sturgeon year class strength appears to be episodic with overall abundance dependent on a few successful spawning events (NMFS 2010b).

Recently, Erickson *et al*. (unpublished) estimated spawning run sizes for Northern DPS rivers ranging from 426 to 734 adult green sturgeon using mark-recapture methods (Israel *et al*. in prep). These estimates appear to be inconsistent with harvest data indicating that 200 to 450 Northern DPS green sturgeon were harvested each year in the Klamath River tribal fishery from 1985 to 2003, with no evidence of declining catches (Adams *et al*. 2007). The inconsistencies may be due to error in the population estimates and/or because the recent population estimates were based on data collected from a different time period compared to the tribal harvest data. Adams *et al*. (2007) concluded that the abundance of mature green sturgeon in the Southern DPS is much smaller than in the Northern DPS (Adams *et al*. 2007), but the absolute and relative abundance of the two DPS remain highly uncertain. Carefully designed studies remain needed to provide absolute estimates of abundance for the species.

Recently enacted fishing regulations and conservation measures have reduced current fishery impacts to green sturgeon throughout its range (http://www.nmfs.noaa.gov/pr/species/fish/greensturgeon.htm). For example, commercial and sport fisheries in California, Oregon, Washington (United States), and British Columbia (Canada) now ban retention of green sturgeon.

Green sturgeon face a variety of threats in the freshwater, estuarine, and marine environments within which they move throughout their life history. Threats to this species include: reduction/loss of spawning areas, insufficient freshwater flow rates in spawning areas, contaminants (e.g., pesticides), harvest bycatch, poaching, entrainment by water projects, influence of exotic species, small population size, impassable barriers, and elevated water temperatures (Adams *et al*. 2007). The most recent status review update concluded the southern DPS green sturgeon is likely to become endangered in the foreseeable (NMFS 2005); a principal factor in NMFS' conclusion was the reduction of potential spawning habitat to a single area in the Sacramento River due to migration barriers (e.g., dams). Historical spawning habitat may have extended up into the three major branches of the upper Sacramento River above the current location of Shasta Dam; however, those habitats have been made inaccessible or altered by dams (Mora *et al*. 2009, Adams *et al*. 2007). The reduction of spawning habitat to a single system increases the vulnerability of the spawning population to catastrophic events and of early life stages to variable environmental conditions within the system. Severe threats to the single remaining spawning population, coupled with the inability to alleviate those threats using current conservation measures, led to the decision to list the species as threatened on April 7, 2006 (71 FR 17757).

3. <u>Pacific Eulachon</u>

a. General Life History

Eulachon are a smelt native to eastern North Pacific waters from the Bering Sea to Monterey Bay, California (Hart and McHugh 1944, Eschmeyer *et al.* 1983a, Minckley *et al.* 1986, Hay and McCarter 2000). The southern DPS of Pacific eulachon extends from the Nass River of British Columbia to the Mad River of California. However, the southern extent of their distribution has receded northward over the past several decades.

Eulachon are semelparous and anadromous, spending most of their lives in marine environments before returning to freshwater to spawn once and die. Because larvae exit the freshwater system almost immediately, they likely retain homing only to the estuarine system that their natal streams drain (Hay and McCarter 2000, Beacham *et al.* 2005). Specific spawning rivers within the natal system are likely selected based upon environmental conditions at the time of return (Hay and Beacham 2005).

Adult eulachon have been observed in California's Humboldt Bay, Klamath, Mad, Russian, and Sacramento Rivers as well as Redwood Creek, the Umpqua and Rogue Rivers in Oregon, and Washington's Puget Sound, Hood Canal, Bear, Naselle, Nemah, Wynoochee, Quinault, Queets, and Nooksack Rivers (Odemar 1964, Moyle 1976, Minckley *et al.* 1986, Emmett *et al.* 1991, Jennings 1996, Wright 1999, Larson and Belchik 2000, Musick *et al.* 2000, WDFW and ODFW 2001). Spawning has been documented in the Elwha River and the Strait of Juan de Fuca, but sightings or spawning in these Oregon and Washington rivers is very limited or unknown (Wright 1999, Shaffer *et al.* 2007). For southern DPS eulachon, most spawning is believed to occur in the Columbia River and its tributaries (Grays, Skamokawa, Elochoman, Kalama, Lewis, and Sandy rivers), with less production from the Mad and Klamath Rivers, as well as sporadic production in the other Oregon and Washington rivers (Emmett *et al.* 1991, Musick *et al.* 2000, WDFW and ODFW 2001). Eulachon from southern rivers generally spawn at a younger age than eulachon from more northern rivers (Clarke *et al.* 2007, NMFS 2010c).

Spawn timing depends upon the river system involved (Willson *et al.* 2006). In the Columbia River and Further south, spawning occurs from late January to May, although river entry occurs as early as December (Hay and McCarter 2000). The peak of eulachon runs in Washington State is from February through March. Fraser River spawning is significantly later, in April and May (Hay and McCarter 2000).

The timing of eulachon entry into spawning rivers is likely tied to water temperature and tidal cycles (Ricker *et al.* 1954, Bishop *et al.* 1989, WDFW and ODFW 2001, Lewis *et al.* 2002, Spangler 2002). Spawning normally occurs when water temperature is between 39° and 50°F. Adults may migrate up to 100 miles upstream to reach spawning grounds (Hart and McHugh 1944). Males tend to arrive on spawning grounds earlier than females and tend to stay longer, making them more susceptible to commercial and recreational fisheries (Hart and McHugh 1944). However, males outnumber females by a roughly 2:1 margin. Eulachon sperm is viable for only minutes and a key factor of eulachon spawning may be male grouping en mass to broadcast their sperm, Once milt reaches downstream females, each female releases 7,000 to

31,000 eggs (in the Columbia River) at which time fertilization occurs (WDFW and ODFW 2001). Females lay eggs over sand, course gravel, or detrital substrate. This reproductive strategy requires high eulachon density to ensure fertilization. Eggs attach to gravel or sand and incubate for 30 to 40 days after which larvae drift to estuaries and coastal marine waters (Wydoski and Whitney 1979) and after three to five years, migrate back to natal basins to spawn.

Eulachon generally die following spawning (Scott and Crossman 1973, Clarke *et al.*2007). Maximum known lifespan is 9 years of age, but 20 to 30 percent of individuals live to 4 years and most individuals survive to 3 years of age, although spawning has been noted as early as 2 years of age (Wydoski and Whitney 1979, Barrett *et al.*1984, Hugg 1996, Hay and McCarter 2000, WDFW and ODFW 2001). However, the age distribution of spawners varies between river and from year-to-year (Willson *et al.*2006).

Adult eulachon are found in coastal and offshore marine habitats possibly to 2,000 feet deep, but more frequently between 50 and 600 feet deep (Allen and Smith 1988, Hay and McCarter 2000, Willson *et al.*2006). Following hatching in freshwater, larvae, and juveniles become thoroughly mixed in coastal waters generally less than 50 feet deep and move deeper as they grow (Barraclough 1964, Hay and McCarter 2000). Larval and post larval eulachon prey upon phytoplankton, copepods, copepods eggs, mysids, barnacle larvae, worm larvae, and other eulachon larvae until they reach adult size (WDFW and ODFW 2001). At this time, the primary prey of eulachon are copepods and euphausiids, including Thysanoessa spp., unidentified malacostracans, and cumaceans (NMFS 2010c, Smith and Saalfeld 1955, Barraclough 1964, Wydoski and Whitney 1979, Drake and Wilson 1991, Studevant *et al.*1999, Hay and McCarter 2000).

b. Population Trend- Southern DPS Pacific Eulachon

The southern DPS of eulachon was listed as threatened on March 18, 2010 (75 FR 13012). It is threatened by decreased abundance, natural predation, commercial and recreational fishing pressure (directed and bycatch), and loss of habitat. Population decline is anticipated to continue as a result of climate change and bycatch in commercial shrimp fisheries. However, as highly fecund fish, eulachon have the ability to rebound quickly if given the opportunity, a feature that is likely necessary to withstand significtant predation pressure and high mortality likely experienced by pelagic larvae (Bailey and Houde 1989).

Eulachon formerly experienced widespread, abundant runs and have been a staple of Native American diets for centuries along the northwest coast. However, such runs that were formerly present in several California rivers as late as the 1960s and 1970s (i.e., Klamath River, Mad River, and Redwood Creek) are thought to no longer occur (Larson and Belchik 2000, Moyle 2002). Eulachon have not been identified in the Mad River and Redwood Creek since the mid-1990s, although the sampling effort within these watershed have been low or non-existent (Moyle 2002).

C. Factors Responsible for Steelhead, Chinook Salmon, Coho Salmon, Eulachon Smelt, and Green Sturgeon Stock Declines: Changes to Habitat and Other Impacts

NMFS cites many reasons (primarily anthropogenic) for the decline of steelhead (Busby *et al*. 1996), Chinook salmon (Myers *et al.* 1998), coho salmon, eulachon smelt, and southern DPS of green sturgeon (Adams *et al.* 2002, NMFS 2005). The foremost reason for the decline in these anadromous populations is the degradation and/or destruction of freshwater and estuarine habitat. Additional factors contributing to the decline of these populations include: commercial and recreational harvest, artificial propagation, natural stochastic events, marine mammal predation, and reduced marine-derived nutrient transport.

The following section details the general factors affecting threatened anadromous salmon ESUs and steelhead, eulachon, and green sturgeon DPSs in California. The extent to which there are species specific differences in population limiting factors is not clear; however, the freshwater ecosystem characteristics necessary for the maintenance of self-sustaining populations of anadromous salmonids are similar. Therefore, most of these factors below affect salmon, steelhead, green sturgeon and eulachon.

1. Habitat Degradation and Destruction

The best scientific information presently available demonstrates a multitude of factors, past and present, have contributed to the decline of west coast salmonids and green sturgeon by reducing and degrading habitat by adversely affecting essential habitat features. Most of this habitat loss and degradation has resulted from anthropogenic watershed disturbances caused by urban development, agriculture, poor water quality, water resource development, dams, gravel mining, forestry (Busby et al. 1996, Adams et al. 2002, Good et al. 2005), and lagoon management (Smith 1990, Bond 2006).

a. Urban Development

Urbanization has degraded anadromous fish habitat through stream channelization, flood plain drainage, and riparian damage (reviewed in 61 FR 56138). When watersheds are urbanized, problems can result simply because structures are placed in the path of natural runoff processes, or because the urbanization itself has induced changes in the hydrologic regime. In almost every area where urbanization activity touches a watershed, point source and nonpoint pollution occur. Sources of nonpoint pollution, such as sediments washed from the urban areas, contain trace metals such as copper, cadmium, zinc, and lead (California State Lands Commission 1993). These, together with pesticides, herbicides, fertilizers, gasoline, and other petroleum products, contaminate drainage waters and harm aquatic life necessary for anadromous salmonid survival. Water infiltration is also reduced due to extensive ground covering. As a result, runoff from the watershed is flashier, with increased flood hazard (Leopold 1968). Flood control and land drainage schemes may concentrate runoff, resulting in increased bank erosion, loss of riparian vegetation, and eventuall widening and down-cutting of the stream channel.

California is projected to be the number one state in the United States in projected growth of human population in both percent change and numbers of individuals, with nearly 18 million new residents and a projected increase of more than 55 percent to nearly 50 million by 2025

(U.S. Census Bureau, www.census.gov). The fastest growing county within the action area is Placer County, growing 44 percent between 1990 and 2000 and making it the second fastest growing county in California. In the San Francisco Bay Area, there are now more than 7.5 million individuals living in the 12 Bay Area counties, making the region the fourth most populous metropolitan area in the United States. Today, nearly 30 percent of the land in the 9 counties surrounding San Francisco Bay is urbanized. These changes have reduced the acreage of valuable farm land, wetlands, and riparian areas, and have increased pollutant discharge and loadings to the tributaries and the bay.

b. Water Quality

Many waterways fail to meet the Federal Clean Water Act and Federal Safe Drinking Water Act water quality standards due to the presence of pesticides, heavy metals, dioxins, and other pollutants. These pollutants originate from both point- (industrial and municipal waste) and nonpoint (agriculture, forestry, urban activities, *etc.*) sources. The types and amounts of compounds found in runoff are often correlated with land use patterns: fertilizers and pesticides are found frequently in agricultural and urban settings, and nutrients are found in areas with human and animal waste. Topography, geology, and seasonal factors also influence pollution levels in various ways. Nutrient and pesticide concentrations vary considerably from season to season, as well as among regions with different geographic and hydrologic conditions. Natural features (such as geology and soils) and land-management practices (such as storm water drains, tile drainage, and irrigation) can influence the movement of chemicals over both land and water. Salmon require clean water and gravel for successful spawning, egg incubation, and fry emergence. Fine sediments clog the spaces between gravel and restrict the flow of oxygen-rich water to the incubating eggs. Pollutants, excess nutrients, low levels of dissolved oxygen, heavy metals, and changes in pH also decrease the water quality for salmon and steelhead.

c. Water Development

Water in California is diverted from natural waterbodies for urban, commercial, agricultural, and residential use. Water development has typically altered historical flow patterns in California, where rivers and streams naturally had high flood flows in the winter and spring and declining flows throughout summer and early fall. In addition to a number of large reservoirs, there are an unknown number of permanent and temporary water withdrawal facilities that divert water for similar purposes. Impacts from water withdrawals include altered seasonal hydrographs, localized dewatering of stream reaches, and depletion of flows necessary for migration, spawning, rearing, flushing of sediment from spawning gravels, gravel recruitment, and transport of large woody debris. Unprotected or poorly screened water diversions can also impact young salmonids. Young fry are easily drawn into water pumps or become stuck against the pump's screened intakes. Unscreened or inadequately screened diversions are common throughout central and northern California.

Water withdrawals (primarily for irrigation) have reduced summer flows in many streams and have thereby decreased the amount and quality of rearing habitat. Water quantity problems are a significant cause of habitat degradation and reduced fish production. Although some of the

water withdrawn from streams eventually returns as agricultural runoff or groundwater recharge, crops consume a large proportion of it. And the water that is returned as runoff is often contaminated with sediment, nutrients, and pesticides.

d. Dams

Dams have a wide variety of functions including hydropower production, residential, commercial and agricultural water supply, and flood and/or debris control. The development of dams in the rivers in central and northern California has dramatically affected anadromous salmonids utilizing these streams. Dams have eliminated spawning and rearing habitat and altered the natural hydrograph of most of the major river systems, decreasing spring and summer flows and increasing fall and winter flows. For example, the water supply dams of the Central Valley Project and State Water Project have permanently blocked or hindered salmonid access to nearly all historical spawning and rearing grounds. Depletion and storage of natural flows have altered natural hydrological cycles in many California rivers and streams. Alteration of streamflows has increased juvenile salmonid mortality for a variety of reasons: migration delay resulting from insufficient flows or habitat blockages; loss of usable habitat due to dewatering and blockage; stranding of fish resulting from rapid flow fluctuations; entrainment of juveniles into unscreened or poorly screened diversions; and increased juvenile mortality resulting from increased water temperatures (Berggren and Filardo 1993, Chapman and Bjornn 1969, 61 FR 56138).

Recent habitat evaluations conducted in the upper Sacramento, Feather, and the San Joaquin Rivers suggest that, as for anadromous salmonids, large amounts of potential green sturgeon spawning habitat were made inaccessible or altered by dams (NMFS 2005). Current green sturgeon spawning habitat is reduced to a limited area of the upper Sacramento River.

e. Gravel Mining

Gravel mining is a major cause of sediment deficit in watersheds. In-channel mining removes gravel by either skimming it from bars or excavating it directly from the channel. Over-harvesting of gravel can lead to river incision, bank erosion, habitat simplification, and tributary downcutting (SEC 1996).

Gravel mining has resulted in morphological changes to many river systems within central and northern California. Decreased sediment load has caused these rivers to increase in depth, resulting in extensive bank erosion (Florsheim and Goodwin 1993). Degradation or downcutting of the channel due to past mining in the middle reaches of some rivers has also lead to impacts on adjacent ground water tables.

Loss of spawning gravels has a direct impact on salmonids. Female salmon choose spawning sites where there is clean, loosely compacted gravel or cobble substrates with less than 20 percent fine silt or sand content, and an intergravel flow sufficient to aerate the eggs. The lack of suitable gravel often limits successful spawning in many streams.

Turbidity as a result of increased erosion and sedimentation caused by gravel mining, can also be a limiting factor for anadromous salmonid populations. Salmonids are particularly sensitive to turbidity (Bjornn and Reiser 1991); it may lead to failed spawning, reduced respiratory efficiency, interruption of migration, altered prey base, reduced visibility, and reduction in plant production. Reduced plant production may, in turn, lead to lower dissolved oxygen levels and diminished food and cover for fish and aquatic insects.

f. Agriculture

Agricultural practices have contributed to the degradation of salmonid habitat on the West Coast through irrigation diversions, overgrazing in riparian areas, and compaction of soils in upland areas from livestock (reviewed in 61 FR 56138). These practices have also altered the natural flow patterns of streams and rivers. Early agricultural practices have resulted in filled sloughs and side channels and removed riparian vegetation. River valleys have been leveled and water courses channelized, altering drainage and runoff patterns. Agricultural operations removed riparian vegetation, small in-channel islands, and gravel bars to increase arable acreage and achieve flood control.

Vegetation removal and channel destabilization have accelerated erosion. In response to increased erosion, bank stabilization measures began and continued as cultivated acreage increased. Stabilization measures increased channel straightening which expedited channel downcutting. In addition to changing river morphology, agricultural practices decrease water quality by releasing fertilizers and pesticides into streams and rivers (Florsheim and Goodwin 1993). Enrichment from manures is also a problem where barns and livestock are adjacent to watercourses. Maahs *et al.* (1984) reported that the largest diffuse source of water quality degradation comes from agriculture-derived contaminants such as sediment, nutrients, and pesticides.

Grazing activities have resulted in loss of native perennial grasses and riparian vegetation, soil loss, hillside trailing and gullying, and the incision of swales and meadows. Soils compacted by overgrazing on land with minimal vegetative cover have significantly reduced infiltration rates. Instead of the water moving into the soil, it moves rapidly over it, delivering heavy runoff to streams, which in turn can result in flashy watersheds (Kohler and Hubert 1993). This altered cycle is characterized by reduced groundwater storage capacity, and a greater propensity for intermittent stream flow during low-flow periods. The response within the stream corridor is one of bank erosion, channel scour, and loss of riparian and fish habitat.

The vigor, composition, and diversity of natural vegetation can be altered by livestock grazing in and around riparian areas. This, in turn, can affect the site's ability to control erosion, provide stability to stream banks, and provide shade, cover, and nutrients to the stream. Compaction can reduce the productivity of the soils appreciably and cause bank slough and erosion. Bank damage often leads to channel widening, lateral stream migration, and excess sedimentation (61 FR 56138).

g. Forestry

Forestry practices have limited production of anadromous salmonids and affected their habitat in many ways. Habitat degradation by forestry activities has mostly occurred in tributaries, which mostly affects spawning and early-rearing juvenile salmonids. Populations are limited in tributary and mainstem habitats by the loss of large woody debris, debris barriers, increased temperatures, massive siltation, loss of riparian cover diversity, road building and maintenance causing increased sedimentation of fines and the filling of pools. Bilby and Bisson (1998) (as reported in Standiford and Arcilla 2001) stated that large woody debris volume in northern California streams has generally decreased over the last century due to forestry practices. The loss of large woody debris affects fish in that there is less habitat complexity, less deposition of sediment, less deposition of fine organic matter that feeds stream invertebrates, and fewer pool forming elements.

The effects of introducing organic debris can be positive in that organic debris controls sediment transport and provides habitat for aquatic organisms (Swanson and Lienkaemper 1978, Keller and Swanson 1979, Bryant 1980); however, the introduction of excessive organic debris can impede fish movement and reduce dissolved oxygen levels (Hall and Lantz 1969). Logging activities can also lead to morphological changes in the channel due to increased sediment inputs (Reid 1994). These changes include the widening and an increase in braiding of some streams and the filling in of pools. When flows on these streams spread too widely, upstream migration of adults is hindered. The loss of pools decreases available habitat for salmonids and removes cool water refuges needed for summer survival in some streams.

Timber harvest related activities in the past have had more impact across forested ecosystems than current timber practices, especially those that employed ground-based equipment methods just after World War II. The majority of private and state timber land holdings within central and northern California have been harvested, leading to a decrease in habitat quality for salmonids. Past timber harvest, and to some extent ongoing timber harvest activities, along many streams have contributed to decreases in wild populations of anadromous salmonids over time.

2. Commercial and Recreational Harvest

Until recently, commercial and recreational harvest of southern DPS green sturgeon was allowed under State and Federal law. The majority of these fisheries have been closed (NMFS 2005). Ocean salmon fisheries off California are managed to meet the conservation objectives for certain stocks of salmon listed in the Pacific Coast Salmon Fishery Management Plan, including any stock that is listed as threatened or endangered under the ESA. Early records did not contain quantitative data by species until the early 1950's. In addition, the confounding effects of habitat deterioration, drought, and poor ocean conditions on salmonids make it difficult to assess the degree to which recreational and commercial harvest have contributed to the overall decline of 18 salmonids and green sturgeon in West Coast rivers.

3. Artificial Propagation

Releasing large numbers of hatchery fish can pose a threat to wild salmon and steelhead stocks through genetic impacts, competition for food and other resources, predation of hatchery fish on wild fish, and increased fishing pressure on wild stocks as a result of hatchery production (Waples 1991).

4. Natural Stochastic Events

Natural events such as droughts, landslides, floods, and other catastrophes have adversely affected salmonid and sturgeon populations throughout their evolutionary history. The effects of these events are exacerbated by anthropogenic changes to watersheds such as logging, roads, and water diversions. These anthropogenic changes have limited the ability of salmonid and sturgeon to rebound from natural stochastic events and depressed populations to critically low levels.

5. Marine Mammal Predation

The population of some marine mammal species, such as the Harbor seal (*Phoca vitulina*) and California sea lion (*Zalophus californianus*), have increased along the Pacific Coast (NMFS 1999). Although predation by these mammals is not believed to be a major factor in overall population decline, there may be substantial localized impacts on salmonids particularly during the migration season (Hanson 1993).

6. Reduced Marine-Derived Nutrient Transport

Marine-derived nutrients from adult salmon carcasses have been shown to be vital for the growth of juvenile salmonids and the surrounding terrestrial and riverine ecosystems (Bilby *et al*. 1996, Bilby *et al*. 1998, Gresh *et al*. 2000). Declining salmon and steelhead populations have resulted in decreased marine-derived nutrient transport to many watersheds. This has contributed to the further decline of ESA-listed salmonid populations (Gresh *et al*. 2000).

7. Ocean Conditions

Recent evidence suggests poor ocean conditions played a significant role in the low number of returning adult fall run Chinook salmon to the Sacramento River in 2007 and 2008 (Lindley *et al.* 2009). The decline in ocean conditions likely affected ocean survival of all west coast salmonid populations (Good *et al.* 2005, Spence *et al.* 2008).

D. Global Climate Change

Modeling of climate change impacts in California suggests average summer air temperatures are expected to increase (Lindley *et al*. 2007). Heat waves are expected to occur more often, and 19 heat wave temperatures are likely to be higher (Hayhoe *et al*. 2004). Total precipitation in California may decline; critically dry years may increase (Lindley *et al*. 2007, Schneider 2007). The Sierra Nevada snow pack is likely to decrease by as much as 70 to 90 percent by the end of this century under the highest emission scenarios modeled (Luers *et al*. 2006). Wildfires are expected to increase in frequency and magnitude, by as much as 55 percent under the medium emissions scenarios modeled (Luers *et al*. 2006). Vegetative cover may also change, with decreases in evergreen conifer forest and increases in grasslands and mixed evergreen forests. The likely change in amount of rainfall in Northern and Central Coastal streams under various warming scenarios is less certain, although as

noted above, total rainfall across the state is expected to decline. For the California North Coast, some models show large increases (75 to 200 percent) while other models show decreases of 15 to 30 percent (Hayhoe *et al*. 2004). Many of these changes are likely to further degrade salmonid habitat by, for example, reducing stream flows during the summer and raising summer water temperatures. Estuaries may also experience changes detrimental to green sturgeon. Estuarine productivity is likely to change based on changes in freshwater flows, nutrient cycling, and sediment amounts (Scavia *et al.* 2002). In marine environments, ecosystems and habitats important to sub adult and adult salmonids are likely to experience changes in temperatures, circulation and chemistry, and food supplies (Feely *et al.* 2004, Brewer 2008, Osgood 2008, Turley 2008). The projections described above are for the mid to late 21st Century. In shorter time frames natural climate conditions are more likely to predominate (Cox and Stephenson 2007, Smith *et al.* 2007).

IV. ENVIRONMENTAL BASELINE

The environmental baseline is an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat, and the ecosystem in the action area. The environmental baseline includes the past and present impacts of all Federal, State, or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone formal or early section 7 consultation, and the impact of State or private actions which are contemporaneous with the consultation in process (50 CFR §402.02).

A. Description of the Action Area

The action area includes all coastal anadromous California streams from Del Norte County at the Oregon/California border south to San Luis Obispo County and all streams draining into San Francisco and San Pablo bays, including the Sacramento-San Joaquin River Basin (Appendix A: Figures 2-8). The action area for the 2012-2016 Program encompasses a range of environmental conditions, has three threatened salmon ESUs, four threatened steelhead DPSs, one threatened green sturgeon DPS, and one threatened eulachon smelt DPS.

