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2 ENDANGERED SPECIES ACT: BIOLOGICAL OPINION AND INCIDENTAL TAKE STATEMENT

The ESA establishes a national program for conserving threatened and endangered species of fish, wildlife, plants, and the habitat upon which they depend. As required by section 7(a)(2) of the ESA, each Federal agency must ensure that its actions are not likely to jeopardize the continued existence of endangered or threatened species, or adversely modify or destroy their designated critical habitat. Per the requirements of the ESA, Federal action agencies consult with NMFS and section 7(b)(3) requires that, at the conclusion of consultation, NMFS provides an opinion stating how the agency's actions would affect listed species and their critical habitats. If incidental take is reasonably certain to occur, section 7(b)(4) requires NMFS to provide an ITS that specifies the impact of any incidental taking and includes non-discretionary reasonable and prudent measures (RPMs) and terms and conditions to minimize such impacts.

2.1 Analytical Approach

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2.1.1 Introduction

This section describes the analytical approach used by NMFS to evaluate the likely effects of the PA on listed species under NMFS jurisdiction and critical habitat designated for those species. The approach is intended to ensure that NMFS comports with the requirements of the statute and regulations when conducting and presenting the analysis. This includes using the best scientific and commercial data available in formulating the Opinion.

ESA section 7(a)(2) requires that the action agency "insure" that a PA "is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [designated critical] habitat…." This Opinion includes both a jeopardy analysis and an adverse modification analysis. The jeopardy analysis relies upon the regulatory definition of "to jeopardize the continued existence of" a listed species, which is "to engage in an action that would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species" (50 CFR §402.02). Therefore, the jeopardy analysis considers both survival and recovery of the species.

This Opinion also relies on the regulatory definition of "destruction or adverse modification," which means "a direct or indirect alteration that appreciably diminishes the value of critical habitat for the conservation of a listed species. Such alterations may include, but are not limited to, those that alter the physical or biological features essential to the conservation of a species or that preclude or significantly delay development of such features" (81 FR 7214; February 11, 2016).

The designations of critical habitat for some of the listed fish included in this consultation use the term "primary constituent elements" (PCE) or "essential features." The revised critical habitat regulations (81 FR 7414; February 11, 2016) replace this term with physical or biological features (PBFs). The shift in terminology does not change the approach used in conducting a "destruction or adverse modification" analysis, which is the same regardless of whether the original designation identified PCEs, PBFs, or essential features. In this Opinion, NMFS uses the term PBF to mean PCE or essential feature, as appropriate for the specific critical habitat.

NMFS uses the following approach to determine whether a PA is likely to jeopardize listed species or destroy, or adversely modify, critical habitat:

- Identify the range-wide status of the species and critical habitat likely to be adversely affected by the PA.
- Describe the environmental baseline in the action area as defined in the ESA implementing regulations (50 CFR §402.02).
- Analyze the effects of the PA on both species and their habitat using an "exposure-response-risk" approach.
- Describe any cumulative effects in the action area.
- Integrate and synthesize the above factors as follows: (1) review the status of the species and critical habitat; and (2) add the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the PA poses to species and critical habitat.
- Reach a conclusion about whether species are jeopardized or critical habitat is destroyed or adversely modified.
- If necessary, suggest a reasonable and prudent alternative to the PA.

The subsections of Section 2.1 outline the specific conceptual framework, key steps, and assumptions NMFS used to assess listed species' jeopardy risk and critical habitat destruction or adverse modification risks. Wherever possible, these subsections apply to all five listed species and associated designated critical habitats occurring in the action area. They include the following:

- Endangered Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU) (*Oncorhynchus tshawytscha*) and its designated critical habitat
- Threatened Central Valley (CV) spring-run Chinook salmon ESU (*O. tshawytscha*) and its designated critical habitat
- Threatened California Central Valley (CCV) steelhead distinct population segment (DPS) (*O. mykiss*) and its designated critical habitat
- Threatened sDPS of North American green sturgeon (*Acipenser medirostris*) and its designated critical habitat
- Endangered Southern Resident killer whale DPS (*Orcinus orca*).

The subsections of the analytical approach are as follows:

- Section 2.1.2 describes the legal and policy framework provided by the ESA, implementing regulations, case law, and policy guidance related to section 7 consultations.
- Section 2.1.3 gives a general overview of how NMFS conducts its section 7 analysis. It includes various conceptual models of the overall approach and specific features of the approach. It also includes information on tools that NMFS used in the analysis specific to this consultation. The section first describes the listed species analysis as it pertains to

individual fish species and the physical, chemical, and biotic changes to the ecosystem caused by the PA. It then describes the critical habitat analysis.
- Section 2.1.4 discusses the evidence available for the analysis and related uncertainties. Also described are the assumptions made to bridge data gaps which enabled the analyses.
- Section 2.1.5 diagrams the overall conceptual approach in the assessment to address integration of all available information and decision frameworks to support the assessment of the effects of the PA.
- Section 2.1.6 discusses the presentation of all analyses within this Opinion as a guide to locating results of specific analytical steps.