The climate in the action area generally falls into two types: coastal and valley climates. The action area in the central and northern California Coast has a Mediterranean climate characterized by cool wet winters with typically high runoff, and dry warm summers characterized by greatly reduced instream flows. Fog is a dominant climatic feature along the coast, generally occurring daily in the summer and frequently throughout the rest of the year. Higher elevations and inland areas tend to be relatively fog free. Most precipitation falls during the winter and early spring as rain, with occasional snow above 1,600 feet. This portion of the action area receives one of the highest annual amounts of rainfall in California, with a few areas averaging over 216 cm a year. Mean rainfall amounts range from 23 to 318 cm. Extreme rain events do occur, with over 610 cm being recorded over parts of the action area during 1982-83. Along the coast, average air temperatures range from 46 to 56 °F. Further inland and in the southern part of the action area, annual air temperatures are much more varied, ranging from below freezing in winter to over 100 °F during the summer months.

High seasonal rainfall on bedrock and other geologic units with relatively low permeability, erodible soils, and steep slopes contribute to the flashy nature (stream flows rise and fall quickly) of the watersheds within the action area in northern and central California coast. In addition, these high natural runoff rates have been increased by extensive road systems and other land uses. High seasonal rainfall combined with rapid runoff rates on unstable soils deliver large amounts of sediment to river systems. As a result, many river systems within this portion of the action area contain a relatively large sediment load, typically deposited throughtout the lower gradient reaches of these systems.

The climate of the action area in the Central Valley of California is largely shaped by the mountain ranges surrounding the great basin. Summers are dry with temperatures frequently over 100 °F and winters are wet with temperatures dropping to below freezing. Precipitation typically falls between October and April, with the Sacramento River basin receiving nearly three times more precipitation than the San Joaquin River basin. Together, the two large river basins drain over two-thirds of the Central Valley basin before entering into the Sacramento-San Joaquin Delta to the Pacific Ocean. Mean annual precipitation in the action area ranges from 12 cm to over 203 cm. Precipitation in the action area is influenced by the Sierra Nevada mountains, where approximately 50 percent of the precipitation falls as snow. The major rivers in the Central Valley have extensive spring runoff from snow melt. Average annual runoff in the Sacramento River Basin is 22.4 million acre feet and 6.4 million acre feet in the San Joaquin River Basin. Streams in the Central Valley flow over metamorphic and granitic rocks in the Sierra Nevada and over sedimentary rocks in the valley floor and Coast Range.

B. Status of the Species in the Action Area

The two main areas with the action area, the California coast and central valley, have been broken down further into a total of six geographic areas, four on the coast and two in the central valley. This section provides a synopsis of the six geographic areas of consideration (Appendix A: Figure 2), the ESUs, DPSs, and the 4th field hydrologic unit codes (HUC) (as defined by United States Geological Survey), present within each area, specific recent information on the status of salmon or steelhead, and a summary of the factors affecting the listed species within the action area. As discussed above, the best information presently available demonstrates that a multitude of factors, past and present, have contributed to the decline of west coast salmonids (Weitkamp *et al.* 1995, Busby *et al.* 1996, NMFS 1996, Myers *et al.* 1998, NMFS 1998, CDFG 2002, CRWQCB 2001, Good *et al.* 2005, Williams *et al.* 2011) and green sturgeon (NMFS 2005, 70 FR 17386). Following is a summary of the specific factors affecting the environment of the species within each HUC in each geographic area.

Information in this section is broken down into the following geographic areas: North Coast Area (Appendix A: Figure 3), North Central Coast Area (Appendix A: Figure 4), San Francisco Bay Area (Appendix A: Figure 5), Central Coast Area (Appendix A: Figure 6), Sacramento River Area (Appendix A: Figure 7), and San Joaquin River Area (Appendix A: Figure 8). Information for the Sacramento River Basin and the San Joaquin River Basin is organized by basin because watersheds in those regions share similar land use, human impacts, hydrology, ESUs, and DPSs.

Information for the North Coast Area is organized by river system as that area is dominated by rivers so large that multiple HUCs are found within each river system. The other coastal areas do not contain river systems that large. The discussion of information from the North Central Coast, San Francisco Bay, and Central Coast areas are organized by HUCs. A few HUCs in these areas contain one river system, but most contain several small systems.

1. North Coast Area

This area includes all coastal streams entering the Pacific Ocean from Oregon/California Border south to Bear Harbor in Mendocino County (Appendix A: Figure 3). The area includes the following USGS 4th field HUCs: Upper Klamath, Lower Klamath, Shasta, Scott, Smith, Salmon, Trinity, South Fork Trinity, Mad-Redwood, Lower Eel, South Fork Eel, Middle Fork Eel, and Upper Eel. Urban development within the North Coast Area is found primarily on the estuaries of the larger streams, though there are some small towns and rural residences throughout the area. Forestry is the dominant land-use throughout the area; there is some agriculture. The area includes the California portion of the SONCC coho salmon ESU and the northern portion of the NC steelhead DPS, and contains designated critical habitat for SONCC coho salmon (64 FR 24049).

a. Smith River

There is a paucity of information with regard to salmon and steelhead populations in the Smith River and trend information is very limited. CDFG (1965) estimated escapement of Chinook salmon for Smith River drainage at approximately 15,000 fish annually. The best information regarding coho salmon abundance and trends was collected during Chinook salmon spawning surveys on an index reach of the West Branch of Mill Creek by Jim Waldvogel, Sea Grant Advisor for Del Norte County (NMFS 2003b). The number of adult coho salmon trapped ranged between 2 (1981, 1990) and 28 (1985) fish annually, with a 23 year average of 11. No negative or positive trend is apparent from these data. Despite the lack of data, NMFS suspects anadromous salmonid populations within the Smith River drainage have likely experienced declines similar to other northern California/southern Oregon coastal watersheds. SONCC coho slamon are the only salmonid species that are listed within this watershed.

Habitat conditions in the Smith River basin have been degraded by high timber harvest rates, mostly from redwood harvest on private lands in the coastal sections. Timber harvest in riparian areas has reduced the recruitment potential for LWD for decades or centuries (USFS 1995). Early logging, prior to more recent forest practice rules, removed much of the streamside vegetation, particularly along larger, more accessible channels. In many cases, regeneration within these areas is now dominated by hardwoods. Hardwood dominance has the dual effect of not providing adequately-sized wood to adjacent channels while suppressing conifer regeneration. The lack of conifer-derived woody debris is likely to persist and perhaps worsen as existing instream wood decays or is transported downstream and the adjacent stands are not capable of providing adequate replacements.

A legacy of mining roads and open pits and shafts that operated in the 1850s-1950s are still very evident in the landscapes of the North Fork Smith subbasin and in the Hardscrabble, Myrtle,

Patrick, and Shelly watersheds. Many of these mining features are potential chronic sources of sediment since revegetation, and restoration is difficult due to the inherent harsh soil conditions of these areas. Hydraulic mining activity was intensive in low gradient reaches of several tributaries, significantly altering stream channel characteristics and impacting fish habitat. Currently, the lower river is being mined for aggregate material and is the primary aggregate source in the Del Norte county. Removal of gravel has likely altered spawning habitat in some areas.

A widespread and aging road network continues to present a sediment hazard to channels in the Smith River basin. Additionally, hillslope landslides from timber harvest and other activities in the watershed (*e.g.*, mining) provide additional sediment. While some information suggests that the upper portions of the Smith River may be able to transport much of the sediment, lower reaches may be vulnerable to the accumulation of this sediment. The Smith River basin is not currently listed as water quality impaired under section 303(d) of the Clean Water Act.

b. Klamath and Trinity Rivers

The Klamath River once supported diverse, abundant anadromous fish runs thought to number in the millions. Now, all of the anadromous fish species inhabiting the Klamath River are in a state of serious decline (Higgins *et al.* 1992), especially those species or stocks which depend on summer freshwater aquatic habitat, such as coho salmon, steelhead, or spring Chinook salmon. However, SONCC coho slamon are the only salmonid species listed in this watershed.

In the Klamath River, poor water quality conditions during the summer season have been recognized as a major contributing factor to the decline of anadromous fish runs (Bartholow 1995). The main causative factor behind the poor water quality conditions in the mainstem Klamath River is the large scale water impoundment and diversion projects above Iron Gate Dam (Klamath) and Lewiston Dam (Trinity). Average annual runoff below Iron Gate Dam has declined by more than 370,000 acre-feet since inception of the Bureau of Reclamation's Klamath Project (National Research Council 2003), while up to 90 percent of the Trinity River flow has been annually diverted into the Sacramento River (Bureau of Land Management 1995). The large volume of water diverted from each of these basins significantly affects downstream flow levels and aquatic habitat. After analyzing both pre- and post-Klamath Project hydrologic records, Hecht and Kamman (1996) concluded that variability and timing of mean, minimum, and maximum flows changed significantly after construction of the project. Project operations tend to increase flows in October and November, and decrease flows in the late spring and summer as measured throughout the Klamath mainstem. Low summer flow volumes within the Klamath River can increase daily maximum water temperatures during critical summer months by slowing flow transit rates and increasing thermal loading when compared to higher flow levels (Deas and Orlob 1999). Moreover, further heating the already-warm, nutrient-rich water released from Iron Gate Dam typically results in poor water quality conditions (*i.e.*, low dissolved oxygen, increased algal blooms, *etc.*) in the Klamath River between the dam and Seiad Valley.

Lower summer flows emanating from the Klamath Project (*i.e.*, released at Iron Gate Dam) are exacerbated by diminished inflow from many of the major tributaries to the middle Klamath River. The Shasta and Scott rivers historically supported strong populations of Chinook salmon, coho salmon, and summer-run steelhead (KRBFTF 1991). However, seasonal withdrawals for agriculture in the spring and summer months can drop stream flows by more than 100 cubic feet per second (cfs) over a 24 hour period, potentially stranding large numbers of rearing juvenile salmon and steelhead. Federal, State and local agencies are currently working with landowners in the Scott and Shasta drainages to implement minimum instream flow levels sufficient to conserve salmon and steelhead habitat.

The Klamath and Trinity rivers both contain numerous instream barriers which preclude salmon and steelhead migration into much of their historic range. Iron Gate Dam and Lewiston Dam block migratory access to the headwaters of the Klamath and Trinity rivers, respectively, while numerous smaller dams, diversions, and road crossings either block or impede adult and juvenile migration within many smaller tributaries.

Much of the middle reach of the Klamath River basin (*i.e.*, between the confluence of the Trinity River and Iron Gate Dam) and Trinity River basin is under Federal ownership and not managed for intensive timber harvest. However, the lower Klamath basin below the Trinity confluence is largely under private ownership and categorized as industrial timberland. In general, surveys in this area indicate low amounts of LWD, and the existing size of LWD tends to be small, primarily 1-2 foot diameter pieces. Further, due to past logging practices and development along streams, many riparian zones tend to be dominated by alder, willow, and younger conifers (Simpson 2002). Given the current vegetation age structure and past logging history along streams, recruitment of adequately sized woody debris to many of the stream reaches is not likely to occur for several decades. Furthermore, hillslope erosion resulting from timber harvest and road building dominates many of the tributary subbasins of the lower Klamath. For example, harvesting over a 50-year period in Hunter Creek was estimated to be responsible for 51 percent of the observed shallow landsliding volume not attributed to road-related activities (Simpson 2002). Both the Klamath River (nutrients, organic enrichment/low dissolved oxygen, and temperature) and Trinity River (sedimentation/siltation) have been listed under section 303(d) of the Clean Water Act as water quality limited (CSWRCB 2003).

c. Mad River and Redwood Creek

The Mad River and Redwood Creek watersheds have endured a long legacy of watershed disturbance. Streamside vegetation removal, channel modifications, and instream gravel extraction dating back several decades, combined with intensive upslope activities such as timber harvest and road construction, have had a significant influence on the condition of both watersheds.

Habitat surveys within the Mad River watershed detail the low amount and small size of existing LWD (primarily 1-2 foot diameter pieces). Further, due to past logging practices and development along streams, many riparian zones tend to be dominated by alder, willow, and younger conifers (Simpson 2002). Given the current vegetation age structure and past logging

history along streams, recruitment of adequately-sized woody debris to many Mad River tributaries is not likely to occur for several decades.

Furthermore, both the Mad River and Redwood Creek watersheds are section 303(d) listed for turbidity and sedimentation due to silviculture, resource extraction, and nonpoint sources (CSWRCB 2003). A principal contributor of fine sediment is hydrologically connected road segments. Simpson (2002) estimated that the average extent of hydrologically connected roads in the lower Mad River and associated tributaries is 30 percent. For Simpson[3] roads within this area, this value equates to approximately 130 miles of roads that are hydrologically connected and capable of delivering road-generated sediment to the stream network. Further exacerbating the problem, severe mass wasting occurs throughout much of the watershed and is also a principal determinant of aquatic habitat condition. Deep-seated landslides also contribute large amounts of sediment to the mainstem Mad River and tributaries.

The Redwood Creek watershed, although naturally prone to extensive storm-induced erosional events, has also experienced accelerated erosion due to land management activities (RNSP 2002). Increased mass wasting and fluvial erosion have overwhelmed the stream channel's ability to efficiently move the delivered sediment, filling deep pools and depositing silt in spawning gravels used by salmonids. The Environmental Protection Agency (EPA) estimates that on average, approximately 4,750 tons of sediment per square mile are produced from the Redwood Creek watershed (EPA 1998). The EPA also estimated that 60 percent of this sediment is controllable (*i.e.*, discharges and depositions resulting from human activities that can influence water quality and can be reasonably controlled) and must be eliminated to meet instream targets. Much observed erosion is associated with an extensive road network (7.3 miles per miles squared) on private lands, improperly designed and maintained roads and skid trails, and timber harvesting. Accelerated erosion from land use practices and other causes are impacting the migration, spawning, reproduction, and early development of cold water anadromous fish such as SONCC coho salmon, CC Chinook salmon, NC steelhead, and Southern DPS eulachon smelt.

d. Eel River

Fishery data indicate depressed or declining abundance trends, yet observational data indicate natural populations still persist in the Eel River, albeit at low levels. Historic land and water management, specifically large-scale timber extraction and water diversion projects, contributed to a loss of habitat diversity within the mainstem Eel River and many of its tributaries. The Eel River has been listed under section 303(d) of the Clean Water Act as water quality limited due to sediment and water temperature problems (CSWRCB 2003). Bear, Jordan, and Stitz creeks, tributaries of the lower Eel River, have also been listed by the California Department of Forestry as cumulatively affected for sediment problems. Essential habitat feature limitations include high water temperatures, low instream cover levels, high sediment levels, and low LWD abundance.

[3] Simpson property is now owned and managed by Green Diamond.

Water diversion within the Eel River basin has occurred since the early 1900s at the Potter Valley facilities. Roughly 160,000 acre feet (219 cfs average) are diverted at Cape Horn Dam, through a screened diversion, to the Russian River basin annually. Flow releases from the Potter Valley facilities have both reduced the quantity of water in the mainstem Eel River, particularly during summer and fall low-flow periods, as well as dampened the within-year and between-year flow variability that is representative of unimpaired watersheds. These conditions have restricted juvenile salmonid rearing habitat, impeded migration of adult fish and late emigrating smolts, and provided ideal low-flow, warm water conditions for predatory Sacramento pikeminnow (*Ptychocheilus grandis*) (NMFS 2002).

Intensive timber extraction within the lower Eel and Van Duzen watersheds has caused chronic erosion in certain areas due to the highly erodible soils common throughout the two watersheds. An extensive study of sediment discharge within the Eel River watershed (Brown and Ritter 1971) determined that the suspended sediment discharge increases downstream, unlike most rivers. The average annual suspended sediment load is 10,000 tons per square mile (Brown and Ritter 1971), which is one of the highest sediment yields in the world. As discussed previously, high levels of suspended sediment can impact salmonid populations by degrading essential freshwater habitat as well as harming individual fish health and modifying behavior.

The South Fork Eel River provides suitable habitat for CC Chinook salmon, SONCC coho salmon and NC steelhead. Existing conditions indicate that the South Fork Eel River has limited rearing habitat due to elevated water temperatures. Cool water seeps, thermal stratification, and habitat complexity all play critical roles in sustaining micro-habitat for juvenile and adult salmonids. Spawning habitat is present and actively used, as indicated by redd observations in the Cooks Valley area. Fishery data indicate that individual natural populations of anadromous salmonids persist at low levels in the South Fork Eel River.

The Van Duzen River watershed reflects a long legacy of upstream and upslope impacts coupled with the effects of continued instream disturbances. Much of the available salmonid habitat within the Van Duzen watershed is currently degraded by high levels of sediment, low pool density, high water temperatures, and low instream cover levels. The Van Duzen River has been listed under section 303(d) of the Clean Water Act as water quality limited due to sediment problems (CSWRCB 2003).

The importance of the mainstem Van Duzen for spawning is likely to increase because of recent landslides that occurred in Grizzly Creek, an important spawning tributary located upstream of the extraction reach. The large landslides will likely adversely affect spawning and rearing conditions in Grizzly Creek for a number of years into the future.

e. Mattole River

Although several factors have contributed to the decline of anadromous salmonid populations in the Mattole River drainage, habitat loss and modification are major determinants of their current status (FEMAT 1993). Large-scale changes to the Mattole River occurred in response to the 1955 and 1964 floods, which coincided with peak years of logging and road building in the

basin. The Mattole watershed has the second highest erosion rate in northern California, second only to the Eel River (Griggs and Hein 1980), and is, thus highly sensitive to human induced disturbances within upper reaches of the watershed.

Logging practices in the Mattole River watershed were identified as the "specific critical habitat problem" in a status review by Myers *et al.* (1998). There were an estimated 3,310 miles of active and abandoned roads in the Mattole River watershed (Perala *et al.* 1993), and the combined effects of these roads may be the single largest source of fine sediment delivered to the Mattole River. Estuary habitat, a crucial link in the lifecycle of Pacific salmonids, has been reduced by excessive sedimentation, which has also resulted in higher water temperatures and adverse impacts to food resources. Likewise, elevated summer water temperatures within the mainstem as well as many tributaries, are also a primary limiting factor for salmonids rearing in the Mattole River. The Mattole River has been listed under section 303(d) of the Clean Water Act as water quality limited due to temperature, turbidity, and sedimentation (CSWRCB 2003).

2. North Central Coast Area

The North Central Coast area includes all coastal California streams entering the Pacific Ocean in Mendocino, Sonoma, and Marin counties, excluding streams draining into San Francisco and San Pablo bays (Appendix A: Figure 4). The North Central Coast Area includes portions two steelhead DPSs (NC steelhead DPS and CCC steelhead DPS) and five USGS 4th field HUCs (Big-Navarro-Garcia, Bodega Bay, Gualala-Salmon, Russian, and Tomales-Drakes Bay). Forestry is the dominant land-use throughout the northern part of this area (north of the Russian River). Agriculture and urbanization are more predominant in the Russian River and areas south.

a. Big, Navarro, and Garcia River

This HUC includes all coastal watersheds from Jackass Creek south to, but not including, the Gualala River. This HUC is wholly within Mendocino County and includes most of the coastal streams of the county. There are several medium-sized watersheds present within the HUC: Garcia River, Navarro River, Albion River, Big River, Noyo River, and Ten Mile River. The HUC also includes many smaller watersheds that drain directly to the Pacific Ocean. The urban development within the HUC is limited primarily to coastal towns on the estuaries of the larger streams, though there are some small towns in other areas of the HUC. In the larger basins within this HUC, private forest lands average about 75 percent of the total acreage (65 FR 36074). Forestry is the dominant land use activity and in some subwatersheds significant portions, up to 100 percent, have been harvested (CRWQCB 2001). Excessive sedimentation, low LWD abundance and recruitment, and elevated water temperature are issues throughout the HUC; these issues are likely attributable to forestry activities. Agriculture has likely contributed to depressed conditions within the Navarro River watershed, and gravel mining may affect salmonids in the Ten Mile and Garcia River watersheds. The effects of land use activities are exacerbated by natural erosive geology, poorly consolidated sediments, the mountainous and rugged terrain, and large recent storms (1964, 1982). Estuaries throughout the HUC have likely decreased in size due to sedimentation. All of the larger watersheds within this HUC are

included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003).

This HUC is within the NC steelhead DPS. Salmonid abundance has declined throughout the HUC. Steelhead are widespread yet reduced in abundance, and coho salmon have a patchy distribution with populations significantly reduced from historic levels (Weitkamp *et al.* 1995, Busby *et al.* 1996, CRWQCB 2001). Increased sedimentation and low LWD recruitment have affected spawning gravels and pool formation throughout the HUC, and are likely limiting production of salmonids (CRWQCB 2001).

b. Gualala-Salmon River

This HUC includes the entire Gualala River watershed and all coastal watersheds between the Gualala River watershed and the Russian River watershed. The Gualala River is the only large watershed within the HUC, though there are several small coastal watersheds. There is limited urban development within the HUC. Within the Gualala River watershed, private forest lands make up about 94 percent of the total acreage, and forestry is the dominant land use of the watershed (65 FR 36074). Agriculture has been a significant land use within the Gualala River watershed; historically orchards and grazing were the dominant agricultural activities, though more recently vineyard development has become more common within the basin (CRWQCB 2001). Gravel mining is a historic activity. Gravel extraction is currently limited to 40,000 tons per year, though extractions in the past 10 years have not reached that limit (CRWQCB 2001). The Gualala River is included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). The pollution factors for the Gualala River are sedimentation and temperature; forestry, agriculture, and land development are listed as the potential sources for those factors. Recently, a TMDL for sedimentation was approved for the Gualala River (www.epa.gov).

This HUC contains NC steelhead. Steelhead, while widespread throughout the Gualala River, are at low abundance (CRWQCB 2001).

c. Russian River

The Russian River Watershed occupies a drainage area of 1,485 square miles that extends from just north of the town of Ukiah in central Mendocino County, south to the town Jenner on the Sonoma County coast. The Russian River Watershed is 4th field HUC #18010110, as defined by United States Geological Survey. The watershed has a Mediterranean climate characterized by cool wet winters and dry warm summers. Precipitation ranges from 27.5 to 85 inches per year depending on location in the watershed (CDF 1990, NMFS 2009). Most precipitation occurs between the months of October and April and includes periods of snow at the higher elevations. Along the coastal areas, fog is a dominant climatic feature throughout much of the year. The watershed supports a wide range of habitats including montane hardwood forest (38 percent), grassland (18 percent), mixed conifer forests (12 percent), and shrub lands (9 percent) (NMFS 2009). Agricultural land occupies approximately 13 percent of the watershed area while urban development covers approximately 9 percent, including the towns and cities of Ukiah, Hopland,

Cloverdale, Healdsburg, Santa Rosa, and Guerneville.

Primary tributaries to the mainstem Russian River include the West Fork Russian River, Big Sulphur, Maacama, Dry, Mark West, Green Valley, and Austin creeks. The watershed has two major dams and water supply reservoirs: Coyote Valley Dam and Lake Mendocino (122,500 acre-feet) on the East Fork Russian River near Ukiah, and Warm Springs Dam and Lake Sonoma (212,000 acre-feet) on Dry Creek northwest of Healdsburg. Both dams represent the end of anadromy in their respective watersheds. In addition to capturing local runoff, Lake Mendocino also receives water from the Eel River Watershed via transfer through the Potter Valley Hydroelectric Project. Stream flow is released from both dams to provide water for municipal and industrial supplies in Mendocino, Sonoma, and Marin counties. Both dams also provide flood protection for downstream property and generate hydroelectric power. There are also four seasonal dams on the lower Russian River mainstem, Healdsburg Dam located just upstream of the Dry Creek confluence in Healdsburg (seasonal summer flash-board dam), Mirabel Dam (seasonally inflatable dam, also known as Wohler Dam) located farther downstream near Hacienda, Johnson's Beach (seasonal summer flash-board dam) located in the town of Guerneville, and Vacation Beach (seasonal summer flash-board dam) located downstream of the town of Guerneville. The seasonal summer dams have fish ladders and are installed and removed prior to the bulk of the adult Chinook salmon run. Mirabel Dam is equipped with fish passage facilities, and includes a video monitoring station to document fish passing the dam.

Land uses in the watershed include agriculture, timber harvest, grazing/ranching, instream and quarry mining, and both urban and rural residential developments. Historic land uses were predominantly logging, mining, grazing, and agriculture which, in addition to stream flow management, have all contributed to the decline in the quality of migration, spawning, and rearing habitat throughout the Russian River Watershed. Many of these activities have undergone section 7 consultation when a Federal Action Agency has been involved. For example, NMFS has conducted section 7 consultations on gravel mining, bank protection activities, bridge and culvert retrofits in the Russian River watershed. Except for the Russian River BO (described below), these consultations have not resulted in jeopardy or adverse modification determinations. Impacts to listed salmonids and critical habitats in the Russian River watershed from these activities (sometimes after they are modified during consultation to reduce effects) are typically minor.

The Russian River, including its tributaries, was once known as one of the premier trout and salmon fishing streams along the coast of California. However, as early as the 1880's salmonid populations began to decline substantially due to human impacts (SEC 1996). The Russian River Watershed now supports both natural and supplemented populations of CCC coho salmon and CCC steelhead, as well as a self-sustaining population of CC Chinook salmon.

d. Bodega Bay

This HUC contains all of the coastal watersheds from the Estero de San Antonio north to the mouth of the Russian River. There are three moderate-sized watersheds within the HUC (Salmon Creek, Americano Creek, and Stemple Creek) and few small coastal watersheds directly

tributary to the Pacific Ocean. The Salmon Creek watershed is wholly within Sonoma County, whereas the Americano Creek and Stemple Creek watersheds are in both Sonoma and Marin counties. There is limited urban development within the HUC; agriculture is the dominant land use within all of the watersheds within this HUC, with dairy farming being the chief activity. There are some forest lands in the headwaters of Salmon Creek. A large winter storm in 1982 exacerbated the impact of land use activities and natural erosive geology of Salmon Creek (Brown and Moyle 1991). Americano Creek and Stemple Creek and their estuaries are included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). The pollution factors for these streams are sedimentation, nutrients, and temperature; Diazinon is listed as a pollutant in Estero de San Antonio. Agriculture and land development are listed as the potential sources for those factors. There are no approved TMDLs in this HUC (www.epa.gov). Many of the streams lack riparian cover, causing increased water temperatures.

This HUC is within the CCC steelhead DPSs. The distribution and abundance of stellhead within the HUC are highly reduced. The watersheds of this HUC historically contained steelhead. Steelhead are found throughout Salmon Creek, but the status of steelhead distribution in tributary streams is unknown. Steelhead are likely extirpated from San Antonio Creek and Americano Creek (Bill Cox, CDFG, personal communication, 2004).

e. Tomales-Drakes Bay

This HUC includes all watersheds draining into the Pacific Ocean from Rodeo Cove north to Tomales Bay. The entire HUC is in Marin County, with the exception of a small portion of the headwaters of Walker Creek, which is in Sonoma County. This HUC is within the CCC steelhead DPS. Most of the watersheds in this HUC are small with the exception of Walker Creek and Lagunitas Creek, both tributaries of Tomales Bay, a prominent artifact of the San Andreas Rift Zone. Urban development within the HUC ranges from single homes to small towns and municipal complexes. Although urbanization has been limited, flood control activities, contaminated runoff from paved lots and roads, and seepage from improperly designed and/or maintained septic systems, continue to impact habitat and water quality in portions of the watershed (Brannon Ketcham, National Park Service, personal communication, 2003). Recreation is a significant factor in land use within the HUC as there are county, state, and Federal parks within the HUC. Agriculture is a dominant land-use, particularly in the northern half of the HUC, and forestry was a historic land use activity within the HUC. Lagunitas Creek, Walker Creek, and Tomales Bay are included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003); nutrients, pathogens, and sedimentation are the factors and are attributed to agriculture and urban runoff or storm sewers. Mercury, associated with mining, is an additional factor for Walker Creek and Tomales Bay. No TMDLs have been developed for waterbodies within the HUC (www.epa.gov). The construction of Kent Reservoir and Nicasio Reservoir cut off 50 percent of the historical salmonid habitat within the Lagunitas Creek watershed, and construction of two large reservoirs within the Walker Creek watershed, Laguna Lake and Soulejoule Reservoir, cut off access to significant amounts of habitat (Weitkamp *et al.* 1995, Busby *et al.* 1996, Myers *et al.* 1998, CDFG 2002).

Anecdotal evidence of a once thriving coho salmon and steelhead run in Walker Creek exists. Sedimentation has had a devastating effect on fish habitat in Walker Creek. Many of the deep, cool pools and gravel that salmonids depend on for spawning and rearing, have been filled in with fine sediment.

Elevated stream temperatures are also a concern within many watershed throughout the HUC. Summer water temperatures are usually below lethal thresholds for salmonids, but can be high enough to retard growth. It was reported that juvenile salmonids in Lagunitas Creek did not show appreciable growth during the summer of 1984, and it is believed that this lack of growth was due to the relatively high summer water temperatures that occurred during this time (Bratovich and Kelly 1988). More recently, the National Park Service has documented water temperatures well over the preferred range for salmonids in Olema Creek and one of its tributaries (Brannon Ketcham, National Park Service, personal communication, 2003).

3. <u>San Francisco Bay Area</u>

The San Francisco Bay Area encompasses the region between the Golden Gate Bridge and the confluence of the San Joaquin and Sacramento rivers (Appendix A: Figure 5). All of the watersheds in this area drain into either San Francisco Bay, San Pablo Bay, or Suisun Bay at Chipps Island. This area contains four 4th Field HUCs: San Pablo Bay, Suisun Bay, San Francisco Bay, and Coyote. Anthropogenic factors affecting listed salmonids in these HUCs are related primarily to urbanization, though agriculture is another prevalent land use in the San Pablo Bay and Suisun HUCs. Urban development is extensive within this area and had dramatically affected the quality and quantity of salmonid habitat. Human population within the San Francisco Bay Area is approximately six million, representing the fourth most populous metropolitan area in the United States, and continued growth is expected (www.census.gov). In the past 150 years, the diking and filling of tidal marshes has decreased the surface area of area of the greater San Francisco Bay by 37 percent. More than 500,000 acres of the estuary's historic tidal wetlands have been converted for farm, salt pond, and urban uses (San Francisco Estuary Project 1992). These changes have diminished tidal marsh habitat, increased pollutant loadings to the estuary, and degraded shoreline habitat due to the installation of docks, shipping wharves, marinas, and miles of rock riprap for erosion protection. Most tributary streams have lost habitat through channelization, riparian vegetation removal, water development, and reduced water quality. Dams blocking anadromy are present on many streams and are used for water supply, aquifer recharge, or recreational activities. Streams have been affected by surface water diversion and groundwater withdrawal. Channelization for flood control, roadway construction, and commercial/residential development have further affected the quality and quantity of available salmonid habitat. Most watersheds within this area are listed under the 2002 Clean Water Act section 303(d) list of impaired water bodies for high levels of Diazinon, reflecting the impacts of urbanization. Agricultural and industrial chemicals and by-products are other factors limiting water quality throughout the area (CSWRCB 2003). There are no approved TMDLs for this HUC (www.epa.gov). These human induced changes have substantially degraded natural productivity, biodiversity, and ecological integrity in streams throughout the area.

The area provides a critical link in the migratory pathway between the ocean and freshwater habitat in the Central Valley for three listed salmonids: SRWR Chinook salmon ESU, CVSR Chinook salmon ESU, and Central Valley steelhead DPS. CCC steelhead occur in tributary streams around the bay area. CCC steelhead also utilize the bays for migration and possibly rearing.

a. San Pablo Bay Tributaries

This HUC contains all of the watersheds draining into San Pablo Bay located east of the Golden Gate Bridge, north of the San Francisco-Oakland Bay Bridge, and west of the Carquinez Bridge. This HUC contains several small to medium sized watersheds within portions of six counties: Marin, Sonoma, Napa, Solano, Contra Costa, and San Francisco. Agriculture has been a significant land use within the San Pablo Bay HUC; historically orcharding, dairy, and grazing were the dominant agricultural activities, though more recently vineyard development has become common within the HUC. Agricultural practices have resulted in numerous small dams and water diversions that alter streamflows and water temperature conditions. Also, agricultural practices have likely altered sedimentation rates of streams. Urbanization is the dominant land use throughout this HUC and has affected habitat through flood control activities, urban runoff, and water development. The following streams are included on the 2002 Clean Water Act section 303(d) list of impaired water bodies for high levels of Diazinon, which can likely be attributed to urban runoff: Arroyo Corte Madera del Presidio, Corte Madera Creek, Coyote Creek, Napa River, Novato Creek, Petaluma River, Pinole Creek, Rodeo Creek, San Antonio Creek, San Pablo Creek, Sonoma Creek, and Wildcat Creek (CSWRCB 2003). In addition, Napa River, Petaluma River, Sonoma Creek are included on the section 303(d) list for: nutrients, pathogens, and sedimentation related to agriculture, land development, and urban runoff. The lower Petaluma River has exceeded the California Toxic Rule and National Toxic Rule criteria for nickel; potential sources of nickel are municipal point source, urban runoff, and atmospheric deposition.

Presently, steelhead occur in Arroyo Corte Madera del Presido, Corte Madera Creek, Napa River, Sonoma Creek, Petaluma River, Novato Creek, and Pinole Creek. Environmental conditions in the upper portions of Arroyo Corte Madera del Presido, Corte Madera Creek, and Pinole Creek watersheds are protected in parks or open space preserves.

b. Suisun Bay Tributaries

This HUC includes all of the watersheds draining into Suisun Bay located east of the Carquinez Bridge and west of the confluence of the San Joaquin and Sacramento rivers. This HUC contains several small to medium sized watersheds within Solano and Contra Costa counties. Urbanization, farming, cattle grazing, and vineyard development have all contributed to habitat degradation in streams in the northern portion of the HUC. Urbanization and industrial development have contributed to habitat degradation in the southern portion of the HUC. Laurel Creek, Ledgewood Creek, Mt. Diablo Creek, Pine Creek, and Walnut Creek are included on the 2002 Clean Water Act section 303(d) list of impaired water bodies for high levels of Diazinon attributable to urban runoff (CSWRCB 2003).

Suisun Creek, Green Valley Creek, and an unnamed tributary to Cordelia Slough currently support small populations of CCC steelhead; these streams are all in Solano County. Streams flowing north from eastern Contra Costa County into south Suisun Bay are generally characterized by very dry summer conditions, and these streams do not currently support steelhead.

c. San Francisco Bay Tributaries

This HUC includes all of the watersheds draining into San Francisco Bay south of the San Francisco-Oakland Bay Bridge and north of the Dumbarton Bridge. This HUC contains several small to medium sized watersheds within Alameda and Contra Costa counties and contains the largest watershed draining into San Francisco Bay - Alameda Creek. Urbanization and industrial development are the predominant land use throughout the HUC; most watersheds within the HUC have severely degraded habitat. The following streams are included on the 2002 Clean Water Act section 303(d) list of impaired water bodies for high levels of Diazinon attributable to urban runoff: Alameda Creek, Alamitos Creek, Arroyo de la Laguna, Arroyo del Valle, Arroyo las Positas, Arroyo Mocho, Miller Creek, San Leandro Creek, San Lorenzo Creek, and San Mateo Creek (CSWRCB 2003). Islais Creek and Mission Creek in San Francisco are particularly polluted, and both are included on the 2002 Clean Water Act section 303(d) list of impaired water bodies for factors related to industrial point sources and combined sewer overflow. These streams are included on the list because of high levels of: ammonia, Chlordane, Chlorpyrifos, Chromium, copper, Dieldren, endosulfan sulfate, hydrogen sulfide, lead, mercury, Mirex, PAHs, PCBs , silver, and Zinc (CSWRCB 2003). Alameda Creek, Mt. Diablo Creek, San Leandro Creek, San Lorenzo Creek, and Walnut Creek historically supported steelhead, but access is currently blocked by dams, flood control facilities, or other barriers. Habitat conditions in the lower reaches of these streams are highly degraded by urbanization, but large portions of the upper watersheds located within public park land are protected from anthropogenic pollution and are generally in relatively good condition.

Currently, small populations of CCC steelhead are found in Cordinices Creek, San Leandro Creek, and San Lorenzo Creek below dams.

d. South San Francisco Bay Tributaries

This HUC is entitled “Coyote” and includes the watersheds draining into San Francisco Bay south of the Dumbarton Bridge. This HUC contains all of the watersheds within Santa Clara County, and a few small watersheds from San Mateo and Alameda counties. Coyote Creek is the largest watershed within the HUC. Urbanization and industrial development are the predominant land uses throughout the HUC and are the primary factors affecting aquatic habitat. The following streams from this HUC are included on the 2002 Clean Water Act section 303(d) list of impaired water bodies for high levels of Diazinon attributable to urban runoff: Calabazas Creek, Coyote Creek, Guadalupe Creek, Guadalupe River, Los Gatos Creek, Matadero Creek, San Felipe Creek, San Francisquito Creek, Saratoga Creek, and Stevens Creek (CSWRCB 2003). Calero Reservoir, Guadalupe Reservoir, and Guadalupe River are included on the section 303(d)

list because of elevated levels of mercury associated with historic surface mining and associated tailings, and San Francisquito Creek is included because of excess sedimentation from nonpoint sources (CSWRCB 2003). Flood control and water development have degraded habitat throughout the HUC and numerous road crossings impair fish passage. In the Guadalupe River watershed, groundwater recharge operations release water imported from the Sacramento-San Joaquin Delta into local stream channels. On Coyote Creek, gravel mining has resulted in large in-channel pools that are populated with non-native predatory bass (*Micropterus* spp.).

Reduced numbers of CCC steelhead occur in few watersheds of this HUC: Coyote Creek, Guadalupe River, San Francisquito Creek, and Stevens Creek. Anadromy is blocked in each watershed by water supply reservoirs; however, small populations of CCC steelhead continue to persist downstream. Built in 1890, Searsville Dam on San Francisquito Creek blocks access to a major portion of the upper watershed including a large tributary, Corte Madera Creek. Three San Francisquito Creek tributaries downstream of Searsville Dam, Los Trancos, West Union, and Bear creeks, all currently support steelhead populations.

4. Central Coast Area

The Central Coast Area encompasses the coastal area from San Francisco County south along the California coast to the southern extent of San Luis Obispo County (Appendix A: Figure 6). This area includes the following seven counties: San Francisco, San Mateo, Santa Cruz, Santa Clara, Monterey, San Benito, and San Luis Obispo. Metropolitan areas within the Central Coast Area include San Francisco, Half Moon Bay, Santa Cruz, the Monterey Peninsula, Hollister, Gilroy, Salinas, and San Luis Obispo. The Central Coast Area includes watersheds that flow into the Pacific Ocean which support steelhead from CCC steelhead DPS and S-CCC steelhead DPS.

In general, available stream flow decreases from north to south within the Central Coast Area. In addition to highly urbanized areas, portions of the Central Coast Area are experiencing low density rural residential development. The majority of the Central Coast Area is privately owned, though there are portions under public ownership including Open Space in San Mateo County, State parks in Santa Cruz County, and Federal lands in southern Monterey County.

The Central Coast Area contains seven 4th Field HUCs: San Francisco Coastal South, San Lorenzo-Soquel, Pajaro, Alisal-Elkhorn Sloughs, Salinas, Carmel, and Central Coastal. Anthropogenic factors affecting listed salmonids in these HUCs include dams constructed for water storage and aquifer recharge, summer dams constructed for recreational activities, urbanization, surface water diversion and groundwater withdrawal, in-channel sediment extraction, flood control projects, and logging. It is unknown what surface water diversions are screened. Agriculture has had the greatest impact on the Pajaro and Salinas HUCs, while logging and urbanization have had the greatest impact on the San Lorenzo-Soquel HUC.

a. San Francisco Coastal South

This HUC contains all of the coastal watersheds from the Golden Gate Strait south to approximately the San Mateo/Santa Cruz county line. The watersheds within this HUC are

wholly within San Mateo County. There are seven moderate-sized watersheds within the HUC: Pilarcitos Creek, Arroyo Leon, Purisima Creek, Lobitos Creek, San Gregorio Creek, Pescadero Creek, and Butano Creek. There is limited urban development within this HUC; agriculture (*e.g.*, brussel sprouts and cattle) is the dominant land use within all of the watersheds. There are several State Parks and Open Space areas within this HUC. Butano Creek, San Gregorio Creek, Pomponio Creek, and Pescadero Creek are included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). The pollution factors for these streams are high coliform count and sedimentation/siltation. The potential sources of these pollutants are nonpoint sources. There are no approved TMDLs within this HUC.

Steelhead are widely distributed throughout this HUC. Steelhead were once abundant in the San Gregorio Creek watershed but are believed to be at critically low levels (NMFS 1999b). Pescadero Creek supports the most viable steelhead population in this HUC (Titus *et al.* 2002).

b. San Lorenzo-Soquel

This HUC begins approximately at the San Mateo/Santa Cruz county line in the north, containing Arroyo de los Frijoles in southern San Mateo County, south to and including Valencia Creek in Santa Cruz County. The HUC extends eastward to the Santa Cruz/Santa Clara county line. There are several moderate-sized streams within this HUC, including Gazos Creek, Waddell Creek, Laguna Creek, Bear Creek, Bean Creek, Branciforte Creek, and Soquel Creek. The San Lorenzo River is the largest river in the HUC and the largest between the two closest major river systems - the Russian River in Sonoma County to the north and the Salinas River to the south. There is a fair amount of urban development within the HUC. Several State Parks (*e.g.*, Big Basin, Henry Cowell Redwoods, The Forest of Nisene Marks) are located within this HUC. Forestry operations are conducted on private timberlands and State forest in this HUC, including Big Creek Lumber Company and the Soquel Demonstration State Forest, respectively.

Aptos Creek, Bean Creek, Bear Creek, Boulder Creek, Branciforte Creek, Carbonera Creek, East Branch Waddell Creek, Fall Creek, Kings Creek, San Lorenzo River, San Lorenzo River Lagoon, Soquel Lagoon, Valencia Creek, and Zayante Creek are included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). The pollutants in these streams are varied, including, but not limited to, pathogens, nutrients, and sedimentation/siltation. The potential sources of these pollutants are also varied. Nonpoint source, urban runoff, and road construction are just a few of the potential sources.

Steelhead are widely distributed throughout this HUC. Gazos, Waddell, and Scott Creeks are in relatively good condition, overall, for CCC steelhead.

c. Pajaro

This HUC is comprised of the Pajaro River and its tributaries and is located in portions of Santa Cruz, Santa Clara, Monterey, and San Benito counties. Moderate-sized tributaries to the Pajaro River include Corralitos Creek, Uvas Creek, Llagas Creek, Pacheco Creek, Santa Ana Creek, and Tres Piños Creek. The San Benito River is also a tributary to the Pajaro River. This HUC

encompasses several municipalities, including Watsonville, Gilroy, and Hollister. Agriculture is the dominant land use within all of the watersheds in this HUC. Clear Creek, Corralitos Creek, Hernandez Reservoir, Llagas Creek, Tequisquita Slough, and Watsonville Slough are included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). The pollutants in these streams are varied, including, but not limited to, mercury, fecal coliform, and sedimentation/siltation. The potential sources of these pollutants are also varied. Nonpoint source, resource extraction (*e.g.*, via in-channel gravel mining), and pasture grazing are just a few of the potential sources. The Pajaro River is also included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). The Pajaro River contains the following pollutants: fecal coliform, nutrients, and sedimentation/siltation. Agriculture and pasture grazing are two potential sources of the pollutants.

The Pajaro HUC is within the S-CCC steelhead DPS. The distribution and abundance of steelhead within this HUC are greatly reduced. The majority of the streams where steelhead are known to be present, are located in the northwest portion of the HUC (*e.g.*, Uvas, Llagas, Corralitos, and Pachecho Creeks). The mainstem Pajaro River once contained suitable spawning and rearing habitat for S-CCC steelhead, but currently functions solely as a migratory corridor because of impacts from flood control projects, agriculture, and water withdrawals for agricultural use.

The San Benito River has been adversely impacted by water withdrawals for agricultural use and in-channel sediment extraction. Steelhead have not been documented in the San Benito River since the mid-1990s, although no formal surveys have been undertaken. The San Benito River is also on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003) due to fecal coliform and sedimentation/siltation. The source of fecal coliform is unknown; agriculture, resource extraction, and nonpoint source have been identified as potential sources of this pollutant.

d. Alisal-Elkhorn Sloughs

The Alisal-Elkhorn Slough HUC encompasses watersheds between the Pajarro and Salinas rivers. This HUC has little permanent flowing water. S-CCC steelhead have been observed in the headwaters of Gabilan Creek, which contains the best freshwater habitat remaining in the HUC. The HUC features mixed oak woodlands and grasslands on rolling hills overlooking tidal salt marsh. Elkhorn Slough is a principal wetland complex in central California, and is considered one of the most ecologically important estuaries in the state and is part of the National Estuarine Research Reserve System. Land use within this HUC is primarily agriculture, though there is some urban/rural development present. Habitat within the HUC has been degraded. Portions of both nominal watersheds within this HUC are included on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003). Alisal Slough and Gabilan Creek are included for high levels of fecal coliform and nitrates attributable to agriculture, urban runoff, natural sources, nonpoint sources, and unknown sources. Elkhorn Slough has high levels of pathogens, pesticides, and sedimentation from agricultural and nonpoint sources. There are no approved TMDLs for this watershed.

e. Salinas

The Salinas HUC is the largest in the Central Coast Area and contains the largest individual watershed within the Central Coast Area, the Salinas River. This HUC lies within interior Monterey and San Luis Obispo counties, as well as a portion of San Benito County. In addition to the Salinas River, there are three other large rivers in this HUC: the Arroyo Seco River, the San Antonio River, and the Nacimiento River. There are isolated areas of urban development, including Salinas, King City, and Paso Robles. Outside of these urban developments, agriculture is the dominant land use. Portions of the Los Padres National Forest, Ventana Wilderness, Fort Hunter Liggett, and Camp Roberts Military Reservation lie within this HUC. Several water bodies, including, but not limited to, Atascadero Creek, Blanco Drain, Cholame Creek, and the Nacimiento Reservoir, are on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003) due to a variety of pollutants from several sources. The Salinas River is also on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003) due to fecal coliform, nutrients, pesticides, chloride, and other pollutants derived from a variety of sources, principally agriculture.

The Salinas HUC is within the S-CCC steelhead DPS. The distribution and abundance of steelhead within the HUC are greatly reduced. The Salinas River is used as a migration corridor by S-CCC steelhead. Two of the largest tributaries, the San Antonio and Nacimiento rivers, have been dammed, eliminating steelhead access to valuable spawning and rearing habitat and severely modifying stream flow. These dams, along with an additional dam on the upper mainstem, in-channel sediment extraction, channel modification and water withdrawals for agricultural use, have impacted the Salinas River. The Arroyo Seco River contains the best spawning and rearing habitat remaining for S-CCC steelhead in this HUC. A number of partial passage barriers affect steelhead access to habitat.

f. Carmel

This HUC is comprised of the Carmel River and its tributaries. Moderate-sized streams within the HUC include Las Gazas Creek, Chupines Creek, and Tularcitos Creek. None of the streams within this HUC are on the 2002 Clean Water Act section 303(d) list of water quality limited segments. There is urban development within the Monterey Peninsula and limited rural residential development elsewhere. Portions of the Los Padres National Forest lie within this HUC.

This HUC is within the S-CCC steelhead DPS. The Carmel River presently maintains the largest adult run of steelhead in the S-CCC DPS (Titus *et al.* 2002). Impacts to S-CCC steelhead include three dams on the mainstem, water withdrawals for domestic use, and channel modifications for flood control purposes.

g. Central Coastal

This long and narrow HUC contains all of the coastal watersheds from San Jose Creek near Point Lobos State Reserve in Monterey County south to, and including, Arroyo Grande Creek in San

Luis Obispo County. Most of the streams in this HUC are short-run and high-gradient, draining directly to the Pacific Ocean. Moderate-sized streams within this HUC include Little Sur River, Big Sur River, Santa Rosa Creek, and San Luis Obispo Creek. Chorro Creek is on the 2002 Clean Water Act section 303(d) list of water quality limited segments (CSWRCB 2003) due to fecal coliform, nutrients, and sedimentation/siltation from a variety of sources.

This HUC is within the S-CCC steelhead DPS and has experienced the least impacts within the Central Coast Area. The Little Sur River is probably the most productive steelhead river south of San Francisco Bay at this time (Titus *et al.* 2002). The Big Sur River is in relatively good shape, but anadromy is limited due to natural barriers.

5. Sacramento River Area

The Sacramento River Area extends from the Pit River basin south through the American River basin (Appendix A: Figure 7). The Sacramento River basin includes all streams draining into the Sacramento River below Shasta Dam. The area includes the following USGS 4th field HUCs where proposed research activities will take place: Sacramento-Lower Cow-Lower Clear, Mill-Big Chico, Butte, Feather, Yuba, American, and Lower Sacramento. Water development, dams, and agriculture are among the major factors affecting salmonids in the Sacramento River basin.

The Sacramento River basin supports both listed Central Valley salmonids, CVSR Chinook salmon ESU and CV steelhead DPS. CVSR is restricted to the mainstem Sacramento River, tributaries in the upper Sacramento River (*e.g.*, Mill Creek, Deer Creek, Butte Creek), Feather River, and Yuba River. Existing wild CV steelhead stocks in the Central Valley are mostly confined to upper Sacramento River and its tributaries, including Antelope, Deer, and Mill Creeks and the Yuba River. Remnant 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). Steelhead in the Yuba River are managed as a naturally sustained population (CDFG 1991). Reliable estimates of CV steelhead abundance for different basins are not available (McEwan 2001), however, McEwan and Jackson (1996) estimate the total annual run size for the entire Sacramento-San Joaquin system, based on counts at the Red Bluff Diversion Dam counts, to be no more than 10,000 adults.

Recent habitat evaluations conducted in the upper Sacramento, Feather, and possibly the San Joaquin Rivers suggest that, as for anadromous salmonids, large amounts of potential green sturgeon spawning habitat were made inaccessible or altered by dams (NMFS 2005). Current green sturgeon spawning habitat is reduced to a limited area of the upper Sacramento River.

Population estimates of salmonids and major factors affecting salmonids for each major watershed in the Sacramento River basin are described below.

a. Mill Creek, Deer Creek, and Butte Creek tributaries

These three tributaries to the Sacramento River support the only remaining self-sustaining wild populations of CVSR Chinook salmon. The CVSR Chinook salmon natal tributaries do not have

large impassable dams but they do have many small hydropower dams and water diversions that have greatly reduced or eliminated in-stream flows during spring-run migration periods. These populations reached low abundance levels in the late 1980's (*e.g.*, 67-243 spawners; NMFS 2003a), but have increased steadily since the 1990's and now are estimated to number 8,583 in 2003 (CDFG, unpublished data). During this period of increased abundance, there have been significant habitat improvements such as removal of several small dams and increases in summer flows.

The wild steelhead stocks in Mill, Deer, and other upper Sacramento River tributaries may be native or mostly native Sacramento River steelhead, but these populations are nearly extirpated (McEwan and Jackson 1996). The latest annual counts of steelhead in the upper Sacramento River tributaries were made in the 1960s, which extimated nearly 1,000 and 2,200 adult steelhead in Deer Creek and Mill Creek, respectively (McEwan and Jackson 1996).

b. Feather River

The State Water Project's Oroville Facility and Feather River Hatchery are major factors affecting salmonid populations in the Feather River. The Oroville Facility alters river flows, which may affect timing of juvenile outmigration and direction of adult migration of salmonids. The Feather River population of CVSR Chinook salmon is dependent and highly influenced by the Feather River Hatchery spring-run Chinook salmon stock (NMFS 2003a). In the Feather River, hatchery and naturally spawning fish appear to form a homogenous population (NMFS 2003a) as a result of hybridation of fall-run and spring-run Chinook salmon from hatchery practices. The Feather River Hatchery is considered a major threat to the genetic integrity of the remaining wild spring-run Chinook salmon populations (NMFS 2003a).

The Feather River once supported large populations of steelhead (McEwan and Jackson), but large dams have made the spawning and rearing habitats of these rivers inaccessible to fish. Limited information exists regarding the abundance, location, and timing of steelhead spawning within the Feather River. The only reliable information available on in-river adult abundance since the construction of Oroville Dam is from steelhead redd surveys, which estimated a minimum of 163 steelhead spawned in 2003 (California Department of Water Resources 2003).

c. Yuba River

The Yuba River population of CVSR Chinook salmon is highly influenced by the Feather River Hatchery spring-run Chinook salmon stock as the result of hatchery fish straying into the Yuba River (NMFS 2003a). Little is known about the size of the spring-run Chinook salmon population in the Yuba River. Englebright Dam and Daguerre Point Dam are among the major structures in the Yuba River that limit salmonid passage.

The Yuba River supports a self-sustaining population of CV steelhead and is essentially the only wild steelhead fishery remaining in the Central Valley (McEwan and Jackson 1996). As with the spring-run Chinook salmon, there has been very little information published on population trends and absolute abundance of steelhead in the Yuba River. It is known that the vast majority of

spawning and rearing habitat for steelhead in the Yuba River was first impacted by gold mining activities and then totally cut off by Englebright Dam. Prior to construction of Englebright Dam, fisheries biologists for CDFG observed large numbers of steelhead spawning in the uppermost reaches of the Yuba River and its tributaries (CDFG1998, Yoshiyama *et al.* 1996). As steelhead have been heavily affected by mining operations and dam construction on the Yuba River since the 1800's, the steelhead population likely has been relatively small since that time. CDFGestimated a spawning population of only about 200 fish annually prior to 1969. During the 1970's, CDFGannually stocked hatchery steelhead from Coleman National Fish Hatchery into the lower Yuba River, and by 1975 estimated a run size of about 2,000 fish (CDFG 1991). Since 1975, the run size has not been estimated, but is believed to be "stable" and supports a significant recreational fishery. CDFG stopped stocking steelhead into the lower Yuba River in 1979, and currently manages the river for natural steelhead production.

d. American River

The Folsom and Nimbus dams and Nimbus Hatchery are some of the major factors affecting salmonids in the American River. Flood control operations in the American River may cause fluctuating flows that strand fish or dewater redds. Salmonid fry survival may additionally be decreased from suboptimal temperatures resulting from flows released from Folsom and Nimbus dams.

CVSR Chinook salmon historically occurred in the American River until water diversion structures such as Nimbus and Folsom dams blocked upstream access to spawning grounds. In addition, warm temperatures in the Lower American River pools are not hospitable for oversummering adult CVSR Chinook salmon. Restoration efforts target the American River as a potentially important non-natal rearing habitat for juvenile CVSR Chinook salmon.

Relatively little is known about the steelhead population in the American River. The population of CV steelhead is almost entirely supported by the Nimbus Hatchery (McEwan and Jackson 1996).

6. <u>San Joaquin River Area</u>

The San Joaquin River Area extends from the Cosumnes River basin south through the southern boundary of the San Joaquin River (Appendix A: Figure 8). The area includes the following USGS 4th field HUCs where proposed research activities will take place: San Joaquin Delta, Cosumnes, Mokleumne, Calaveras, Stanislaus, Tuolumne and Merced.

The major streams in the San Joaquin River basin, such as Merced, Tuolumne and upper San Joaquin Rivers, historically supported large Chinook salmon populations, while streams with less regular streamflow, such as Calaveras River, had intermittent salmon runs (Yoshiyama *et al.* 2001). However, hydroelectric and irrigation projects throughout the San Joaquin basin in the 19th and 20th centuries have since made oversummering and spawning grounds inaccessible and temperature uninhabitable to CVSR Chinook salmon. CVSR Chinook salmon no longer occur in the San Joaquin River basin.

The distribution and abundance of steelhead in the San Joaquin River basin has not been well documented. It is thought that the installation of diversion dams on major tributaries in the late 19th and 20th centuries (*e.g.,* La Grange Dam on the Tuolumne River and Exchequer Dam on the Merced River) may have caused the decline in steelhead numbers before the early fish surveys of the 1930s and 1940s (McEwan and Jackson 1996). Recent monitoring has detected self sustaining populations of steelhead in the Stanislaus, Mokelumne, Calaveras, and other streams previously thought to be void of steelhead (McEwan 2001). It is possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring programs (Interagency Ecological Program Steelhead Project Work Team 1999). Gathering information about steelhead today is challenged by the inability to distinguish a juvenile resident trout from an anadromous rainbow trout (*i.e.,* steelhead), which are both considered to be simply *O. mykiss*.

Efforts to monitor CV steelhead populations in the San Joaquin River basin, including many of the proposed projects under CDFG's Research Program, may help to shed light on their distribution and abundance, especially in the San Joaquin River basin where information about steelhead is sparse.

The watersheds in the San Joaquin River basin share similar factors that may affect salmonids, such as water diversions, dams, and elevated water temperature from flows released from dams. For example, water diversions may reduce survival of emigrating juvenile salmonids through direct losses at unscreened or inadequately screened diversions, and indirect losses resulting from reduced stream flows. Fish screening and salvage efforts at major agricultural diversions have met with variable amounts of success, and many smaller unscreened or inadequately screened diversions continue to operate. Fish losses at diversions can result from physical injury, impingement, entrainment, or predation. Delayed passage, increased stress, and increased vulnerability to predation may also contribute to indirect mortality at diversions. Secondly, dams impede or block access to spawning habitats in the headwaters. In some cases, fish ladders provide inadequate passage for fish, such as when ladders are destroyed by flood events (*e.g.,* Mokelumne River dams). And lastly, water released from dams tend to be suboptimal in temperature. Water temperature is a primary factor limiting natural steelhead production in many Central Valley streams. Although cold water releases occur below some dams, the amount and quality of habitat available for steelhead rearing below these dams is a fraction of what was once available. In addition, cold water releases are not available below many migration barriers, or are only possible when reservoirs are at capacity. Appropriate water temperature regimes below many dams cannot be maintained at levels comparable to temperatures achieved naturally in the upper watersheds that once provided habitat (Jones and Stokes Associates 2000).

The abundance and distribution of steelhead in the major tributaries to the San Joaquin River, such as Merced, Tuolumne, Stanislaus, and Calaveras Rivers are not well documented. More information about steelhead is known in the Mokelumne River, where the Mokelumne River Fish Installation produces about 30,000 to 50,000 yearling steelhead per year from eggs taken at Nimbus Hatchery on the American River, from which adult return to Mokelumne River has been less than 50 steelhead per year over the last 20 years (McEwan and Jackson 1996). Data from

video monitoring showed 191 hatchery steelhead and 166 unclipped (natural) steelhead migrating past Woodbridge Irrigation Dam from April 1 through September 15, 2004 (East Bay Municipal Utility District 2004).

V. EFFECTS OF THE PROPOSED ACTION

The purpose of this section is to identify direct and indirect effects on ESA-listed salmonids and on the Southern DPS of North American green sturgeon resulting from NMFS annual approval of a research limit (salmonids) and a research exemption (green sturgeon) to the ESA take prohibitions for CDFG's annual research program during the next five years (2012-2016) of the Program. Several sampling methods and procedures utilized by projects in the Program and associated impacts methods and procedures will be implemented in individual research projects in the Program. Common methods used in fisheries research and the potential effects they have on fish are first described and then the potential specific effects to ESA-listed salmonids and the Southern DPS of North American green sturgeon resulting from the annual Program are analyzed below. Detailed descriptions of each of the projects approved for inclusion in the annual Program, including the project objectives, methods, sampling locations, time, frequency, and amount of estimated take requested for each project is available on the APPS website and in the Administrative Record.

NMFS annually reviews all project applications for the Program, and requests modification and resubmission of some applications to address concerns, and analyzes project effects and locations of projects within each HUC or watershed to determine impacts to populations. In some cases, NMFS and/or CDFG does not approve projects in the Program. The research methods and potential impacts are discussed, then a summary of the effects to salmon, steelhead and green sturgaon are discussed. A few project may also have minor effects to eulachon smelt, these effects are discussed at the end of this section.

CDFG Program research on salmonid populations proposed under the 4(d) limit will utilize a variety of methods. These methods, and their impacts on salmonids are described as follows.

A. Research Methods and Potential Impacts

1. <u>Effects Associated with Direct Observation</u>

Approximately one-third of the annual research projects request observation of spawned adult carcasses, adult, smolt, and juvenile salmonids, and adult green sturgeon. These projects will not capture or handle live fish, but will observe them via snorkel surveys, adult spawner/carcass surveys, weirs, fish ladders, video, etc. Direct observation is the least intrusive method for determining presence/absence of the species and estimating their relative abundance. Effects of direct observation are generally the shortest-lived among any of the research activities discussed in this section. Videography (DIDSON, deepwater camera, digital video, etc) should induce no effects on ESA-listed fish. Using other forms of direct observations, a cautious observer can effectively obtain data without disrupting the normal behavior of a fish.

Provided that visibility and other conditions are sufficient, direct observation is used to gather important data on habitat utilization, behavior, distribution, and for estimating population size and structure. Direct observation can entail walking the side of the water body, or underwater observation techniques such as snorkeling, scuba diving, and video photography. Observing fish by walking the side of the water body is done only on small bodies of water or the littoral zones of large bodies of water. Underwater observation is most frequently used in small lakes, streams, and tidepools, however, can be undertaken efficiently in large, deep water bodies (*e.g.*, oceans, rivers, and reservoirs) provided that conditions are adequate (Dolloff *et al.* 1996). Turbidity, turbulence, target species behavior, habitat structure and complexity, hydrology, ambient light, and, perhaps, weather affect the efficiency of direct observation.

Another type of direct observation involves spawning surveys. In these surveys the observer walks directly in the stream during spawning season, as close to the edge as possible, locating redds and carcasses. These surveys usually involve the concurrent observation and notation of spawning salmonids as well. Salmonid carcasses are measured, the sex is determined, and scale and tissue samples are usually collected. Redds are usually flagged and the locations recorded. One of the effects of this type of survey is the possible disturbance of redds if the observer accidentally steps on one. If spawning salmonids are present during these surveys then the fish can be unintentionally frightened off by the observer, disrupting their spawning activities or their effort to guard the redd after spawning.

There is no evidence that fish are injured by direct observations. Observations made by State and Federal fishery biologists counting Chinook salmon and steelhead in Central Valley streams indicate that direct observation does not cause any behavioral effects that prevent salmon and steelhead from successfully holding, spawning, or feeding (Paul Ward, CDFG, personal communication 2002, Sarah Giovannetti, U.S. Fish and Wildlife Service, personal communication 2003, Jeffrey Jahn, NMFS, personal communication, 2012). Snorkeling surveys may frighten adult and juvenile spring-run Chinook salmon and steelhead, which may cause the fish to seek temporary refuge behind rocks, vegetation, and deep water areas. Frightened juveniles return to feeding habitats, and adults return to holding and spawning habitats within seconds after the observer passes through the habitat unit. In some cases, salmon may temporarily leave the particular pool or habitat type when observers are in their area. Adult mortalities do not occur because snorkel encounters with Chinook salmon are brief and do not involve any physical contact. Researchers minimize the amount of disturbance by limiting the number of times that each habitat unit is snorkeled and by moving through areas deliberately and without unnecessary, abrupt, or erratic body movements.

2. <u>Effects Associated with General Capture and Handling</u>

Capturing and handling fish causes them stress, though they typically recover fairly rapidly from the process and, therefore, the overall effects of the handling are generally short-lived. The primary contributing factors to stress and death from handling are excessive doses of anesthetic, differences in water temperatures (between the original habitat and the container in which the fish are held), dissolved oxygen conditions, the amount of time that fish are held out of the water,

and physical trauma (Kelsch and Shields 1996). Stress on salmonids increases rapidly from handling if the water temperature exceeds 64 °F or dissolved oxygen is below saturation. Fish that are transferred to holding tanks can experience trauma if care is not taken in the transfer process. In addition, when fish are handled by samplers to obtain measurements and other data, it is not uncommon for fish to be dropped on the ground by the handlers because the fish are not sedated enough or properly restrained. This can result in internal injuries, especially in females with developing ovaries (Stickney 1983). An injured fish is more susceptible to developing diseases, which can lead to delayed mortality. Some of the injuries which can lead to disease are the loss of mucus, loss of scales, damage to integument and internal damage (Stickney 1983, Kelsch and Shields 1996). In addition to the risks associated with handling, all fish handled will be exposed to additional risks specific to the various methods of capture described in the following subsection.

3. Collection Gear Specific Effects

Following are brief descriptions of effects of different capture methods and their associated collection gears. More detailed descriptions can be found in Nielsen and Johnson (1983) and Murphy and Willis (1996). Limited information exists on the injury and mortality rates to fish resulting from the capture methods described below.

a. Hoop Nets

Hoop nets are cylindrical or conical nets that are distended by a series of hoops or frames covered by web netting. A hoop net has one or more internal funnel shaped throats that are directed inward from the mouth of the net. The throats direct and trap the fish in the back end (codend) of the net. The net is held in place by ropes, weights, or stakes. Hoop nets are typically used in lakes and reservoirs, but are sometime used in river habitats. To increase capture efficiency of highly migratory fish, some hoop nets are set with "wings" of netting attached to the mouth of the net. The wings intercept migrating fish and direct them into the mouth of the net. Typically, fish are removed from hoop nets by scooping the fish out of the internal compartments using a dip net. Hoop nets are most effective for species that are attracted to cover, or other fish, or that are intercepted by the wings. Net construction (size and materials) and placement influence efficiency of hoop nets. Fish captured with hoop nets are generally captured unharmed, though there are some risks associated with hoop nets: small fish can be "gilled" in the netting, captured fish are subject to crowding and in-net predation from other fish, or injury by removal of the fish by dip net.

b. Seines

A seine is a net that traps fish by encircling them with a long wall of webbing. Typically, the top edge of a seine has floats, the bottom edge is weighted, and the seine has a brail (wooden pole) on each end. As the net is closed the fish become concentrated in the net. Seines are usually large enough that they are fished by two or more people, though can be small enough to be fished by one person. Generally, seines are set in an arc around the targeted fish and then dragged to shore. Seines are effective for sampling littoral areas of lentic habitats. In lotic

habitats, seines are most easily used in areas of low velocity, but can be used in high velocity areas if the brails are held in place while someone approaches the net from upstream, herding fish into the net. To be most effective, a seine needs to be deployed quickly enough that the target species cannot escape the encircling net. Accordingly, habitat structure and complexity negatively influence seine efficiency by reducing the speed at which one deploys a seine and by offering escape cover. Small fish can be gilled in the mesh of a seine. Scales and dermal mucus can be abraded by contacting the net. Fish can be suffocated if they are not quickly removed from the net after the net is removed from the water to process the fish. Also, the fish can be crushed by the handler when removing the net from the water.

c. Trawls

Trawls are cone-shaped, mesh nets that are towed, typically, along benthic habitat (Hayes 1983, Hayes *et al.* 1996). Rectangular doors, attached to the towing cables, keep the mouth of the trawl open. Most trawls are towed behind a boat, but small trawls can be operated by hand. As fish enter the trawl, they tire and fall to the codend of the trawl. Mortality and injury rates associated with trawls can be high, particularly for small or fragile fish. Fish can be crushed by debris or other fish caught in the net. Depending on mesh size, some small fish are able to escape the trawl through the netting. However, not all fish that escape the trawl are uninjured, as fish may be damaged while passing through the netting. Short duration trawl hauls (5 to 10 minutes maximum) may reduce injuries (Hayes 1983, Stickney 1983, Hayes *et al.* 1996).

d. Hook and Line

The use of hook and line (angling) is typically associated with recreational or commercial fishing, but can be used for collecting research samples (Hayes *et al.* 1996). Angling can target specific species or size of fish. Angling has been used in scientific studies for a variety of research activities including conducting radiotelemetry studies, studies of fish genetics, fish mortality and fish population structure and abundance. Another form of hook and line capture is a trotline. A trotline has a main line strung horizontally with short vertical lines (drop lines) attached to it (Hubert 1996). Each of the vertical lines has a baited hook attached to it. Trotlines are used frequently in warmwater inland fisheries and are generally used to capture catfish or common carp. Hook and line captures exercise size selectivity and extreme variability in catch rates. Injuries related to hook and line capture are influenced by hook size and type, bait or lure choice, and species behavior. Common hook and line injuries include damage to the skeletal structure of the mouth, injury to gills, and secondary infections. Fish may be additionally stressed from handling, especially if the fish is kept out of the water before it is released. Mortality resulting from hook and line capture and release averaged 7.5 percent with wound location and bleeding as primary factors associated with mortality; most mortalities occurred within 72 hours of release (Bendock and Alexandersdottir 1993).

e. Electrofishing

Electrofishing is a process by which an electrical current is passed through water in order to stun fish and facilitate capture. It can also be used to guide or block their movements. There are

three general systems for electrofishing related to where the electrical generator is maintained: backpack, boat, and shore. Backpack electrofishing is the most common system used for salmonids. Boat and shore electrofishing units often use more current than backpack electrofishing equipment because they are used to cover larger (and deeper) areas and, as a result, potentially have a greater impact on fish. This opinion considers only backpack electrofishing.

Two or three technicians work together while backpack electrofishing. One person carries the backpack and searches the target habitats with the anode, while one or two others net stunned fish. Operators work in teams to increase the number of fish that may be seen or captured. Working in teams also allows the researcher to net fish before they are subjected to higher electrical fields.

The use of electricity to capture fish is one of the most intrusive and risky methods. This method of capture can result in a variety of effects from simple harassment to injury to the fish (adults and juveniles) and death. There are two major forms of injuries from electrofishing; hemorrhages in soft tissues and fractures in hard tissues. Only a few recent studies have examined the long-term effects of electrofishing on salmonid survival and growth (Dalbey *et al.* 1996, Ainslie *et al.* 1998). These studies indicate that although some of the fish suffer spinal injury, few die as a result. Dalbey *et al.* (1996), reports that the growth of rainbow trout was markedly lower when there was moderate to severe electrofisher induced spinal injury. Electrofishing can also result in trauma to fish from stress. The stress caused by electrofishing is usually not recognized because the fish often appear normal upon release. Recovery from this stress can take up to several days, and during this time the fish are more vulnerable to predation, and less able to compete for resources. Stress related deaths can also occur within minutes or hours of release, with respiratory failure usually the cause.

The waveform produced by the electrofisher affects injury potential. Continuous direct current or low-frequency (#30 Hz) pulsed direct current have been recommended for electrofishing (Fredenberg 1992, Snyder 1992, Snyder 1995, Dalbey *et al.* 1996) because lower spinal injury rates, particularly in salmonids, occur with these waveforms (Fredenberg 1992, McMichael 1993, Sharber *et al.* 1994, Dalbey *et al.* 1996).

The age or stage of development of the target species affects injury rates too. Electrofishing can have severe effects on adult salmonids, particularly spinal injuries from forced muscle contraction. Sharber and Carothers (1988) reported .that have been conducted on juvenile salmonids indicate that spinal injury rates are substantially lower than they are for large fish. Smaller fish intercept a smaller head-to-tail potential than larger fish (Sharber and Carothers 1988) and may therefore be subject to lower injury rates (e.g., Hollender and Carline 1994, Dalbey *et al.* 1996, Thompson *et al.* 1997). McMichael *et al.* (1998) found a 5.1 percent injury rate for juvenile steelhead captured by electrofishing in the Yakima River subbasin. Cho *et al.* (2002) showed that electrofishing has dramatic negative effect on survival of eggs from electroshocked females (up to 93 percent mortality) and eggs electrofished post spawning (up to 34 percent mortality).

f. Dip Nets

Dip nets are bag shaped nets on a frame attached to a handle. The net is placed under the fish and then lifted from the water in a scooping motion. Dip nets are useful when collecting fish that have been trapped by other methods, such as electrofishing or trap nets. Scales and mucus can be abraded by the net, and fish can be crushed by the frame when the handler is attempting to catch them.

g. Weirs

Capture of adults by weirs is common practice in order to ascertain information regarding (1) enumerate adult salmon and steelhead entering the watershed, (2) determine the run timing of adult salmon and steelhead entering the watershed, (3) estimate the age, sex and length composition of the salmon escapement into the watershed, and (4) used to determine the genetic composition of fish passing through the weir (i.e. hatchery versus natural). Information pertaining to the run size, timing, age, sex and genetic composition of salmon and steelhead returning to the respective watershed will provide managers valuable information to refine existing management strategies.

Where used in the Program, resistance board weirs will meet the following specifications. Resistant board weirs and underwater video systems are constructed using a combination of floating resistance board panels, a rigid-picket panel, and flexible resistance board panels. These will be constructed using specifications by Tobin (1994), with minor changes to some materials, panel width, and resistance boards. The panels are attached to a steel rail anchored to the river bottom and are configured to pass fish near the deepest part of the channel through a fish passage panel. For some projects, the resistant board weir is fitted with a trap to capture adult migrating fish (potential effects associated with traps are discussed below). Other projects do not trap fish, but instead record the fish on video to get a count of returning adult salmon or steelhead. The underwater video camera is located within a water tight box attached to the fish passage cute. Fish are passively monitored as they pass by the lens. All video images are recorded on an external hard drive. These stored files are then reviewed daily and weekly to provide the run timing and population estimates. Effects to listed salmonids from this type of resistance board weir are minimal as they will pass freely through the chute and resume their upstream migration. The resistance boards and cameras are turned off during times of high flows or debris when water clarity will be minimal. This prevents impingement of the listed salmonids on the weir equipment.

h. Traps

There are several common types of traps used to catch fish (e.g., fyke traps, rotary screw traps, minnow traps, and pot gears). Fyke nets also are known as wing nets, frame nets, trap nets, and hoop nets (Hubert 1996). These nets generally are used in shallow waters of lakes and reservoirs, but they can also be used in deep water and in streams with slow currents. Modified fyke nets have frames across them near the mouth for stabilization. Fyke nets have leads or wings of webbing attached to the mouth to guide fish into the enclosure. Fish will swim into the

enclosure as they follow the lead or wing in an attempt to get around the netting. Fish captured with fyke and trap nets are less stressed than fish captured with entanglement gears and are usually released unharmed. However, the use of these nets can cause abrasion to fish from shaking fish down into the cod end prior to removal. Furthermore, these nets can result in mortality when small fish are gilled in the mesh of the nets.

Rotary screw traps are used in rivers of medium flow to capture fish as they travel downstream. They are large cones attached to a catamaran. Rotary screw traps are manufactured in various diameters (approximately 5-8 feet), and are placed horizontally in the stream bed with the open end of the cone facing upstream. Half of the open end of the cone is above the water. The fish enter the open end and proceed through a corkscrew in the downstream end of the trap. At the end of the corkscrew is a box for live capture, which will hold the fish. The purpose of the corkscrew is to prevent the fish from escaping out the open funnel end of the trap.

Pot gears are traps that are portable and rigid, with small openings for animals to enter and are usually small enough to be carried by hand (Hubert 1996). They are typically weighted with stones and marked by a buoy. Some examples of typical pot gears are lobster pots, minnow traps, slat traps for catfish, eel pots and crab pots. These traps are used to capture fish and crustaceans and are most efficient at capturing bottom-dwelling species seeking food or shelter. Fish are captured in the trap when they pass through a conical shaped funnel to reach a receptacle containing bait. One of the risks associated with the use of pot gears is that the gear can continue to capture animals if it is lost, a process called ghost fishing. Fish caught in the various types of pot traps can be crushed by in-trap weight.

Fish caught in traps experience stress and injury from overcrowding if the traps are not emptied on a regular basis. Debris buildup at traps can also kill or injure fish if the traps are not monitored and cleared on a regular basis. Fish caught in traps are vulnerable to in-trap predation by other fish and to predation by mammals, birds, or reptiles that are able to enter the trap.

h. Gill Nets

Gill nets are walls of netting suspended vertically in the water by a float line on the top and lead line on the bottom. The mesh of gill nets is relatively large; fish attempt to pass through the mesh and are captured. Fish are caught in the net in one of three ways: (1) gilled – held by mesh slipping behind the opercula, (2) wedged – held by the mesh around the body, or (3) tangled – held by teeth, spines, maxillaries or other protrusions without penetration of the mesh (Nielsen and Johnson 1983). Fish are primarily caught in the net by being gilled. When a fish is gilled the opercula do not open and close efficiently and disrupt respiratory gas exchange, leading to suffocation. Sometimes fish are injured while being removed from a gill net, including damage to internal organs from being squeezed, damage to scales and mucus, and damage to jaws and other protruding segments of the body. Soak time proportionally affects the lethal nature of gill nets (Hubert 1983, Hubert 1996); therefore, use of short-length gill nets that are checked frequently should reduce injury. Since gill nets are highly lethal and stress fish more than other forms of passive gears (Hubert 1996), gill nets should not be the preferred gear for capturing live fish for release. Mortality associated with gill nets can be reduced to as little as 6 percent with

the use of short net soak times, careful handling of fish on removal from the net, and a recovery box (Fraser *et al.* 2002).

4. Tagging and Marking

The use of passive integrated transponder (PIT) tags, coded wire tags (CWT), fin-clips, and biotelemetry transmitters are common to many scientific research efforts using ESA-listed species. Some tags or marks allow biologists to identify groups of fish (e.g., hatchery-produced fish or test fish) and some allow for the identification of individual fish. All sampling, handling, and tagging procedures have an inherent potential to stress, injure, or even kill the marked fish.

a. PIT Tags

A PIT tag is an electronic device that relays signals to a receiver; it allows individual fish to be identified whenever they pass a location containing such a receiver (e.g., some fish ladders) without researchers having to handle the fish. The tag is inserted into the body cavity of the fish using a modified hypodermic needle, typically, just in front of the pelvic girdle. The insertion of PIT tags requires that the fish be captured and extensively handled, therefore the fish can be affected by any or all of the associated risks mentioned in the section on capture and handling methods. PIT tags have very little effect on growth, survival, swimming speed, stamina, or behavior (Jenkins and Smith 1990, Prentice *et al.* 1990, Prentice *et al.* 1994). Mortalities associated with PIT tags have been found to be less than 1 percent (Dare 2003).

b. Coded Wire Tags

Coded wire tags are made of magnetized, stainless-steel wire. They bear distinctive notches that can be coded for such data as species, brood year, and hatchery of origin (Nielsen 1992). The tags are intended to remain within the animal indefinitely, consequently making them ideal for long-term, population-level assessments of Pacific salmon. In salmon, CWTs are injected into the nasal cartilage and, therefore, cause little direct tissue damage (Bergman *et al.* 1968). A major advantage to using CWTs is that external and internal tissue damage from the tag and injections heals rapidly and is minor (Bergman *et al.* 1968, Fletcher *et al.* 1987, Buckley and Blankenship 1990). In order for researchers to be able to determine later (after the initial tagging) which fish possess CWTs, it is necessary to mark the fish externally—usually by clipping the adipose fin—when the CWT is implanted (see text below for information on fin clipping). One major disadvantage to recovering data from CWTs is that the fish must be killed in order for the tag to be removed. However, tag recovery does not, in and of itself, impact salmonid populations because researchers generally recover CWTs from salmon that have been taken during the course of commercial and recreational harvest, or post-spawning carcass surveys.

c. Biotelemetry Tags

Biotelemetry tags (or radio tags) are implanted transmitters which allow one to identify and follow an individual fish continuously and remotely and to gather information on migration and

habitat utilization. There are two main ways to implant a tag and they differ in both their characteristics and consequences. The first method of implanting a tag is to slip it into the fish's stomach through the esophagus. Stomach insertion does not cause a wound and does not interfere with swimming. This technique is benign when salmon are in the portion of their spawning migrations during which they do not feed (Nielsen 1992). In addition, for short-term studies, stomach tags allow faster post-tagging recovery and interfere less with normal behavior than do tags attached in other ways. A second common method for implanting a tag is to surgically implant the tag within the body cavity. These tags generally do not interfere with feeding or movement, though the size of the tag and fish do influence effects. However, the surgical procedure is difficult, requiring considerable experience and equipment (Summerfelt and Smith 1990, Nielsen 1992). Because the tag is placed within the body cavity, the tag may injure a fish's internal organs. An improperly positioned incision may cause serious injury to the fish. Also, infections of the sutured incision and the body cavity itself are also possible, especially if the tag and incision are not treated with antibiotics (Chisholm and Hubert 1985, Mellas and Haynes 1985, Summerfelt and Smith 1990). Fish with internal radio tags often die at higher rates than fish tagged by other means because radio tagging is a complicated and stressful process. Mortality is both acute (occurring during or soon after tagging) and delayed (occurring long after the fish have been released into the environment). Acute mortality is caused by trauma induced during capture, tagging, and release. It can be reduced by handling fish as gently as possible. Delayed mortality occurs if the tag or the tagging procedure harms the animal in direct or subtle ways. Tags may cause wounds that do not heal properly, may make swimming more difficult, or may make tagged animals more vulnerable to predation (Howe and Hoyt 1982, Matthews and Reavis 1990, Moring 1990). Tagging may also reduce fish growth by increasing the energetic costs of swimming and maintaining balance. Radio tag mortalities for gastric and surgically implanted tags is 2-3 percent (Adams *et al.* 1998).

d. Fin Clipping

Fin clipping is the process of removing part or all of one or more fins to alter a fish's appearance and thus make it identifiable. When entire fins are removed, it is expected that they will never grow back. Alternatively, a permanent mark can be made when only a part of the fin is removed or the end of a fin or a few fin rays are clipped. Although researchers have used all fins for marking at one time or another, the current preference is to clip the adipose, pelvic, or pectoral fins.

Many studies have examined the effects of fin clips on fish growth, survival, and behavior. The results of these studies are somewhat variable; however, it appears that fin clips do not generally alter fish growth. Moreover, wounds caused by fin clipping usually heal quickly, especially those caused by partial clips. Mortality among fin-clipped fish is also variable (Duke 1986). Some immediate mortality may occur during the process, especially if fish have been handled extensively for other purposes (e.g., stomach sampling). Mortality depends on species and ambient conditions. Also, small fishes are more sensitive to handling; Coble (1967) suggested that fish shorter than 90 mm are at particular risk. The degree of mortality among individual fishes also depends on which fin is clipped. Mortality is generally higher when the major median and pectoral fins are clipped. By convention, an adipose mark has significance in

California and implies that a fish has been implanted with a coded-wire tag. The main risk to fish, therefore, would likely result from initial capture and handling to clip the fin.

5. Gastric Lavage

Information on fish diet may be useful in endangered species management. A significant component of diet studies is to know the content of a fish's stomach; the simplest and most primitive method is to kill the fish, surgically remove its stomach, and describe the stomach contents. However, sacrificing ESA-listed fish for diet analyses is not acceptable. Fortunately, there are several non-lethal methods available for determining the diet of listed fish. Most times gastric evacuation entails inserting a tube through the esophagus to the stomach of a fish and then flushing the stomach contents. Alternative methods include the use of emetics, vacuuming the stomach, the use of forceps, or flushing the anus. Kamler and Pope (2001) reviewed several gastric evacuation methods and found that most procedures were relatively safe and effective at removing stomach contents.

Some risks associated with gastric lavage include: increased handling time and associated stress; injury to the soft tissues of the esophagus, stomach, or intestine; and, with some techniques, injury to the jaws and anesthetic-related injury. Most reported levels of injury are quite low, frequently zero (reviewed in Kamler and Pope 2001), but Sprague *et al.* (1993) reported 33 percent mortality in juvenile white sturgeon (*Acipenser transmontanus*) and Hartleb and Moring (1995) reported mortality of 60 percent in golden shiner (*Notemigonus crysoleucas*). Haley (1998), however, showed that mortality in juvenile sturgeon could be greatly reduced by using smaller, more ductile tubing than used by Sprague *et al.* (1993), and by anesthetizing test fish. Gastric lavage has been used safely, and effectively in salmonids (Meehan and Miller 1978, Meehan 1996, Kamler and Pope 2001). Meehan and Miller (1978) reported 10-15 percent mortality (after 30 days) in coho salmon that were collected by electrofisher, subjected to gastric lavage, transferred to a laboratory, and held 30 days; it is not possible to determine which factor had the greatest influence on survival.

6. Carcass Sampling

Carcass sampling entails the handling and tissue sampling of previously dead ESA-listed salmonids. NMFS believes that this will not cause any adverse effects to ESA-listed salmonids because the adult fish will have already died from natural causes. Once sampled, the carcasses will be returned to the location where they were found. As a result, no reduction in the levels of marine-derived nutrients[4] or indirect adverse effects to ESA-listed salmonids will occur in the survey area.

B. Research Methods and Impacts on Green Sturgeon Life Stages

[4] Marine derived nutrients likely play an important role in salmonid freshwater ecosystems. See, for example, Bilby *et al.* 1996, Bilby *et al.* 1998, and Gresh *et al.* 2000.

The annual CDFG Program research on green sturgeon proposed under the green sturgeon 4(d) exemption will utilize a variety of methods. Green sturgeon research projects will use three methods (trammel nets, Benthic D-nets, egg mats). The 2012 Program is is the second year of the Program that includes research projects that target green sturgeon. Green sturgeon research projects will adhere to NOAA Technical Memorandum NMFS-OPR-45, *A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons* (Kahn and Mohead 2010) except if justification to not adhere to specific protocols was submitted by the researcher and approved by NMFS. In addition to the methods described below, hoop nets, fyke nets, deepwater camera, DIDSON, hook and line, weir, and screw traps will be used (discussed above). A portion of green sturgeon captured will also be anesthetized, PIT tagged, acoustic tagged, sonic tagged, and tissue sampled. These methods and procedures are described in the previous section.

1. Effects Associated with Trammel Nets and Benthic D-nets

Trammel nets are typically used by researchers to capture sturgeon. This netting technique, while potentially lethal for many species of fish, is somewhat safer for sturgeon. Both soak times and mesh size are important factors considered for safely capturing and handling sturgeon (Kahn and Mohead 2010). Mesh size that is too small for the targeted life stage is more likely to constrict gills resulting in mortality via suffocation. The mesh size chosen for trammel netting sturgeon, therefore, should be carefully considered and appropriate for the species and life stage targeted. Experimental nets with multiple mesh sizes may be appropriate for researchers to discover the safest and most effective mesh size (Kahn and Mohead 2010).

None of the research projects in the annual Program will be use 10 inch stretch mesh which has the highest mortality rate (Kahn and Mohead 2010), projects will use 4 square inch inner panel and 16 square inch outer panel trammel net. Effects of trammel nets is similair to gillnets, in that fish may have their gills impinged on the netting and stress fish more than other passive gear types (Kahn and Mohead 2010). Trammel nets will not be soaked for more than one hour and will be manned at all times to check as soon as fish entanglement is observed, and will not be fished in water temperature exceeding 23°C.

2. Effects Associated with Benthic D-Nets

When targeting eggs and early life stage (ELS) sturgeon, two commonly used sampling methods are D-nets and artificial substrates (described below). Both techniques can be non-lethal, but due to the risk of mortality, no more eggs and ELS sturgeon should be captured than are absolutely necessary. While not mandatory, in rivers with unknown spawning runs, adults can be tagged and tracked to document possible spawning runs and spawning areas prior to sampling for eggs (Kieffer and Kynard 1996). Otherwise, D-nets should be deployed well before the earliest time spawning would be expected. Due to the risks associated with capturing and impinging ELS sturgeon in the D-Nets, they should be checked at least every three hours to minimize unintentional mortality (Kahn and Mohead 2010).

A few projects per year request the use of Benthic D-nets to investigate historic green sturgeon spawning areas, verify the duration of spawning at known spawning locations, and determine

what flow parameters are optimal for ELS green sturgeon. Larval drift sampling is typically scheduled to occur two weeks following the first egg sample collection, based on spawning and juvenile outmigration timing through August (Poytress *et al.* 2010). Successful egg capture during the concurrent egg mat sampling surveys conducted by the United States Fish and Wildife Service will refine the exact start and end dates. Benthic D-nets will be constructed of 1.6 mm polyester mesh fashioned into 2.4 m long tapered cone and attached to a steel frame with a circumference of 2.8 m including a flat base of 80 cm (Poytress *et al.* 2010). A 2,200 mL Wildco Dolphin bucket is attached to the cod end allowing for easy access to collected green sturgeon larva. Steel bar stock is added to the base of the net frame to properly orient the net in the current and sink it to the river bottom during sampling. A total weight of 27 kg was determined to be sufficient for proper net orietation during sampling. The net is attached via a 4.8 mm diameter wire rope bridle to 4.8 mm Amsteel Blue rope and positioned using a hydraulic winch. The net drifts downriver behind the boat until it contacts the river bottom (Poytress *et al.* 2010). Larval direct sampling occurs five nights per week, sampling effort consists of 300 minutes of wetted net time per night between the hours of 20:00 to 01:00 and continued for one hour past the callection of green sturgeon larva. Collected samples are field sorted with the amount and type of debris recorded.

All green sturgeon larvae will be identified, measured, enumerated, recorded and returned to the river (Poytress *et al.* 2010). Green sturgeon caught in Benthic D-nets are generally unharmed, however there is a risk associated with capturing and impinging ELS sturgeon in D-nets. The D-nets will be set for 10, 20, 30, or 60 minute increments depending on debris accumulation, fish occurrence, and mortality (Poytress *et al.* 2010). Based on these measures, NMFS expects mortalities to be low, if any, and will be within the amounts requested.

3. Effects Associated with Egg Mats

Egg Mats are artifical substrates which consist of floor buffing pads, furnace filters, or similar materials, approximately two feet in diameter (described in Fox *et al.* 2000) for the purpose of collecting eggs as they are deposited in the water column. These pads should be anchored to the river bottom in suspected spawning areas. No more pads should be fished than is necessary. If the researcher is unsure of the number of pads required to identify spawning areas and success, no more than 100 to 150 pads should be fished at once across several sites (Kahn and Mohead 2010). Pads should be checked at least twice a week or more frequently of circumstances allow. The artificial substrates should be examined in the field for sturgeon eggs and only returned to mat, the matcan be returned to the river bottom allowing the eggs to incubate and hatch before being removed (Kahn and Mohead 2010).

Egg Mats that will be used in the annual Program are constructed using two 89 X 61 cm rectangular sections of furnace filter material secured back to back within a welded steel framwork (McCabe and Beckman 1990, Schaffter 1997). The orientation of the furnace filter material allows either side of the egg mat to collect eggs (Poytress *et al.* 2010). Egg mats will be held in position by a three-fluke cement-filled poly-vinyl chloride (PVC) anchor attached to the upstream end of the egg mat using 9.5 mm diameter braided polypropylene rope. A labeled float

is attached to the downstram end of each egg mat using 9.5 mm diamter braided polyproplyene rope (Poytress *et al.* 2010).

A few projects per year will be utilizing this method. Sampling will consist of visual inspection, generally twice a week, throughout the sample period. Paired egg mats are retrieved from the river after initial deployment, placed on the deck of a boat in a custom made egg mat carrier, and initially inspected on both sides by at least two of the crew members. After initial inspection, crew members will rinse the egg mat to remove debris and sediment and re-inspected. Rinse water and debris are filtered by a removable 3.2 mm mesh net placed within the egg mat carrier below each egg mat to capture any dislodged eggs. After the second inspection and mesh net inspection, egg mats are redeployed (Poytress *et al.* 2010).

Egg samples are counted and identified to species for each egg mat in the field. Eggs are measured, both maximum length and width, in the field using digital calipers (± 0.01 mm) (Poytress *et al.* 2010). All suspected green sturgeon and unidentified eggs are placed in vials of 95 percent ethyl alcohol (EtOH) for laboratory identification, species confirmation, and further analysis. Eggs are pooled, by species, into the same vial only when found on the same side of one egg mat. Suspected green sturgeon and unidentified eggs are sent to University of California at Davis (UC Davis) for positive species confirmation, photography, measurement of egg diameter, and determination of developmental stage (Dettlaff *et al.* 1993, Poytress *et al.* 2010). The two projects will also sacrifice less than 10 eggs per sampling event to determine kinship groups to develop spawner abundance indices, all other eggs will be enumerated and placed back into the river to hatch normally. Researchers will have to adhere to the amount of take approved for each project, if approved take is exceeded, the conditions of the Program require that the research activities stop and the researcher must contact CDFG and NMFS.

C. Impacts of Annually Approving the 2012-2016 Programs

Since the 2004 Program, the number of research and monitoring projects in the annual 2004-2011 Programs have ranged from 78 to 108 projects. However, NMFS anticipates that the number of Program research and monitoring projects approved may increase over the next five years as both state and Federal recovery actions are implemented and the economy improves. For this programmattic opinion, NMFS assumes that the number of research and monitoring projects will not exceed 105 projects per year and the amount of take approved annually will not exceed the take levels identified in Appedix B: Tables 1 and 2.

Although the amount in Appendix B: Tables 1 and 2 represent the maximum amount of take that will be approved annually, NMFS expects that the annual amount approved will not be realized for most, if not all, salmon ESUs and steelhead DPSs annually. A percentage of the projects that are annually approved are not actually implemented due to lack of funding and other reasons. Additionally, and some of the projects implemented did not result in take of ESA-listed salmonids even though they had take authorized.

Based on annual reports from the last eight years of the program, several projects approved annually are not actually implemented (Appendix B: Table 4) due to lack of funding and other

reasons. The percent of projects not implemented annually has ranged from 11 to 28 percent (Appendix B: Table 4) with an average of 22 percent. This means that on average, almost a quarter of the projects approved are not implemented, thus resulting in no affect to listed fish from these projects. Of the total number of research projects implemented annually from 2004 through 2011, five to 15 projects that were implemented did not encounter ESA-listed fish and thus did not result in take (Appendix B: Table 5). The percent of projects that were implemented annually without take of ESA-listed salmonids has ranged from 8 to 17 percent (Appendix B: Table 5) of the total projects approved, with an average of 11 percent.

The major effects of the annual Program will consist of temporary behavior modification and rare instances of physical damage and/or possible unintentional mortality as a result of capture, handling or tagging of individual fish. In some years, one or more projects might request a low level of intentional mortality. NMFS carefully reviews and evaluates the request including the justification provided. If intentional mortality is approved, only a small number would be approved and the researchers are to utilize unintentional mortalities before intentionally killing the fish. These impacts are unlikely to affect salmonids and green sturgeon at the local population level because: (1) although the projects are spread out over most of California, potential impacts are expected to be confined to specific sampling sites during certain time periods in the action area, leaving most fish unaffected in streams where sampling occurs, (2) most of the projects do not propose intentional lethal take, and precautions will be required to minimize the chances of mortality to captured fish, (3) sampling gears are not 100 percent effective, and therefore, a portion of fish in the sampling areas will be unaffected by the projects, and (4) projects within the same watersheds are coordinated so that efforts are complimentary, are not duplicated, and are not concentrated in the same area in order to minimize impacts to local salmonid populations. NMFS does not anticipate impacts to migrating, spawning, and rearing habitat associated with the research activities, therefore, these losses of fish are so small that adult returns are unlikely to be affected and the small losses are likely to be replaced each year.

Data collected from the annual Program will be benefecial for the management and recovery of ESA-listed salmonids. The present body of scientific information relative to the abundance, distribution, and genetic composition of anadromous salmonid populations in California is incomplete (Good *et al.* 2005, Williams *et al.* 2011). This paucity of data limits the ability of managers to evaluate proposed recovery actions and to know if populations are increasing or decreasing over time. Several of the projects in the annual Program are "life stage monitoring stations" that are being implemented as part of the California Coastal Monitoring Plan that was developed by CDFG and NMFS. Future recovery monitoring of ESA-listed salmonids will likely depend on long-term datasets at life cycle monitoring stations, which include survey locations within watersheds where research activities monitor multiple ESA-listed salmonid life stages through redd/spawner surveys, smolt outmigration monitoring, summer juvenile monitoring, and most importantly, adult salmonid counts.

1. <u>Effects of the Annual Program on Salmonid Life Stages</u>

CDFG Program research on salmonids proposed under the salmonid 4(d) limit will utilize a variety of methods. The methods and their effects on fish are described above in section *V. Effects of the proposed action.* Methods include, but are not limited to, direct observations (snorkeling, spawner surveys), migrant trapping, seining, backpack electrofishing, and angling (hook and line). The proposed methods, procedures, and estimated amount of take for each project approved for inclusion in the annual Program is confirmed for accuracy and reasonableness by CDFG and NMFS biologists. In some cases, NMFS and/or CDFG request modifications to project activities to minimize effects and/or to reduce requested take levels.

The primary effects of the annual Programs on ESA-listed salmonids are expected to be stress and other sub-lethal effects caused by observing, capturing, and handling fish. Non-lethal take from methods described in the previous sections should not, in general, impact the chance of survival of individual fish. The effects of the 2012-2016 Programs will mostly consist of temporary behavior modification and rare instances of physical damage and/or possible mortality as a result of capture, handling or tagging of individual fish, and a low level of intentional mortality.

The cumulative total annual maximum take of adults, smolts and juvenile fish from each salmon ESU and each steelhead DPS estimated to result from projects within the annual Program are presented in Appendix B: Table 1. The maximum amount of take that would be approved annually presented in Appendix B: Table 1 is based on previous amounts approved and reported, and accounts for fluctuations in the populations and for inflated percent mortality due to total research capture of low numbers with mortality to a few fish. As described above, actual annual amounts approved will most likely be lower than the amounts specified in Appendix B: Table 1, especially the percent mortality which has been generally below one percent for most life stages.

NMFS' analysis of the total reported actual annual observational take for the 2004 through 2010 Programs indicates that the amount of observation planned by researchers is higher compared to the amount of actual observation that occurs. Direct observation is the least intrusive method for determining presence/absence of the species and estimating their relative abundance. These activities are not expected to cause any behavioral effects that prevent salmon and steelhead from successfully holding, rearing, spawning, or feeding.

Similar to the 2004 through 2011 Programs, the majority of salmonid capture take that will be approved annually in the 2012-2016 Programs will be for non-lethal take of salmon and steelhead juveniles and smolts. The effect on the survival of individual fish exposed to such non-lethal take (capture, handle, sample, and release) is likely to be discountable because the effects will be minor and short-term and are not anticipated to result in mortality.

Most of the impacts to adult salmonids related to the annual Program are expected to be short-term non-lethal impacts. NMFS' analysis of the total annual reported capture take for the 2004 through 2010 Programs indicates that the amount of requested non-lethal and lethal take is typically higher compared to the amount of actual reported take. Appendix B: Tables 6 and 7 summarizes the total adult, smolt, and juvenile capture take approved, the actual reported capture take, and the percent of the approved capture take as reported for the 2009 and 2010 Programs.

For example, 0 to 47 percent of the total non-lethal take of natural origin adult salmonids, 0 to 91 percent of the non-lethal take of natural origin smolts, and 3 to 88 percent of the total non-lethal take approved for natural origin juvenile salmonids actually occurred in 2009 (Appendix B: Table 6). Similarly, in the 2010 Program 0 to 89 percent of the total non-lethal take of natural origin adult salmonids (except for 219 percent for CC Chinook salmon due to an increase in the population and capture associated with one project), 0 to 45 percent of the non-lethal take of natural origin smolts, and 7 to 48 percent of the total non-lethal take approved for natural origin juvenile salmonids actually occurred in 2010 (Appendix B: Table 7).

Therefore, NMFS expects actual non-lethal take for most monitoring and research projects in the 2012-2016 Programs to be less than the take levels requested and approved annually. Biologists from the CDFG and cooperating researchers have included overestimates of expected take to gain the flexibility to make in-season adjustments to research protocols in response to annual fluctuations in environmental conditions such as water flows, and larger than expected adult run sizes, *etc.* In addition, the abundance of juvenile salmon and steelhead may vary considerably from year to year in response to fluctuations in freshwater and ocean habitat conditions and other stochastic events. NMFS believes that overestimating requested levels of take is a reasonable precaution so as to be prepared for times when fish are abundant and the actual take is likely to be higher relative to years when fish are less numerous.

NMFS does not expect that the mortality levels, as a result of the research activities proposed for 2012-2016 Programs, will have an appreciable impact on individual populations based on reported data from the 2004-2010 annual Programs. Appendix B: Table 1 provides the total maximum amount of intentional and unintentional lethal take that will be approved annually for juvenile, smolt and adult salmon and steelhead. Appendix B: Tables 8-14 summarize the amount of take approved and the actual reported take for the last seven years of the Program. Data submitted annually for the Program indicates that the amount of reported mortality for all life stages of salmonids is only a fraction of the total fish captured and is usually less than the amount approved.

In most years, the actual reported percent mortality of juveniles and smolts for most salmon ESUs and steelhead DPSs is below one percent (Appendix B: Tables 8-14). This means that less than one percent of the total fish captured died as a result of the research activities. In some years it was above one percent for a few ESUs and DPSs mostly due to the 2004-2008 Programs not separating out the hatchery origin fish and due to intentional mortality of CV steelhead to determine if the fish were resident trout or anadromous steelhead. The actual reported percent lethal take of adult salmonids from the 2004-2010 Programs is zero for most ESUs and DPSs with a few below two percent in some years (Appendix B: Tables 8-14). This means that most adult salmonids that are captured during the research Program are released without being injured or killed. The actual low amount of lethal take of salmon and steelhead associated with the annual Program represent a negligible impact on the salmon and steelhead populations in the watersheds where take will occur because the actual amount of take is small, relative to the watershed populations where the sampling will occur, and the actual take will be spread out over a large number of creeks. As described above, since the annual Program affects more juvenile

fish than adult fish, NMFS expects less of an impact on the local population, the ESU and the DPS.

In summary, the primary effects of the 2012-2016 Programs on ESA-listed salmonids are expected to be stress and other sub-lethal effects caused by observing, capturing, and handling fish. NMFS expects that actual non-lethal and lethal take for most monitoring and research projects in the 2012-2016 Programs to be less than the take levels requested annually and will not exceed the maximum amount represented in Appendix B: Table 1. Non-lethal take from methods described above should not, in general, impact the chance of survival of individual fish. Unintentional harassment, harm, and mortality may occur during handling or after the fish has been released. Based on prior experience with the research techniques and protocols that will be used to conduct the proposed scientific research, no more than three percent of the juvenile salmonids and no more than two percent of the smolts encountered are likely to be killed as an indirect result of being captured and handled and, in most cases, the mortality rates will be at or below one percent. NMFS expects that less than one percent of the adults handled will die, and in most cases no adults will be injured or killed.

2. Effects of the Annual Program on Green Sturgeon

Up to 10 projects that may capture green sturgeon will be in the Program annually. These projects will include take of adult, juvenile, larvae and eggs of Southern DPS of North American green sturgeon at sampling locations, sampling methods, and green sturgeon abundance and distribution in the Sacramento River and Feather River, and potentially the San Joaquin River. The maximum amount of annual take of green sturgeon (adult, juvenile, larvae and eggs) that will be approved annually is presented in Appendix B: Table 2. In order to minimize impacts and to have consistent research protocols for sturgeon nationally, all researchers[5] in the Program will adhere NOAA Technical Memorandum NMFS-OPR-45, *A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons* (Kahn and Mohead 2011).

Data collected from the 2012-2016 Programs will be beneficial for the management and recovery of the Southern DPS of North American green sturgeon. The present body of scientific information relative to the abundance, distribution, and genetic composition of the Southern DPS of North American green sturgeon in Central Valley, California is incomplete (NMFS 2010b). This paucity of data limits the ability of managers to evaluate proposed recovery actions and to know if populations are increasing or decreasing over time. The 2011 Program was the first year that projects directly targeting green sturgeon were included in the Program; most of these projects are investigating watersheds were information about the occurrence of this species is sparse or has been inferred. As the Southern DPS green sturgeon Recovery Plan is developed, these datasets will provide valuable information regarding areas were restoration projects and recovery strategies should be focused.

The approved amount of take for each project targeting Southern DPS green sturgeon in the annual Program will be confirmed for accuracy and reasonableness by the principal investigator,

[5] Except if justification to not adhere to specific protocols was submitted by the researcher and approved by NMFS.

CDFG, and NMFS (including review and comments from the Recovery Coordinator, Regional Sturgeon experts, and NMFS Headquarters Sturgeon experts). In some cases, NMFS and/or CDFG request modifications to project activities to minimize effects and/or to reduce requested modifications to projects activities to minimize effects and/or to reduce requested take levels. If a project is determined to impact the species too much, the project is denied for inclusion in the Program. NMFS expects that the majority of impacts on green sturgeon will be minor, short-term, and primarily related to increased stress associated with capture, handling, and tagging. NMFS anticipates that these effects will not lead to adverse impacts to the green sturgeon population. The information gained from the research on sturgeon will provide useful information towards the management and conservation of green sturgeon.

The primary effects of the annual Programs on green sturgeon are expected to be stress and other sub-lethal effects caused by observing, capturing, handling and tagging fish. Non-lethal take from methods described in the previous sections should not, in general, impact the chance of survival of individual fish. The effects of the 2012-2016 Programs will mostly consist of temporary behavior modification and rare instances of physical damage and/or possible mortality as a result of capture, handling or tagging of individual fish, and a low level of intentional mortality.

Recently developed surveys using DIDSON have estimated 175 to 250 sturgeon (±50) in the mainstem Sacramento River during the spawning season in 2010 and 2011 (personal communication, Ethan Mora, UC Davis, on January 10, 2012). Adult green sturgeon will be observed via DIDSON and deep water camera. Direct observation is the least intrusive method for determining presence/absence of the species and estimating their relative abundance. These activities are not expected to cause any behavioral effects that prevent green sturgeon from successfully holding, rearing, spawning, or feeding. Some adult green sturgeon will be captured, anesthetized, tagged, tissue sampled and then released. Only experienced biologist will be performing the tagging. The small number of post-spawn adults that may be captured and tagged is unlikely to affect the overall subpopulations in the Sacramento River and Feather River basins, because the adult fish will be captured after they have spawned and are expected to fully recover such that their fitness will not be reduced.

Larvae will be captured through benthic D-nets and fyke nets. Because larvae are very fragile and sampling mortality is highly variable, all efforts will be taken to reduce sampling and handling stress of captured juveniles. Efforts include reduced sample times and longer recovery times (post sampling) prior to release. Sample times are typically <30 minutes using a benthic d-net. Eggs will be collected using egg mats and will be sacrificed for genetic confirmation of potential family reconstruction and spawning abundance indices. All other eggs on the egg mat will only be enumerated, identified to species, and placed back into the river to hatch. The genetic studies are necessary to determine if the captured eggs and larvae are Southern DPS green sturgeon or white sturgeon. Since green sturgeon females produce thousands of eggs and larvae, only a small fraction will be affected, so impacts to the population is not anticipated.

D. Effects of the Annual Program on Southern DPS of Pacific Eulachon Smelt

The Southern DPS of Pacific eulachon is threatened by decreased abundance, natural predation, commercial, and recreational fishing pressure (directed and by catch), and loss of habitat. NMFS anticipates that low numbers of Southern DPS of Pacific eulachon may be encountered during the implementation of the annual Program. Effects to eulachon are expected to be limited to only a few projects located in the sloughs and tidal portions of north coast rivers. The effects to eulachon associated with these projects are expected to be localized, minor, short-term, and primarily related to increased stress associated with capture and handling. This activity is not expected to cause any behavioral effects that would prevent Southern DPS Pacific eulachon from successfully holding, rearing, spawning, or feeding. Most of the effects will be minor, from capture, handle and releases of fish, and only a few will die (if any). If mortality occurs, NMFS expects that only one to a few individual may be killed or injured which is not expected to effect to the overall population since eulachon are highly fecund fish.

VI. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR 402.02 as "those effects of future State or private activities, not involving Federal activities, that are reasonably certain to occur within the action area of the Federal action subject to consultation." For the purpose of this analysis, the action area includes all coastal California streams from north of the Santa Maria River in San Luis Obispo County to the Oregon/California border and streams draining into San Francisco and San Pablo bays, including the Sacramento and San Joaquin River basins. Future Federal actions, including the ongoing operation of dams, hatcheries, fisheries, water withdrawals, and land management activities will be reviewed through separate ESA section 7 consultation processes and not considered here. On-going non-Federal actions which may affect listed species within the action area in the future are discussed in the environmental baseline.

VII. INTEGRATION AND SYNTHESIS

Populations of coho salmon, Chinook salmon, and steelhead in California have declined drastically over the last century and some subpopulations of salmonids have been lost. Within the action area, there are three salmon ESUs, four steelhead DPSs, one green sturgeon DPS, and one eulachon DPS listed as threatened under the ESA. The current status of listed salmonids in California, based upon their risk of extinction, has not significantly improved since the species were listed and some have deteriorated (NMFS 2003a, Good *et al.* 2005, Williams *et al.* 2011). The current status demonstrates the need for actions which will assist in the conservation and recovery of all of the listed salmonids, and that if measures are not taken to reverse these trends, the continued existence of these salmon ESUs and steelhead DPSs could be at risk. Southern DPS green sturgeon and Southern DPS eulachon populations have also decreased prompting them to be listed under the ESA.

A major cause of the decline of anadromous salmonids, green sturgeon and eulachon in California is the loss or severe decrease in quality and function of essential habitat. Most of this

habitat loss and degradation has resulted from anthropogenic watershed disturbances caused by agriculture, water diversion, urban development, erosion and flood control, dams, forestry, and gravel mining. Most of this habitat degradation has resulted in the loss of essential habitat components necessary for the survival of anadromous salmonids. In addition to habitat loss, eulachon have also be impacted by natural predation, and commercial and recreational fishing pressure (directed and bycatch).

The present body of scientific information relative to the abundance, distribution, and genetic composition of anadromous salmonid populations in California is incomplete (Good *et al.* 2005, Spence *et al.* 2007, Williams *et al.* 2011). In order to facilitate the restoration and recovery of ESA-listed salmonids in California, a mechanism directed toward developing a more robust and complete body of information is needed. NMFS has established protective regulations for threatened anadromous salmonids in California and has limited the prohibitions on take, as long as the take occurs as the result of a program that adequately protects the listed species and its habitat. The CDFG has annually requested a limit to take prohibitions for specific research and monitoring activities affecting all ESUs and DPSs of threatened anadromous salmonids in California since 2004.

The objective of this programmatic biological opinion is to determine if NMFS' annual approval of a 4(d) research limit for the Program for the next five years is likely to reduce appreciably the likelihood of both the survival and recovery of listed species in the wild by reducing the reproduction, numbers, or distribution of those species. Specific activities involving take of ESA-listed salmonids and green sturgeon anticipated in the Program may include: surveys by direct observation, capture by standard fishery gears, tagging, and other activities necessary to conduct studies aimed at the recovery of the species. The effect of the Program will consist of temporary behavior modification and rare instances of physical damage and/or possible unintentional mortality as a result of harassment, capture, or handling of individual fish, and a low level of intentional mortality.

The effects of the annual Program will consist of temporary behavior modification and rare instances of physical damage and/or possible unintentional mortality as a result of harassment, capture, handling or tagging of individual fish, and a low level of intentional mortality. These effects are unlikely to appreciably reduce the likelihood of survival and recovery of threatened salmon, steelhead, green sturgeon and eulachon at the sub-population, ESU or DPS scale because: (1) although the projects are spread out over most of California, potential impacts are expected to be confined to specific sampling sites during certain time periods in the action area, leaving most fish unaffected in streams where sampling occurs, (2) most of the projects do not propose intentional lethal take, and precautions will be required to minimize the chances of mortality to captured fish, (3) sampling gears are not 100 percent effective, and therefore, a portion of fish in the sampling areas will be unaffected by the projects, (4) projects within the same watersheds are coordinated so that efforts are complimentary, are not duplicated, and are not concentrated in the same area in order to minimize impacts to local salmonid populations, and (5) Eulachon are not specifically targeted and only very few are likely to be captured in a small portion of their range.

NMFS does not anticipate impacts to migrating, spawning, and rearing habitat associated with the research activities. The adult fish that are not killed as a result of the research activities are expected to produce thousands of offspring during and beyond the five years of the program, which will fill available habitat, regardless of the loss of a small number of spawning adults in some or all years of the program. With habitat filled, the impact of adult loss on the population will not be transmitted any further into the future during or after the program.

In addition, NMFS annually analyzes the impacts of the specific projects proposed for the annual Program. Projects approved in the annual Program must adhere to the general conditions and operating requirements of the Program including not exceeding the amount of take approved for each project annually. The majority of anticipated take for the annual Program will be non-lethal. Although proposed research activities may have an adverse impact on listed salmonid populations, NMFS expects the salmonid populations to be resilient to these impacts because none of the projects affect the species' production potential as spawning and rearing habitat will not be affected by the annual Program's impact for the next five years and populations are expected to successfully rebound from the total amount of mortalities anticipated. NMFS believes that the projects implemented in the Program for the next five years will make a significant contribution to the body of scientific knowledge and assist in conservation and management decisions for the protection of ESA-listed salmonids.

VIII. CONCLUSION

After reviewing the best available scientific and commercial information, the current status of SONCC coho salmon, CCC coho salmon, CC Chinook salmon, CVSR Chinook salmon, NC steelhead, CCC steelhead, S-CCC steelhead, CV steelhead, Southern DPS Pacific Eulachon smelt and Southern DPS green sturgeon, the environmental baseline for the action area, the effects of the proposed research and monitoring activities, and the cumulative effects, it is NMFS' biological opinion that approval to exempt ESA take prohibitions for the annual Program for the next five years (2012-2016), under the authority of section 4(d) of the ESA, is not likely to jeopardize the continued existence of these species.

IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit 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 as an act which actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, 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 the purpose of the agency action is not considered to be prohibited taking under the ESA

provided that such taking is in compliance with the terms and conditions of this incidental take statement.

A. Amount or Extent of Incidental Take

No incidental take is anticipated for salmon ESUs, steelhead DPSs, and Southern DPS green sturgeon. NMFS proposes to limit the take prohibitions for salmonids and provide and exemption to the take prohibitions for green sturgeon, exempting take for the 2012-2016 annual Programs for three salmon ESUs, four steelhead DPSs and one green sturgeon DPS pursuant to section 4(d) of the ESA.

The take prohibitions for the Southern DPS of Pacific eulachon Smelt do not exist until the 4(d) take prohibitions for this species have been issued. However, NMFS advises CDFG and their permitees to consider implementing the following reasonable and prudent measures for Pacific eulachon. Once the 4(d) take prohibitions are issued and become effective for Pacific eulachon, the terms and conditions below will be non-discretionary for any research projects that are currently described in this BO.

B. Effect of the Incidental Take

Only a few projects are likely to encounter Southern DPS Pacific eulachon smelt, based on sampling locations and Pacific eulachon abundance and distribution. Adult Pacific eulachon smelt will be captured, handled, and released. NMFS expects that mostly, only minor short-term, non-lethal effects to eulachon are likely to occur as a result of the research. No more than three percent of the total adult eulachon captured may die as result of the research activities. NMFS has determined that this amount of take is unlikely to jeopardize the continued existence of Southern DPS Pacific eulachon smelt.

C. Reasonable and Prudent Measures

The following reasonable and prudent measures are necessary and appropriate to minimize and monitor the impacts of incidental take of Pacific eulachon.

1. Measures shall be taken to determine the amount of actual take of Pacific eulachon.

D. Terms and Conditions

NMFS and CDFG must comply with the following terms and conditions, which implements the reasonable and prudent measure described above.

1. NMFS must require that CDFG and/or the principal investigators report the number of Pacific eulachon captured (non-lethal and lethal) in the annual reports for the annual Programs.

X. REINITIATION STATEMENT

This concludes formal programmatic consultation on NMFS' annual approval of a 4(d) research limit (salmonids) and 4(d) research exemption (green sturgeon) to the ESA take prohibitions for CDFG's Research Program for the next five years (2012-2016), under the authority of section 4(d) of the ESA. As provided in 50 CFR §402.16, reinitiation of programmatic or 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) the amount or extent of incidental take is exceeded, (2) new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered, (3) the identified action is subsequently modified in a manner that causes an effect to listed species or critical habitat that was not considered in the biological opinion, or (4) a new species is listed or critical habitat designated that may be affected by the identified action.

XI. LITERATURE CITED

Adams, N.S., D.W. Rondorf, S.D. Evans, and J.E. Kelly. 1998. Effects of Surgically and Gastrically Implanted Radio Transmitters on Growth and Feeding Behavior of Juvenile Chinook Salmon. Transactions of the American Fisheries Society 127(1):128-136 pages.

Adams, P.B. 2000. Status Review Update for the Steelhead Northern California Evolutionarily Significant Unit. National Marine Fisheries Service, Southwest Fisheries Science Center, Tiburon, California.

Adams, P. B., C. B. Grimes, S. T. Lindley, and M. L. Moser. 2002. Status review for North American green sturgeon, *Acipenser medirostris*. NOAA, National Marine Fisheries Service, Southwest Fisheries Science Center, Santa Cruz, California. 50 pages.

Adams, P. B., C. B. Grimes, J. E. Hightower, S. T. Lindley, M. L. Moser, and M. J. Parsley. 2007. Population status of North American green sturgeon, *Acipenser medirostris*. Environmental Biology of Fishes 79:339-356 pages.

Ainslie, B.J, J.R. Post, and A.J. Paul. 1998. Effects of pulsed and continuous DC electrofishing on juvenile rainbow trout. North American Journal of Fisheries Management 18:905-918 pages.

Alderdice, D.F. and Velsen, F.P.J. 1978. Relationship between temperature and incubation time for eggs of chinook salmon (Oncorhynchus tshawytscha). Journal of the Fisheries Research Board of Canada 35: 69-75 pages.

Allen, M.A., and T.J. Hassler. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific southwest) - Chinook salmon. United States Fish and Wildlife Service Biological Report 82(11.49):1-26.

Allen, M.J. and G.B. Smith. 1988. Atlas and zoogeography of common fishes in the Bering Sea and Northeastern Pacific. U.S. Department of Commerce, NOAA Technical Report NMFS-NWFSC-66.

Allen P.J., J.J. Cech, Jr. 2007. Age/size effects on juvenile green sturgeon, Acipenser medirostris, oxygen consumption, growth, and osmoregulation in saline environments. Environmental Biology of Fishes 79:211–229 pages.

Bailey, K.M. and E.D. Houde. 1989. Predation on eggs and larvae of marine fishes and the recruitment problem. Advances in Marine Biology 25:1-83 pages.

Baker, P., and F. Reynolds. 1986. Life history, habitat requirements, and status of coho salmon in California. Report to the California Fish and Game Commission.

Barnhart, R.A. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) B steelhead. U.S. Fish and Wildlife Service Biological Report 82(11.60):1-21 pages.

Barraclough, W.E. 1964. Contributions to the marine life history of the eulachon (Thaleichthys pacificus). Journal of the Fisheries Research Board of Canada 21(5):1333-1337 pages.

Barrett, B.M., F.M. Thompson, and S.N. Wick. 1984. Adult anadromous fish investigations: May-October 1983. Susitna Hydro Aquatic Studies, report No. 1, APA Document No. 1450. Alaska Department of Fish and Game, Anchorage, Alaska.

Bartholow, J.M. 1995. Review and analysis of Klamath River basin water temperatures as a factor in the decline of anadromous fish with recommendations for mitigation. River Systems Management Section, Midcontinent Ecological Science Center, United States National Biological Service, Fort Collins, Colorado. Final Draft.

Beacham, T.D., D.E. Hay, and K.D. Le. 2005. Population structure and stock identification of eulachon (Thaleichthys pacificus), an anadromous smelt, in the Pacific Northwest. Marine Biotechnology 7:363-372 pages.

Beamesderfer, R. C. P., M. L. Simpson, and G. J. Kopp. 2007. Use of life history information in a population model for Sacramento green sturgeon. Environmental Biology of Fishes 79:315-337 pages.

Bell, M.C. 1973. Fisheries handbook of engineering requirements and biological criteria. State Water Resources Control Board, Fisheries Engineering Research Program Portland Oregon. Contract No. DACW57-68-C-006.

Bell, M.C. 1991. Fisheries handbook of engineering requirements and biological criteria. 3rd Ed. U.S. Army, Corps of Engineers, Office of the Chief of Engineers, Fish Passage Development and Evaluation Program. Portland, Oregon.

Bendock, T. and M.Alexandersdottir. 1993. Hooking mortality of Chinook salmon released in the Kenai River, Alaska. North American Journal of Fisheries Management 13:540-549 pages.

Berggren, T.J., and M.J. Filardo. 1993. An analysis of variables influencing the migration of juvenile salmonids in the Columbia River Basin. North American Journal of Fisheries Management 13:48-63 pages.

Bergman, P.K., K.B. Jefferts, H.F. Fiscus, and R. Hager. 1968. A preliminary evaluation of an implanted coded-wire fish tag. Washington Department of Fisheries. Fisheries Research Paper 3(1):63-84 pages.

Bilby, R.E., B.R. Fransen, and P.A. Bisson. 1996. Incorporation of nitrogen and carbon from spawning coho salmon into the trophic system of small streams: evidence from stable isotopes. Canadian Journal of Fisheries and Aquatic Sciences 53:164-173 pages.

Bilby, R.E., B.R. Fransen, P.A. Bisson, and J.K. Walter. 1998. Response of juvenile coho salmon (Onchorynchus kisutch) and steelhead (Onchorynchus mykiss) to the addition of salmon carcasses to two streams in southwestern Washington, United States. Canadian Journal of Fisheries and Aquatic Sciences 55:1909-1918 pages.

Bilby, R.E., and P.A. Bisson. 1998. Function and distribution of large woody debris. Pages 324-346 in R. Naiman and R.E. Bilby, editors. River and Stream Ecology. Springer-Verlag. New York, New York.

Bjorkstedt, E.P., B.C. Spence, J.C. Garza, D.G. Hankin, D. Fuller, W.E. Jones, J.J. Smith, and R. Macedo. 2005. An analysis of historical population structure for evolutionarily significant units of Chinook salmon, coho salmon, and steelhead in the north-central California coast recovery domain. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center. 210 pages.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Pages 83-138 in W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland.

Boles, G. 1988. Water temperature effects on Chinook salmon (Oncorhynchus tshawytscha) with emphasis on the Sacramento River: A literature review. Report of the California Department of Water Resources, Northern District.

Bond, M.H. 2006. The importance of estuary rearing to Central California steelhead (Oncorhynchus mykiss) growth and marine survival. Master's thesis. University of California, Santa Cruz.

Boughton, D.A., P.B. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, and F. Watson. 2007. Viability criteria for steelhead of the South-central and Southern California Coast. NOAA-TM-NMFS-SWFSC-407. 41 pages.

Brandes, P.L., McLain J.S. 2001. Juvenile Chinook salmon abundance, distribution, and survival in the Sacramento-San Joaquin Estuary. In Brown R.L. editor, Contributions to the Biology of Central Valley salmonids. Fish Bulletin 179. Volume 2. Sacramento, Ca: California Department of Fish and Game. 39-136 pages.

Bratovich, P.M., and D.W. Kelley. 1988. Investigations of salmon and steelhead in Lagunitas Creek, Marin County, California: Volume I. Migration, Spawning, Embryo Incubation and Emergence, Juvenile Rearing, Emigration. Prepared for the Marin Municipal Water District, Corte Madera, California.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus Oncorhynchus. Journal of the Fisheries Research Board of Canada 9:265-323 pages.

Briggs, J.C. 1953. The behavior and reproduction of salmonid fishes in a small coastal stream. State of California Department of Fish and Game, Fish Bulletin 94:1-63 pages.

Brown, L.R., and P.B. Moyle. 1991. Status of coho salmon in California. Report to the National Marine Fisheries Service, Northwest Region, Portland, Oregon.

Brown, L.R., P.B. Moyle, and R.M. Yoshiyama. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14(2):237-261 pages.

Brown, W. M., III, and J. R. Ritter. 1971. Sediment transport and turbidity in the Eel River basin. United States Geological Survey. Water Supply Paper. 1986, 70.

Brungs, W.A., and B.R. Jones. 1977. Temperature criteria for freshwater fish: protocol and procedures. United States Environmental Protection Agency, Environmental Research Laboratory, EPA-600/3-77-061, Duluth, Minnesota.

Bryant, M.D. 1980. Evolution of large, organic debris after timber harvest: Maybeso Creek, 1949 to 1978, U. S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station.

Buckley, R.M. and H.L. Blankenship. 1990. Internal extrinsic identification systems: overview of implanted wire tags, otolith marks, and parasites. American Fisheries Society Symposium 7:173-182 pages.

Bureau of Land Management. 1995. Mainstem Trinity River watershed analysis. Section VI Detailed investigations. Redding, California.

Busby, P.J., T.C. Wainwright, G.J. Bryant., L. Lierheimer, R.S. Waples, F.W. Waknitz, and I.V. Lagomarsino. 1996. Status review of west coast steelhead from Washington, Idaho, Oregon and California. U.S. Department of Commerce, National Oceanic and Atmospheric Administration Technical Memo NMFS-NWFSC-27.

California Department of Water Resources. 2003. SP F-10 Task 2B Report. 2003 Lower Feather River Steelhead (*Oncorhyncus mykiss*) Redd Survey. Oroville Facilities Relicensing, FERC No. 2100.

California State Lands Commission. 1993. California=s rivers: A public trust report. Second edition, California State Lands Commission, 334 pages.

CALFED, 2001: Annual Report 2001. CALFED Bay-Delta Program, Sacramento, 78 pages.

CDFG (California Department of Fish and Game). 1965. California fish and wildlife plan. Volume III supporting data: part B, inventory salmon-steelhead and marine resources. California Department of Fish and Game, Sacramento, California.

CDFG (California Department of Fish and Game). 1991. Lower Yuba River Fisheries Management Plan. Stream Evaluation Report No. 91-1, February 1991.

CDFG (California Department of Fish and Game). 1994. Petition to the California Board of Forestry to list coho salmon (Oncorhynchus kisutch) as a sensitive species. California Department of Fish and Game Report, 35 pages, plus appendices.

CDFG (California Department of Fish and Game). 1997. Eel River Salmon and Steelhead Restoration Action Plan. Final Review Draft, January 28, 1997. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California.

CDFG (California Department of Fish and Game). 1998. Report to the Fish and Game Commission: A status review of the spring-run Chinook salmon (Oncorhynchus tshawytscha) in the Sacramento River drainage. Prepared by the Department of Fish and Game. Candidate Species Status Report 98-01.

CDFG (California Department of Fish and Game). 2001. Draft Russian River Basin Fisheries Restoration Plan. California Department of Fish and Game, Central Coast Region. Hopland, California.

CDFG (California Department of Fish and Game). 2002. Status review of California coho salmon north of San Francisco. Report to the California Fish and Game Commission. Candidate Species Status Review Report 2002-3, 232 pages, plus appendices.

CDFG (California Department of Fish and Game). 2002. California Department of Fish and Game comments to NMFS regarding green sturgeon listing. California Department of Fish and Game, Inland Fisheries Division, Sacramento, California. 79 pages. (plus appendices).

CDFG (California Department of Fish and Game). 2003. California Coastal Salmonid Restoration Monitoring and Evaluation Program, Interim Restoration Effectiveness and Validation Monitoring Protocols, March 2003. State of California, Resources Agency, California Department of Fish and Game. Sacramento, California.

Casagrande, J.M. 2010. Distribution, abundance, growth, and habitat use of steelhead in Uvas Creek, CA. Master's Thesis, San José State University. 174 pages.

Chambers, J. 1956. Fish passage development and evaluation program. Progress Report No. 5. United States Army Corps of Engineers, North Pacific Division, Portland, Oregon.

Chapman, D.W. and T.C. Bjornn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Pages 153-176 in T.G. Northcote, editor. Symposium on Salmon and Trout in Streams. H.R. Macmillan Lectures in Fisheries. Institute of Fisheries, University of British Columbia, Vancouver, British Columbia, 388 pages.

Chisholm, I.M. and W.A. Hubert. 1985. Expulsion of dummy transmitters by rainbow trout. Transactions of the American Fisheries Society 114:766-767 pages.

Cho, G.K., J.W. Heath, and D.D. Heath. 2002. Electroshocking influences Chinook salmon egg survival and juvenile physiology and immunology. Transactions of the American Fisheries Society 131:224-233 pages.

Clarke, A.D., A. Lewis, and K.H. Telmer. 2007. Life history and age at maturity of an anadromous smelt, the eulachon Thaleichthys pacificus (Richardson). Journal of Fish Biology 71:1479-1493 pages.

Coble, D.W. 1967. Effects of fin-clipping on mortality and growth of yellow perch with a review of similar investigations. Journal of Wildlife Management 31(1):173-180 pages.

CRWQCB (California Regional Water Quality Control Board). 2001. Assessment of Aquatic Conditions in the Mendocino Coast Hydrologic Unit. California Regional Water Quality Control Board, North Coast Region, Santa Rosa, California.

CSWRCB (California State Water Resources Control Board). 2003. 2002 Clean Water Act section 303(d) list of water quality limited segments. California Regional Water Quality Control Board, Sacramento, California.

Dalbey, S.R., T.E. McMahon, and W. Fredenberg. 1996. Effect of electrofishing pulse shape and electrofishing-induced spinal injury on long-term growth and survival of wild rainbow trout. North America Journal of Fisheries Management 16:560-569 pages.

Dare, M. R. 2003. Mortality and Long-Term Retention of Passive Integrated Transponder Tags by Spring Chinook Salmon. North American Journal of Fisheries Management 23(3):1015-1019 pages.

Deas, M.L., and G.T. Orlob. 1999. Klamath River Modeling Project. Center for Environmental and Water Resources Engineering, Department of Civil and Environmental Engineering, Water Resources Modeling Group. University of California, Davis. Sponsored by the United States Fish and Wildlife Service, Klamath Basin Fisheries Task Force. December.

Demko, D.B., C. Gemperle, A. Phillips, and S.P. Cramer. 2000. Outmigrant trapping of juvenile salmonids in the lower Stanislaus River, Caswell State Park site, 1999. Prepared for U.S. Fish and Wildlife Service. Prepared by S.P. Cramer and Associates, Inc. Gresham, Oregon.

Dettlaff, T.A., A.S. Ginsburg, and O.I. Schmalhausen. 1993. Sturgeon Fishes: Developmental Biology and Aquaculture. Springer-Verlag, New York. 300 pages.

Dolloff, C.A, J. Kershner, and R. Thurow. 1996. Underwater observation. Pages 533-554 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, second edition. American Fisheries Society. Bethesda, Maryland, 732 pages.

Drake, A. and L. Wilson. 1991. Eulachon, a fish to cure humanity. UBC Museum of Anthropology, Museum Note 32.

Duke, R. 1986. Protection of Wild Adult Steelhead in Idaho by Adipose Fin Removal. Project No. 1984-00200, 47 pages, (BPA Report DOE/BP-14903-2).

Dunford, W.E. 1975. Space and food utilization by salmonids in marsh habitats in the Fraser River Estuary. Master of Science Thesis. University of British Colombia, Vancouver, British Columbia.

Eames, M., T. Quinn, K. Reidinger, and D. Haring. 1981. Northern Puget Sound 1976 adult coho and chum tagging studies. Washington Department of Fisheries Technical Report 64:1-136 pages.

East Bay Municipal Utility District. 2004. Lower Mokelumne River Fisheries Monitoring Program: Annual Section 10 Permit Report, Permit #1414, April 1- September 15, 2004, Lodi, California.

EPA (Environmental Protection Agency). 1998. Total Maximum Daily Load for Sediment. Redwood Creek, California. Region 9.

Erickson, D. L. and M. A. H. Webb. 2007. Spawning periodicity, spawning migration, and size at maturity of green sturgeon, Acipenser medirostris, in the Rogue River, Oregon. Environmental Biology of Fishes 79:255-268pages.

Eschmeyer, W.N., E.S. Herald, and H. Hammann. 1983. A field guide to Pacific coast fishes of North America. Houghton Mifflin Company, Boston, Massachusetts.

Everest, F.H., and D.W. Chapman. 1972. Habitat selection and spatial interaction by juvenile Chinook salmon and steelhead trout. Journal of the Fisheries Research Board of Canada 29:91-100.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment.

Fletcher, D.H., F. Haw and P.K. Bergman. 1987. Retention of coded-wire tags implanted into cheek musculature of largemouth bass. North American Journal of Fisheries Management 7:436-439.

Florsheim, J.L. and P. Goodwin. 1993. Geomorphic and hydrologic conditions in the Russian River, California historic trends and existing conditions. Prepared for the California State Coastal Conservancy and the Mendocino County Water Agency.

Flosi, G., S. Downie, J. Hopelain, M. Bird, R. Coey, and B. Collins. 1998. California Salmonid Stream Habitat Restoration Manual. Third Edition. Inland Fisheries Division. California Department of Fish and Game. Sacramento, California.

Fox, D.A., J.E. Hightower, and F.M. Parauka. 2000. Gulf sturgeon spawning migration and habitat in the Choctawhatchee River System, Alabama-Florida. Transactions of the American Fisheries Society 129:811-826.

Fraser, J., P. Gallaugher, R. Joy, and R. Routledge. 2002. Reducing gill-net mortality of incidentally caught coho salmon. North American Journal of Fisheries Management 22:1270-1275.

Fredenberg, W.A. 1992. Evaluation of electrofishing induced spinal injuries resulting from field electrofishing surveys in Montana. Montana Department of Fish, Wildlife and Parks, Helena, Montana.

Good, T.P., R.S. Waples, and P. Adams (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Department of Commerce, NOAA Technical Memo NMFS-NWFSC-66.

Gresh, T., J. Lichatowich, and P. Schoonmaker. 2000. An estimation of historic and current levels of salmon production in the northeast pacific ecosystem. Fisheries 15(1):15-21.

Griggs, G.B., and J.R. Hein. 1980. Sources, dispersal, and clay material composition of fine-grained sediment off central and northern California. Journal of Geology 88:541-566.

Groot, C., and L. Margolis. 1991. Pacific salmon life histories. University of British Columbia, Vancouver, Canada.

Habersack, H. and H.P Nachtnebel. 1995. Short-term effects of local river restoration on morphology, flow field, substrate and biota. Regulated Rivers: Research & Management 10(3-4):291-301.

Haley, N. 1998. A gastric lavage technique for characterizing diets of sturgeons. North American Journal of Fisheries Management 18(4):978-981.

Hall, J.D. and R.L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. Pages 355-375 in T.G. Northcote, editor. Symposium on salmon and trout in streams. University of British Columbia, Vancouver, Canada.

Hanson, L.C. 1993. The foraging ecology of harbor seals, Phoca vitulina, and California sea lions, Zalophus californianus, at the mouth of the Russian River, California. Master of Arts thesis, Sonoma State University, Rohnert Park, California.

Hart, J.L. and J.L. McHugh. 1944. The smelts (Osemeridae) of British Columbia. Fisheries Research Board of Canada 64. 27 p.

Hartleb, C.F., and J.R. Moring. 1995. An improved gastric lavage device for removing stomach contents from live fish. Fisheries Research 24:261-265.

Hassler, T.J. 1987. Species Profiles: life histories and environmental requirements of coastal fishes and invertebrates (Pacific Southwest) - coho salmon. United States Fish and Wildlife Service Biological Report 82(11.70):1-19.

Hay, D.E. and P.B. McCarter. 2000. Status of the eulachon Thaleichthys pacificus in Canada. Department of Fisheries and Oceans Canada, Canadian Stock Assessment

Secretariat, Research Document 2000-145. Ottawa, Ontario. Online at http://www.dfo-mpo.gc.ca/csas/csas/DocREC/2000/PDF/2000_145e.pdf.

Hay, D.E., P.B. McCarter, R. Joy, M. Thompson, and K.C. West. 2002. Fraser River eulachon biomass assessment and spawning distribution: 1995-2002. Fisheries an Oceans Canada, Science Branch, Stock Assessment Division, Nanaimo, British Columbia.

Hay, D.E., K.C. West, and A.D. Anderson. 2003. Indicators and 'response' points for management of Fraser River eulachon: a comparison and discussion with recommendations. Canadian Science Advisory Secretariat Research Document 2003/051. Online at http://www.dfompo.gc.ca/csas/Csas/DocREC/2003/RES2003_051_E.pdf.

Hay, D.E. and T.D. Beacham. 2005. Stock identification of eulachon (Thaleichthys pacificus), an anadromous smelt in the eastern Pacific. Paper presented at ICES 2005 Annual Science Conference, Aberdeen, Scotland, UK. Online at http://www.ices.dk/products/CMdocs/2005/K/K1405.pdf.

Hayes, D.B., C.P. Ferreri, and W.W. Taylor. 1996. Active fish capture methods. Pages 193-220 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, Maryland.

Hayes, M.L. 1983. Active capture techniques. Pages 123-146 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland.

Hayes, S.A., Bond, M.H., Hanson, C.V., Freund, E.V., Smith, J.J., Anderson, E.C., Ammann, A., and MacFarlane, R.B. 2008. Steelhead growth in a small central California watershed: upstream and estuarine rearing patterns. Trans. Am. Fish. Soc. 137: 114-128, DOI: 110.1577/T1507-1043.1571.

Healey, M.C. 1991. Life history of Chinook salmon (Oncorhynchus tshawytscha). Pages 396-445 in C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, British Columbia.

Hecht, B., and G.R. Kamman. 1996. Initial Assessment of Pre- and Post-Klamath Project Hydrology on the Klamath River and Impacts of the Project on instream Flows and Fishery Habitat. Balance Hydrologics, Incorporated. March.

Heublein, J. C., J. T. Kelly, C. E. Crocker, A. P. Klimley, and S. T. Lindley. 2009. Migration of green sturgeon, Acipenser medirostris, in the Sacramento River. Environmental Biology of Fishes 84:245–258.

Higgins, P., S. Dobush, and D. Fuller. 1992. Factors in northern California threatening stocks with extinction. Unpublished manuscript, Humboldt Chapter American Fisheries Society.

Hilderbrand, R.H., A.D. Lemly, C.A. Dolloff, and K.L. Harpster. 1997. Effects of large woody debris placement on stream channels and benthic macroinvertebrates. Canadian Journal of Fisheries and Aquatic Sciences 54:931-939.

Hilderbrand, R.H., A.D. Lemly, C.A. Dolloff, and K.L. Harpster. 1998. Design considerations for large woody debris placement in stream enhancement projects. North American Journal of Fisheries Management 18(1):161-167.

Hokanson, K. E. F., C. F. Kleiner, and T. W. Thorslund. 1977. Effects of constant temperatures and diel temperature fluctuations on specific growth and mortality rates of juvenile rainbow trout, Salmo gairdneri. Journal of the Fisheries Research Board of Canada 34:639-648.

Hollender, B.A. and R.F. Carline. 1994. Injury to wild brook trout by backpack electrofishing. North American Journal of Fisheries Management 14:643-649.

Holtby, L.B., B.C. Anderson, and R.K. Kadowaki. 1990. Importance of smolt size and early ocean growth to interannual variability in marine survival of coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Sciences 47(11):2181-2194.

Howe, N.R. and P.R. Hoyt. 1982. Mortality of juvenile brown shrimp Penaeus aztecus associated with streamer tags. Transactions of the American Fisheries Society 111(3):317-325.

Hubert, W.A. 1983. Passive capture techniques. Pages 95-122 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland.

Hubert, W.A. 1996. Passive capture techniques. Pages 157-192 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques. Second Edition. American Fisheries Society. Bethesda, Maryland.

Huff, D.D., S.T. Lindley, P.S. Rankin, and E.A. Mora. 2011. Green sturgeon physical habitat use in the coastal Pacific Ocean. PLOS One 6(9):e25156.

Hugg, D.O. 1996. MAPFISH georeferenced mapping database. Freshwater and estuarine fishes of North America. D.O. and S. Hugg, editors. Life Science Software, Edgewater, Maryland.

Hughes, R.M. 2004. Year 2004 Annual Report for research completed in California by Dynamic Corporation (USEPA research contractor) under Section 10 permit #1288. 7 pages.

Interagency Ecological Program Steelhead Project Work Team. 1999. Monitoring, assessment, and research on Central Valley steelhead: status of knowledge, review existing programs, and assessment needs. In Comprehensive Monitoring, Assessment, and Research Program Plan, Tech. Appendix VII.

Israel, J. 2010. Memo to Melissa Neuman (NMFS) regarding unknown observer sample genotypes and assignment, dated August 11, 2010. 4 pp.

Israel, J.A., K.J. Bando, E.C. Anderson, and B. May. 2009. Polyploid microsatellite data reveal stock complexity among estuarine North American green sturgeon (Acipenser medirostris). Canadian Journal of Fisheries and Aquatic Sciences 66:1491 – 1504.

Israel, J.A. and A.P. Klimley. 2008. "Life history conceptual model for North American green sturgeon (Acipenser medirostris)" CDFG Delta Regional Ecosystem Restoration and Implementation Program. FINAL, 45 pages.

Israel, J.A. and B. May. 2010. Indirect genetic estimates of breeding population size in the polyploidy green sturgeon (Acipenser medirostris). Molecular Ecology 2010:1058-1070.

Israel, J.A., M. Neuman, M.L. Moser, S.T. Lindley, B.W McCovey Jr., D.L. Erickson, and P. Klimley. In prep. Recent advances in understanding the life history of green sturgeon (Acipenser medirostris) and potential anthropogenic threats to this imperiled fish.

Jenkins, W.E. and T.I.J. Smith. 1990. Use of PIT tags to individually identify striped bass and red drum brood stocks. American Fisheries Society Symposium 7:341-345.

Jennings, M.R. 1996. Past occurrence of eulachon, Thaleichthys pacificus, in streams tributary to Humboldt Bay, California. California Fish and Game 82(6):147-148.

Jensen, P.T., and P.G. Swartzell. 1967. California salmon landings 1952 through 1965. California Department of Fish and Game, Fish Bulletin 135:1-57.

Jones and Stokes Associates, Incorporated. 2000. Final environmental impact report/environmental impact statement for the lower Mokelumne River Restoratation Program. (J&S 98-059.) May. Prepared for the Woodbridge Irrigation District, Woodbridge, California.

Kahn, Jason, and Malcolm Mohead. 2010. A Protocol for Use of Shortnose, Atlantic, Gulf, and Green Sturgeons. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-OPR-45, 62 p

Kamler J.F. and K.L. Pope. 2001. Nonlethal methods of examining fish stomach contents. Reviews in Fisheries Science 9:1-11.

Keefer, M.L., Peery, C.A., Jepson, M.A., Tolotti, K.R., Bjornn, T.C., Stuehrenberg, L.C. 2004: Stock-Specific Migration Timing of Adult Spring–Summer Chinook Salmon in the Columbia River Basin, North American Journal of Fisheries Management, 24:4, 1145-1162

Keljson, M.A., P.F. Raquel, and F.W. Fisher. 1981. Life history of fall-run juvenile Chinook salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin Estuary. In R.D. Cross and D.L. Williams (editors), Proceedings of the National Symposium on Freshwater Inflow to Estuaries, pages 88-108. U.S. Fish and Wildlife Service, FWS/OBS-81-04.

Keljson, M.A., P.F. Raquel, and F.W. Fisher. 1982. Life history of fall-run juvenile Chinook salmon (Oncorhynchus tshawytscha) in the Sacramento-San Joaquin Estuary, California, pp.393-411. In: V.S. Kennedy (ed.). Estuarine comparisons Academic Press, New York NY.

Keller, E.A. and F.J. Swanson. 1979. Effects of large organic material on channel form and fluvial processes. Earth Surface Processes 4:361-380.

Kelly, J. T., A. P. Klimley, and C. E. Crocker. 2007. Movements of green sturgeon, Acipenser medirostris, in the San Francisco Bay Estuary, California. Environmental Biology of Fishes 79:281-295.

Kelsch, S.W. and B. Shields. 1996. Care and handling of sampled organisms. Pages 121-156 in B.R. Murphy and D.W. Willis, editors. Fisheries Techniques, 2nd edition. American Fisheries Society. Bethesda, Maryland.

Kohler, C.C. and W.A. Hubert. 1993. Inland Fisheries Management in North America. American Fisheries Society. Bethesda, Maryland.

KRBFTF (Klamath River Basin Fisheries Task Force). 1991. Long Range Plan for the Klamath River Basin Conservation Area Fishery Restoration Program. Klamath River Basin Fisheries Task Force. January.

Larson, Z.S. and M.R. Belchik. 2000. A preliminary status review of eulachon and 15 Pacific lamprey in the Klamath River Basin. Yurok Tribal Fisheries Program, Klamath, California.

Leidy, R.A. 1997. Estuary Report June 1997. United States Environmental Protection Agency. San Francisco Estuary Project.

Leopold, L.B. 1968. Hydrology for urban land planning - A guidebook on the hydrologic effects on urban land use. United States Geologic Service Circular 554.

Levings, C.D. 1982. Short term use of low-tide refugia in a sand flat by juvenile chinook, (Oncorhynchus tshawytscha), Fraser River estuary. Canadian Technical Reports of Fisheries and Aquatic Sciences, Number 1111.

Levings, C.D., C.D. McAllister, and B.D. Chang. 1986. Differential use of the Campbell River estuary, British Columbia, by wild and hatchery-reared juvenile Chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences 43:1386-1397.

Levy, D.A., and T.G. Northcote. 1982. Juvenile salmon residency in a marsh area of the Fraser River estuary. Canadian Journal of Fisheries and Aquatic Sciences 39:270-276.

Lindley, S. T., R. S. Schick. 2007. "Framework for assessing viability of threatened and endangered Chinook salmon and steelhead in the Sacramento-San Joaquin Basin." San Francisco Estuary and Watershed Science 5(1).

Lindley, S. T., C. B. Grimes, M. S. Mohr, W. Peterson, J. Stein, J. T. Anderson, L.W. Botsford, D. L. Bottom, C. A. Busack, T. K. Collier, J. Ferguson, J. C. Garza, A. M. Grover, D. G. Hankin, R. G. Kope, P. W. Lawson, A. Low, R. B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F. B. Schwing, J. Smith, C. Tracy, R. Webb, B. K. Wells, and T. H. Williams. 2009. What caused the Sacramento River fall Chinook stock collapse? Pre-publication report to the Pacific Fishery Management Council. March 18, 2009, 57 pp.

Lindley, S.T., D.L. Erickson, M.L. Moser, G. Williams, O.P. Langness, B.W. McCovey, M. Belchik, D. Vogel, W. Pinnix, J.T. Kelly, J.C. Heublein, and A.P. Klimley. 2011. Electronic tagging of green sturgeon reveals population structure and movement among estuaries. Transactions of the American Fisheries Society 140:108-122.

Lindley, S. T., M. L. Moser, D. L. Erickson, M. Belchik, D. W. Welch, E. Rechisky, J. T. Kelly, J. C. Heublein, and A. P. Klimley. 2008. Marine migration of North American green sturgeon.
Transactions of the American Fisheries Society 137:182-194.

Maahs, R.P., S.A. Dressing, J. Spooner, M.D. Sniolen and F.J. Himenik. 1984. Best management practices for agricultural nonpoint source control-IV. Pesticides. National Water Quality Evaluation Project Report. North Carolina University, Raleigh, North Carolina.

MacFarlane, RB, Norton, EC. 2002. Physiological ecology of juvenile chinook salmon (Oncorhynchus tshawytscha) at the southern end of their distribution, the San Francisco Estuary and the Gulf of the Farallones, 343 California. Fishery Bulletin 100:244-257.

Martin, C.D., P.D. Gaines, and R.R. Johnson. 2001. Estimating the abundance of Sacramento River juvenile winter Chinook salmon with comparisons to adult escapement. Red Bluff

Research Pumping Plant Report Series, Volume 5. U.S. Fish and Wildlife Service, Red Bluff, California.

Maslin, P., M. Lennox, and W. McKinney. 1997. Intermittent streams as rearing habitat for Sacramento River Chinook salmon (Oncorhynchus tshawytscha). California State University, Chico, Department of Biological Sciences. 89 pages.

Matthews, K.R. and R.H. Reavis. 1990. Underwater tagging and visual recapture as a technique for studying movement patterns of rockfish. American Fisheries Society Symposium 7:168-172.

Matter, A. L. and Sandford, B. P. 2003. A comparison of migration rates of radio- and PIT-tagged adult Snake River Chinook salmon through the Columbia River hydropower system. North American Journal of Fisheries Management, 23: 967–973.

McCabe, G.T., and L.G. Beckman. 1990. Use of an artificial substrate to collect white sturgeon eggs. California Department of Fish and Game 76(4):248-250.

McDonald, J. 1960. The behavior of Pacific salmon fry during the downstream migration to freshwater and saltwater nursery areas. Journal of the Fisheries Research Board of Canada 17:655-676.

McEwan, D. 2001. Central Valley steelhead. Contributions to the biology of Central Valley salmonids. California Department of Fish and Game Fish Bulletin 179(1):1-44.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. California Department of Fish and Game, Sacramento, California.

McMahon, T.E. 1983. Habitat suitability index models: coho salmon. United States Fish and Wildlife Service, FWS/OBS-82/10.49:1-29.

McMichael, G.A. 1993. Examination of electrofishing injury and short-term mortality in hatchery rainbow trout. North American Journal of Fisheries Management 13:229-233.

Meehan, W.R. and T.C. Bjornn. 1991. Salmonid distributions and life histories. Pages 47-82 in W.R. Meehan, editor. Influences of Forest and Rangeland Management on Salmonid Fishes and Their Habitats. American Fisheries Society Special Publication 19. American Fisheries Society. Bethesda, Maryland.

Meehan, W.R., and R.A. Miller. 1978. Stomach flushing: effectiveness and influence on survival and condition of juvenile salmonids. Journal of the Fisheries Research Board of Canada 35:1359-1363.

Meehan, W.R. 1996. Influence of riparian canopy on macroinvertebrate composition and food habits of juvenile salmonids in several Oregon streams. Research Paper PNW-RP-496.

United States Department of Agriculture, Forest Service, Pacific Northwest Research Station. Portland, Oregon.

Mellas, E.J. and J.M. Haynes. 1985. Swimming performance and behavior of rainbow trout (Salmo gairdneri) and white perch (Morone americana): effects of attaching telemetry transmitters. Canadian Journal of Fisheries and Aquatic Sciences 42:488-493.

Minckley, W.L., D.A. Hendrickson, and C.E. Bond. 1986. Geography of western North American freshwater fishes: Description and relationship to intracontinental tectonism. In C. H. Hocutt and E. O. Wiley (eds.), The zoogeography of North American freshwater fishes, p. 519-613. New York, John Wiley and Sons.

Mora, E.A., S.T. Lindley, D.L. Erickson, and A.P. Klimley. 2009. Do impassable dams and flow regulation constrain the distribution of green sturgeon in the Sacramento River, California? Journal of Applied Ichthyology 25 (Supplement 2):39-47.

Mora, Ethan. PhD candidate, UC Davis, Davis, CA. January 10, 2012. Personal communication with Joe Heublein, via phone call with Susan Wang (NMFS), regarding estimates of green sturgeon abundance in Southern DPS rivers in 2010 and 2011.

Moring, J.R. 1990. Marking and tagging intertidal fishes: review of techniques. American Fisheries Society Symposium 7:109-116.

Moser, Mary. Research fishery biologist, NMFS NWFSC, Seattle, WA. Unpublished data regarding preliminary observations from feeding pit mapping surveys conducted in Willapa Bay, WA. Cited in: NMFS. 2011. Endangered Species Act Section 7 consultation - Biological Assessment for the continued operation of the Pacific Coast Groundfish Fisheries for the period of January 1 – December 31, 2012. Prepared by the NMFS Northwest Region Sustainable Fisheries Division. 162 pages.

Moser, M. and S. Lindley. 2007. Use of Washington estuaries by subadult and adult green sturgeon. Environmental Biology of Fishes 79:243-253.

Moyle, P.B. 2002. Inland Fishes of California. University of California Press. Berkeley, California.

Murphy, B.R., and D.W. Willis, editors. 1996. Fisheries Techniques, 2nd edition. American Fisheries Society, Bethesda, Maryland.

Musick, J.A., M.M. Harbin, S.A. Berkeley, G.H. Burgess, A.M. Eklund, L. Findley, R.G. Gilmore, J.T. Golden, D.S. Ha, G.R. Huntsman, J.C. McGovern, G.R. Sedberry, S.J. Parker, S.G. Poss, E. Sala, T.W. Schmidt, H. Weeks, and S.G. Wright. 2000. Marine, estuarine, and diadromous fish stocks at risk of extinction in North America (exclusive of Pacific salmonids). Fisheries 25(11): 6-30.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grant, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. Technical Memorandum NMFS-NWFSC-35. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Myrick, C. A., and J. J. Cech. 2005. Effects of temperature on the growth, food consumption, and thermal tolerance of age-0 Nimbus-strain steelhead. North American Journal of Aquaculture 67:324–330.

Nakamoto, R. J., T. T. Kisanuki, and G. H. Goldsmith. 1995. Age and growth of Klamath River green sturgeon (Acipenser medirostris). U.S. Fish and Wildlife Service Project 93-FP-13, Yreka, CA. 20 pages.

National Research Council. 1995. Science and the Endangered Species Act. National Research Council Committee on Scientific Issues in the Endangered Species Act. National Academy Press, Washington, D.C.

National Research Council. 1996. Upstream: Salmon and Society in the Pacific Northwest. National Research Council Committee on Protection and Management of Pacific Northwest Anadromous Salmonids. National Academy Press, Washington, D.C.

National Research Council. 2003. Endangered and Threatened Fishes in the Klamath River Basin: Causes of Decline and Strategies for Recovery. National Academy Press, Washington, D.C.

Nehlson, W., J.E. Williams, and L.A. Lichatowich. 1991. Pacific salmon at the crossroads: stocks at risk from California, Oregon, Idaho, and Washington. Fisheries 16:4-21.

Newcombe, C. P., and J. O. T. Jensen. 1996. Channel suspended sediment and fisheries: A synthesis for quantitative assessment of risk and impact, North American Journal of Fisheries Management 16:693-727.

Nielsen, J.L. 1992. Microhabitat-specific foraging behavior, diet, and growth of juvenile coho salmon. Transactions of the American Fisheries Society 121:617-634.

Nielsen L.A. and D.L. Johnson, editors. 1983. Fisheries Techniques. American Fisheries Society, Bethesda, Maryland, 468 pages.

NMFS (National Marine Fisheries Service),. 1996. Factors for decline: a supplement to the notice of determination for West Coast steelhead under the Endangered Species Act. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service),. 1997. Status review update for West Coast steelhead from Washington, Idaho, Oregon, and California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service),. 1998. Factors contributing to the decline of Chinook salmon: an addendum to the 1996 West Coast steelhead factors for decline report. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service),. 1999a. Impacts of California sea lions and Pacific harbor seals on salmonids and West Coast ecosystems. Report to Congress. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service), 1999b. Biological and conference opinion on the Natural Resources Conservation Service=s Emergency watershed protection project on La Honda Creek. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. File Number 151422SWR99SR811. Santa Rosa Area Office. March 1, 1999.

NMFS (National Marine Fisheries Service), 2001. Status review update for coho salmon (Oncorhynchus kisutch) from the Central California Coast and the California portion of the Southern Oregon/Northern California Coasts Evolutionarily Significant Units. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

NMFS (National Marine Fisheries Service), 2002. Biological opinion for the proposed license amendment for the Potter Valley Project (Federal Energy Regulatory Commission Project Number 77-110). United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. File Number 151422SWR02SR6412. Santa Rosa Area Office. November 26, 2002.

NMFS (National Marine Fisheries Service),. 2003a. Draft Report of Updated Status of Listed ESUs of Salmon and Steelhead. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. , Northwest Fisheries Science Center, Seattle, Washington. (http://www.nwfsc.noaa.gov/cbd/trt/brt/brtrpt.html)

NMFS (National Marine Fisheries Service),. 2003b. Letter and Biological Opinion on United States Army Corps of Engineer=s Letter of Permission Procedure for Gravel Mining and Excavation Activities in Del Norte County (LOP 2003-2) and Granite Construction's proposed gravel extraction operations. United States Department of Commerce, National

Oceanic and Atmospheric Administration, National Marine Fisheries Service. , Southwest Region, Long Beach, California. September 22.

NMFS (National Marine Fisheries Service),. 2005. Green sturgeon (Acipenser medirostris) Status Review Update. National Marine Fisheries Service. Biological review team-Southwest Fisheries Science Center, Santa Cruz, California. 35 pages.

NMFS (National Marine Fisheries Service),. 2007a. Southern Oregon/Northern California Coast Coho Salmon 2007 Federal Recovery Outline. Prepared by the National Marine Fisheries Service Southwest Region. 44 pages.

NMFS (National Marine Fisheries Service),. 2007b. 2007 Federal Recovery Outline for the Distinct Population Segment of South-Central California Coastal Steelhead. Prepared by the National Marine Fisheries Service Southwest Region. 56 pages.

NMFS (National Marine Fisheries Service). 2008. Listing endangered and threatened species: Notification of finding on a petition to list Pacific eulachon as an endangered or threatened species under the Endangered Species Act. Federal Register (Docket Number 080229343–8368–01; 21 March 2008) 73(49):13185–13189.

NMFS (National Marine Fisheries Service). 2009a. Biological Opinion and Conference Opinion on the long-term operations of the Central Valley Water Project and State Water Project. 839 pages.

NMFS (National Marine Fisheries Service),. 2010a. Environmental assessment for the proposed application of protective regulations under Section 4(d) of the Endangered Species Act for the threatened Southern Distinct Population Segment of North American green sturgeon. Department of Commerce, NOAA, NMFS, Southwest Region, Long Beach, CA. 101 pages. Available online at: http://swr.nmfs.noaa.gov/gs/GreenSturgeon4d_Final_Environmental_Assessment.pdf.

NMFS (National Marine Fisheries Service),. 2010b. Federal Recovery Outline for North American green sturgeon, Southern Distinct Population Segment. Prepared by NMFS Southwest Region, Santa Rosa, CA. 23 pages. December 2010. Available online at: http://swr.nmfs.noaa.gov/gs/jd/Green_Sturgeon_sDPS_Recovery_Outline.pdf.

NMFS (National Marine Fisheries Service), 2010c. Biological Opinion for the Reinitiation of a Protected Species Conservation and Recovery Grant to the Yurok Tribe (Award File NA10NMF4720374) to Conduct Research on Eulachon Smelt in northern California. 31 pages.

NMFS (National Marine Fisheries Service). 2011a. Southern Oregon/ Northern California Coast Recovery Domain 5-year Review: Summary and Evaluation of Southern Oregon/Northern California Coast Coho Salmon ESU. Southwest Region 59 pages.

NMFS (National Marine Fisheries Service). 2011b. North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon ESU and Central California Coast Coho Salmon ESU. Southwest Region. 54 pages.

NMFS (National Marine Fisheries Service). 2011c. Central Valley Recovery Domain 5-Year Review: Summary and Evaluation of Central Valley Spring-run Chinook Salmon ESU. Southwest Region. 34 pages.

NMFS (National Marine Fisheries Service). 2011d. North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of Central California Coastal Steelhead DPS and Northern California Steelhead DPS. Southwest Region. 67 pages.

NMFS (National Marine Fisheries Service). 2011e. South-Central/Southern California Coast Steelhead Recovery Planning Domain. 5-Year Review: Summary and Evaluation of South-Central California Coast steelhead Distinct Population Segment. National Marine Fisheries Service, Southwest Region, Long Beach, California. 24 pages.

NMFS NMFS (National Marine Fisheries Service). 2011f. Central Valley Recovery Domain 5-Year Review: Summary and Evaluation of Central Valley Steelhead DPS. Southwest Region. 34 pages.

Odemar, M.W. 1964. Southern range extension of the eulachon, Thaleichthys pacificus. California Fish Game 50:305-307.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife. 2007. Status report: Columbia River fish runs and fisheries, 1938-2002.

(PSFMC) Pacific States Fisheries Management Council 2010 Review of 2009 Ocean salmon fisheries: Appendix B. Pacific States Fisheries Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384.

Perala, N. C., T. Dunklin, F. Euphrat, W. Smith, and C. May. 1993. ARapid evaluation of sediment budgets: Annual sediment contribution from roads in the Mattole watershed.@ Unpublished paper.

Poole, G.C., C.H. Berman. 2001. An ecological perspective on in-stream temperature: Natural heat dynamics and mechanisms of human-caused thermal degradation. Environmental Management 27, 787-802. DOI: 10.1007/s002670010188

Powell, M.A. 1997. Water-quality concerns in restoration of stream habitat in the Umpqua basin. Pages 129-132 in J.D. Hall, P.A. Bisson and R.E. Gresswell, editors. Sea-run Cutthroat Trout: Biology, Management, and Future Conservation. American Fisheries Society, Oregon Chapter, Corvallis, Oregon.

Poytress, W.R., J.J. Gruber, and J.P. Van Eenennaam. 2011. 2010 Upper Sacramento River Green Sturgeon Spawning Habitat and Larval Migration Surveys. Annual Report of U.S. Fish and Wildlife Service to U.S. Bureau of Reclamation, Red Bluff, CA.

Prentice, E.F., T.A. Flagg, and C.S. McCutcheon. 1990. Feasibility of using implantable passive integrated transponder (PIT) tags in salmonids. American Fisheries Society Symposium 7:317-322.

Prentice, E.F., D.J. Maynard, S.L. Downing, D.A. Frost, M.S. Kellett, D.A. Bruland, P. Sparks-McConkey, F.W. Waknitz, R.N. Iwamoto, K. McIntyre, and N. Paasch. 1994. A study to determine the biological feasibility of a new fish tagging system (1990-93). United States Department of Energy, Bonneville Power Administration, Division of Fish and Wildlife, Portland, Oregon. Project Number 83-3 19, Report DOE/BP-11982-5.

Reid, L.M. 1994. Evaluating timber management effects on beneficial uses in Northwest California, Arcata, Pacific Southwest Research Station. Report to the California Department of Fire and Forestry Protection, 164 pages.

Reiser, D.W., and T.C. Bjornn. 1979. Habitat requirements of anadromous salmonids. United States Department of Agriculture Forest Service General Technical Report PNW-96, 54 pages.

Rich, A. A. 1997. Testimony of Alice A. Rich, Ph.D. Regarding Water Rights Applications for the Delta Wetlands Project, Proposed by Delta Wetlands Properties for Water Storage on Webb Tract, Bacon Island, Bouldin Island, and Holland Tract in Contra Costa and San Joaquin Counties. California Department of Fish and Game Exhibit DFG-7. Submitted to State Water Resources Control Board.

Ricker, W.E., D.F. Manzer, and E.A. Neave. 1954. The Fraser River eulachon fishery, 1941-1953. Fisheries Research Board of Canada, Manuscript Report Number 583.

RNSP (Redwood National and State Parks). 2002. A Biological Assessment of Impacts to Aquatic Threatened Species from the Watershed Restoration Program in the Northern Portion of Lost Man Creek Watershed, Redwood National and State Parks. June, 2002.

Salo, E., and W.H. Bayliff. 1958. Artificial and natural production of silver salmon, Oncorhynchus kisutch, at Minter Creek, Washington. Washington Department of Fisheries Research Bulletin 4, Washington Department of Fish and Wildlife, Olympia, Washington.

San Francisco Estuary Project. 1992. State of the Estuary, A report on conditions and problems in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary. Prepared under Cooperative Agreement #CE-009486-02 with the United States Environmental Protection Agency by the Association of Bay Area Governments, Oakland, California. June 1992.

Sandercock, F.K. 1991. Life history of coho salmon (Oncorhynchus kisutch). Pages 395-445 in C. Groot and L. Margolis, editors. Pacific Salmon Life Histories. University of British Columbia Press, Vancouver, British Columbia.

Satterthwaite, W.H, M.P. Beakes, E.M. Collins, D.R. Swank, J.E. Merz, R.G. Titus, S.M. Sogard, and M. Mangel. 2010. State-dependent life history models in a changing (and regulated) environment: steelhead in the California Central Valley. Evolutionary Applications 3: 221-243.

Schaffter, R.G. 1997. White sturgeon spawning migrations and location of spawning habitat in the Sacramento River, California. California Fish and Game 83:1-20.

Scott, W.B. and E.J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada Bulletin Number 184.

(SEC) Steiner Environmental Consulting. 1996. A history of the salmonid decline in the Russian River. Steiner Environmental Consulting, Potter Valley, California.

Seesholtz, Alicia 2011 4(d) Annual Report for Project 16073: Lower Feather River Green Sturgeon Spawning Survey. Submitted January 27, 2012. 6 pages.

Shaffer, J.A., D. Penttila, M. McHenry, and D. Vilella. 2007. Observations of eulachon, Thaleichthys pacificus, in the Elwha River, Olympic Peninsula Washington. Northwest Science 81:76-81.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout (Salmo gairdneri gairdneri) and silver salmon (Oncorhynchus kisutch) with special reference to Waddell Creek, California, and recommendations regarding their management. California Department of Fish and Game, Fish Bulletin 98:1-375.

Sharber, N.G. and S.W. Carothers. 1988. Influence of electrofishing pulse shape on spinal injuries in adult rainbow trout. North American Journal of Fisheries Management 8:117-122.

Sharber, N.G., S.W. Carothers, J.P. Sharber, J.C. de Vos, Jr., and D.A. House. 1994. Reducing electrofishing-induced injury of rainbow trout. North American Journal of Fisheries Management 14:340-346.

Shelton, J.M. 1995. The hatching of Chinook salmon eggs under simulated stream conditions. Progressive Fish-Culturist 17:20-35.

Sigler, J.W., T.C. Bjornn, and F.H. Everest. 1984. Effects of chronic turbidity on density and growth of steelhead and coho salmon. Transactions of the American Fisheries Society 113:142-150.

Simpson (Simpson Resource Company). 2002. Aquatic Habitat Conservation Plan and Candidate Conservation Agreement with Assurances. July, 2002.

Smith, A. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Transactions of the American Fisheries Society, 102: 312–316.

Smith, J. J., and H. W. Li. 1983. Energetic factors influencing foraging tactics of juvenile steelhead trout Salmo gairdneri. Pages 173-180 in D. L. G. Noakes, D. G. Lindquist, G. Helfman, and J. Ward, editors. Predators and Prey in Fishes. Dr. W. Junk Publishers, The Hague, Netherlands.

Smith, J. J. 1990. The effects of sandbar formation and inflows on aquatic habitat and fish utilization in Pescadero, San Gregorio, Waddell, and Pomponio creeks estuary/lagoon systems, 1985-1989. Report prepared under Interagency Agreement 84-04-324, between Trustees for California State University and the California Dept. of Parks and Rec. 38 p + tables and figs.

Smith, W.E. and R.W. Saalfeld. 1955. Studies on Columbia River smelt Thaleichthys pacificus (Richardson). Washington Department of Fisheries, Fisheries Research Paper 1(3):3-26.

Snider B., B. Reavis, and J. Hill. 2001. Upper Sacramento River fall-run Chinook salmon escapement survey, September - December 2000. Calif. Dept. Fish and Game, Envir. Serv. Div., Stream Habitat Evaluation Program.

Snyder, D.E. 1992. Impacts of electrofishing on fish. American Fisheries Society Fisheries Management Section Newsletter 12:5-6.

Snyder, D.E. 1995. Impacts of electrofishing on fish. Fisheries 20:26-27.

Sommer, T., D. McEwan, and G. H. Burgess. 2001. Factors Affecting Chinook Salmon Spawning in the Lower Feather River in Contributions to the biology of Central Valley salmonids. R.L.Brown. (ed.), CDFG, 269-297.

Southwest Fisheries Science Center. 2008. Coho and Chinook salmon decline in California during the spawning seasons of 2007/2008. R.B. MacFarlane, S. Hayes, and B. Wells. Southwest Fisheries Science Center. Internal memorandum for NMFS. February 2.

Spence, B., E. Bjorkstedt, J. C. Garza, D. Hankin, J. Smith, D. Fuller, W. Jones, R. Macedo, T.

H. Williams, and E. Mora. 2008. A framework for assessing the viability of threatened and endangered salmon and steelhead in North-Central California Recovery Domain. U. S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-SWFSC-423.

Sprague, C.R., L.G. Beckman, and S.D. Duke. 1993. Prey selection by juvenile white sturgeon in reservoirs of the Columbia River. Pages 229-243 in R.C. Beamsderfer and A.A. Nigro, editors. Status and habitat requirements of the white sturgeon populations in the Columbia River downstream from McNary Dam, volume 2. Final Report on the Oregon Department of Fish and Wildlife to Bonneville Power Administration, Portland, Oregon.

Standiford, R.B. and R. Arcilla. 2001. A scientific basis for the prediction of cumulative watershed effects. University of California Wildland Resource Center Report No. 46.

Stein, R.A., P.E. Reimers, and J.D. Hall. 1972. Social interaction between juvenile coho (Oncorhynchus kisutch) and fall Chinook salmon (O. tshawytscha) in Sixes River, Oregon. Journal of the Fisheries Research Board of Canada 29:1737-1748.

Stickney, R.R. 1983. Care and handling of live fish. Pages 85-94 in L.A. Nielsen and D.L. Johnson, editors. Fisheries Techniques. American Fisheries Society. Bethesda, Maryland, 468 pages.

Stillwater Sciences. 2004. Technical Report: Stevens Creek Limiting Factors Analysis. Prepared for Santa Clara Valley Urban Runoff Pollution Prevention Program September 2004, 150 pages.

Sturdevant, M.V., T.M. Willette, S. Jewett, E. Deberc. 1999. Diet composition, diet overlap, and size of 14 species of forage fish collected monthly in PWS, Alaska, 1994–1995. Chapter 1. Forage Fish Diet Overlap, 1994–1996. Exon Valdez Oil Spill Restoration final report 98163C, 12-36.

Summerfelt. R.C. and L.S. Smith. 1990. Anesthesia, surgery, and related techniques. Pages 213-172 in C.B. Schreck and P.B. Moyle, editors. Methods for Fish Biology. American Fisheries Society, Bethesda, Maryland.

Swanson, F.J. and G.W. Lienkaemper. 1978. Physical consequences of large organic debris in pacific northwest streams. General Technical report PNW-69. USDA Forest Service, Pacific Northwest forest and range experiment station, Portland, Oregon.

Titus, R.G., D.C. Erman, and W.M. Snider. July 5, 2002. History and status of steelhead in California coastal drainages south of San Francisco Bay. In preparation.

Thompson, K.G., E.P. Bergersen, R.B. Nehring, and D.C. Bowden. 1997. Long-term effects of electrofishing on growth and body condition of brown trout and rainbow trout. North American Journal of Fisheries Management 17:154-159.

Tobin, J. H. 1994. Construction and performance of a portable resistance board weir for counting migrating adult salmon in rivers. U.S. Fish and Wildlife Service, Kenai Fishery Resource Office, Alaska Fisheries Technical Report Number 22, Kenai, Alaska.

United States Army Corps of Engineers. 1982. Northern California Streams Investigation Russian River Basin Study. Final Report. San Francisco, California. United States Army Corps of Engineers, San Francisco, California.

Unwin, M. J. 1997. Survival of Chinook salmon, Oncorhynchus tshawytscha, from a spawning tributary of the Rakaia River, New Zealand, in relation to spring and summer mainstem flows. U.S. National Marine Fisheries Service Fishery Bulletin 95:812– 825.

USFS (United States Forest Service). 1995. Ecosystem Analysis of the Smith River Ecosystem at the Basin and Subbasin Scales. United States Department of Agriculture, Forest Service, Six Rivers National Forest, Eureka, California.

USFWS (United States Fish and Wildlife Service). 1995. Sacramento-San Joaquin Delta Native Fishes Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon.

Van Eenennaam, J.P., J. Linares-Casenave, X. Deng, and S.I. Doroshov. 2005. Effect of incubation temperature on green sturgeon, Acipenser medirostris. Environmental Biology of Fishes 72:145-154.

Van Eenennaam, J. P., J. Linares, S. I. Doroshov, D. C. Hillemeier, T. E. Willson, and A. A. Nova. 2006. Reproductive conditions of the Klamath River green sturgeon. Transactions of the American Fisheries Society 135:151-163.

Van Eenennaam, J.P., J. Linares-Casenave, J. Muguet, and S.I. Doroshov. 2008. Induced Spawning, Artificial Fertilization, and Egg Incubation Techniques for Green Sturgeon. North American Journal of Aquaculture 70:434–445.

Waples, R.S. 1991. Pacific Salmon, Oncorhynchus spp., and the definition of Aspecies@ under the Endangered Species Act. Marine Fisheries Review 53:11-21.

Waples, R.S. 1999. Dispelling some myths about hatcheries. Fisheries 24(2):12-21.

Ward, P.D. and T.R. McReynolds. 2001. Butte and Big Chico Creeks spring-run Chinook salmon, Oncoryhnchus tshawytscha life history investigation, 1998-2000. California Department of Fish and Game. Inland Fisheries Administrative Report No. 2001-2.

WCGOP (West Coast Groundfish Observer Program) NMFS NWFSC. 2011. Biological data (unpublished), provided on June 8, 2011. Fishery Resource Analysis and Monitoring, WCGOP. Northwest Fisheries Science Center, National Marine Fisheries Service, 2725 Montlake Blvd East, Seattle, Washington.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2001. Washington and Oregon eulachon management plan. 17 Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife. Online at http://wdfw.wa.gov/fish/creel/smelt/wa-ore_eulachonmgmt.pdf.

WDFW (Washington Department of Fish and Wildlife). 2009. Final season smelt update, Tuesday – March 31, 2009. Online athttp://wdfw.wa.gov/fish/creel/smelt/2009/mar3109.pdf.

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status Review of Coho Salmon from Washington, Oregon, and California. Technical Memorandum NMFS-NWFSC-24. United States Department of Commerce, National Oceanic and Atmospheric Administration.

Werner, I., T. Smith, M. Johnson, and J. Feliciano. 2001. Heat-shock protein (hsp70) expression and apparent growth differences among steelhead parr along a coastal temperature gradient. Platform presentation, Annual Meeting of the American Fisheries Society, California-Nevada and Humboldt Chapters, March 29-31, 2001. Santa Rosa, California.

Williams, J.G. 2006 Central Valley Salmon A Perspective on Chinook and Steelhead in the Central Valley of California. San Francisco Estuary and Watershed Science Volume 4 pages 398

Williams, T. H., S. T. Lindley, B.C. Spence, and D.A. Boughton. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. 17 May 2011 – Update to 5 January 2011 report. National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, California.

Willson, M.F., R.H. Armstrong, M.C. Hermans, and K. Koski. 2006. Eulachon: a review of biology and an annotated bibliography. Alaska Fisheries Science Center Processed Report 2006-12. Auke Bay Laboratory, Alaska Fisheries Science Center, NOAA, National Marine Fisheries Service, Juneau, Alaska. Online at http://www.afsc.noaa.gov/publications/ProcRpt/PR%202006-12.pdf.

Wright, S. 1999. Petition to list eulachon Thaleichthys pacificus as threatened or endangered under the Endangered Species Act. Online at http://www.nwr.noaa.gov/Other-Marine-Species/upload/Smelt_Petition_7_99.pdf.

Wurtsbaugh, W. A. and G. E. Davis. 1977. Effects of temperature and ration level on the growth and food conversion efficiency of Salmo gairdneri, Richardson. Journal of Fish Biology 11:87-98.

Wydoski, R.S. and R.R. Whitney. 1979. Inland fishes of Washington. University of Washington Press, Seattle, Washington.

Yoshiyama, R.M., E.R.Gerstung, F.W. Fisher, and P.B. Moyle. 1996. Historical and present distribution of Chinook salmon in the Central Valley drainage of California. Sierra Nevada Ecosystem Project: final report to Congress. Pages 309-362 in Volume 3. Assessments, commissioned reports, and background information. University of California, Center for Water and Wildland Resources, Davis.

XII. FEDERAL REGISTER NOTICES CITED

58 FR 33212. June 16, 1993. Final Rule: Designated Critical Habitat; Sacramento River Winter-Run Chinook Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 58 pages 33212-33219.

61 FR 56138. October 31, 1996. Final Rule: Endangered and Threatened Species; Threatened Status for Central California Coast Coho Salmon Evolutionarily Significant Unit (ESU). United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 61 pages 56138-56149.

62 FR 38479. July 18, 1997. Interim Rule Governing Take of the Threatened Southern Oregon/Northern California Coast Evolutionarily Significant Unit (ESU) of Coho Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 62 pages 38479-38485.

62 FR 43974. August 18, 1997. Notice: Partial 6-Month Extension on the Final Listing Determination for Several Evolutionarily Significant Units (ESUs) of West Coast Steelhead. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 62 pages 43974-43976.

64 FR 24049. May 5, 1999. Final Rule and Correction: Designated Critical Habitat for Central California Coast Coho and Southern Oregon/Northern California Coast Coho Salmon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 64 pages 24049-24062.

65 FR 42422. July 10, 2000. Final Rule: Governing Take of 14 Threatened Salmon and Steelhead Evolutionary Significant Units. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 65 pages 42422-42481.

65 FR 36074. June 7, 2000. Final Rule: Endangered and threatened species; Threatened Status for One Steelhead Evolutionarily Significant Unit (ESU) in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 65 pages 36074-36094.

67 FR 1116. January 9, 2002. Final Rule: Governing Take of Four Threatened Evolutionarily Significant Units (ESUs) of West Coast Salmonids. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 67 pages 1116-1133.

70 FR 37160. June 28, 2005. Final Rule: Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 70 pages 37160-37160.

70 FR 52488. September 2, 2005. Final Rule: Endangered and Threatened Species: Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 70 pages 52488-52627.

70 FR 17386. April 6, 2005. Proposed Rule: Endangered and Threatened Wildlife and Plants: Proposed Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 70 pages 17386-17401.

71 FR 834. January 5, 2006. Final Rule: Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 71 pages 834-862.

71 FR 17757. April 7, 2006. Final Rule: Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of North American Green Sturgeon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 71 pages 17757-17766.

74 FR 52300. October 9, 2009. Final Rule: Endangered and threatened wildlife and plants: Final rulemaking to designate critical habitat for the threatened Southern Distinct Population Segment of North American green sturgeon. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 74 pages 52330-52351.

75 FR 13012. March 18, 2010. Endangered and Threatened Wildlife and Plants: Threatened Status for Southern Distinct Population Segment of Eulachon; Final Rule. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 75 pages 13012-13024.

75 FR 30714. June 2, 2010. Endangered and Threatened Wildlife and Plants: Final Rulemaking To Establish Take Prohibitions for the Threatened Southern Distinct Population Segment of North American Green Sturgeon; Final Rule. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 75 pages 30714-30730.

76 FR 50447. August 15, 2011. Notice of availability of 5-year reviews: Endangered and Threatened Species; 5-Year Reviews for 5 Evolutionarily Significant 96 Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, 76: 50447-50448.

76 FR 76386. December 7, 2011. Endangered and Threatened Species; 5-Year Reviews for 4 Distinct Population Segments of Steelhead in California. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. *Federal Register*, Volume 76, Page 76386.

XV. PERSONAL COMMUNICATIONS AND OBSERVATIONS

Alicia Seesholtz. June 16, 2011. Personal communication, via email to recipients at CDFG, Cramer Fish Sciences, NMFS, ODFW, US Bureau of Reclamation, US Fish and Wildlife Service, and US Geological Survey, regarding green sturgeon egg samples collected in the lower Feather River in 2011. DWR. Oroville CA.

Bill Cox. 2004. Personal Communication. CDFG (retired).

Matt Brown. 2011. Personal Communication. USFWS, Red Bluff, CA.

Jeffrey Jahn. 2012. Personal Communication. NMFS, Santa Rosa, CA.

Ethan Mora. January 10, 2012. Personal Communication. UC Davis, Davis, CA.

Brannon Ketcham. 2003. Personal Communication. NPS. Tomales Bay, CA.

Jon Ambrose. 2011. Personal Communication. NMFS, Santa Rosa, CA.

Paul Ward. 2002. Personal Communication. CDFG.

Sarah Giovannetti. 2003. Personal Communication. USFWS, Red Bluff, CA.