NMFS has evaluated the PA for this consultation as a "mixed programmatic" action as defined by 50 CFR 402.02 because it includes some action components for which no additional authorization will be necessary and others that are considered at a framework level. Components that require no additional authorization are analyzed in this biological opinion and exemptions from take prohibitions provided in the incidental take statement of this Opinion. Action components that are considered at a framework level are also analyzed in this biological opinion, but with a broader scale of examination of the components' potential impacts on listed species and critical habitat. Exemption from take prohibitions are not provided for these components in the incidental take statement of this Opinion. Once framework-level action components are further developed and provide sufficient detail for take determination, they will require additional ESA section 7 consultation before implementation; this subsequent consultation will include an incidental take statement for those components.

For components of the PA that lacked the specificity in description required to analyze a particular outcome of effect, NMFS made assumptions that are reasonably conservative of the species and analyzed the range of effects that would result. This approach, paired with NMFS' identification of framework-level action components and the inclusion of additional analytical methods not used in the BA, could result in NMFS drawing different conclusions from our analysis than the action agency's conclusions in the biological assessment. We identify the lines of evidence to support NMFS' conclusions in the Effects Analyses and Integration and Synthesis sections of this Opinion.

2.1.2 Legal and Policy Framework

The statutory requirement to use the best scientific and commercial data available to complete formal consultations is a demanding one. In reviewing whether a Federal agency used the best scientific and commercial data available and adequately assessed whether a PA is not likely to jeopardize the continued existence of a listed species or destroy or adversely modify its critical habitat, courts have cited Congress' intent in the ESA to give the benefit of the doubt to the species.[1] The U.S. Supreme Court has called this principle "institutionalized caution."[2]

As will become clear in this Opinion, determining the effects of the PA in this manner requires a highly complex analytical process. The results of each step are aptly inserted into further

[1] Conner v. Burford, 848 F.2d 1441, 1454 (9th Cir. 1988), referencing H.R. Conf. Rep. No. 96-697, 96th Cong., 1st Sess. 12, reprinted in 1979 U.S. Code Cong. & Admin. News 2572, 2576.
[2] Tennessee Valley Authority v. Hill, 437 U.S. 153, 194 (1978).

analyses. The final determination of whether or not the PA is likely to jeopardize the species' continued existence or destroy or adversely modify its critical habitat will be the product of this multi-layered analytical approach in which many of the intermediate results have associated degrees of uncertainty. Consequently, to comply with the requirements of ESA section 7 and Congress' intent, NMFS will apply the general principle of institutionalized caution, or giving the benefit of the doubt to the species, when considering the uncertainty of the data, analytical methods, and results. In addition, as described below in this section, adaptive management will apply to the PA in order to address uncertainties in effects.

Consultations designed to allow Federal agencies to fulfill the requirements of section 7 of the ESA conclude with issuing a biological opinion or a concurrence letter. For biological opinions, section 7 of the ESA, implementing regulations (50 CFR 402.14), and associated guidance documents (e.g., USFWS and NMFS 1998) require biological opinions to present the following:

- A description of the proposed Federal action
- A summary of the status of the affected species and its critical habitat
- A summary of the environmental baseline within the action area as defined in the ESA implementing regulations (50 CFR 402.02)
- A detailed analysis of the effects of the PA on the affected species and critical habitat
- A description of cumulative effects
- A conclusion as to whether it is reasonable to expect that the PA is not likely to appreciably reduce the species' likelihood of both surviving and recovering in the wild by reducing its reproduction, numbers, or distribution or result in the destruction or adverse modification of the species' designated critical habitat

The purpose of the jeopardy analysis is to determine whether appreciable reductions of both the survival and recovery of the species in the wild are reasonably expected, but not to precisely quantify the amount of those reductions. As a result, this assessment often focuses on whether an appreciable reduction is expected or not; it does not focus on detailed analyses designed to quantify the absolute amount of reduction or the resulting population characteristics (absolute abundance, for example) that could occur as a result of PA implementation.

For this analysis, NMFS equates a listed species' probability (or risk) of extinction with the likelihood of both the survival and recovery of the species in the wild. In the case of listed salmonids and sturgeon, NMFS uses the Viable Salmonid Population (VSP) framework (McElhany et al. 2000) as a bridge to the jeopardy standard. A designation of "a high risk of extinction" or "low likelihood of becoming viable" indicates that the species faces significant risks from internal and external processes that can drive it to extinction. The status assessment considers and diagnoses both internal and external processes affecting a species' extinction risk.

As identified in McElhany et al. 2000, the four VSP parameters for salmonids are important to consider because they are predictors of extinction risk. The parameters reflect general biological and ecological processes that are critical to the survival and recovery of the listed salmonid species (McElhany et al. 2000). The VSP parameters of productivity, abundance, and population spatial structure are consistent with the "reproduction, numbers, or distribution" criteria found within the regulatory definition of jeopardy (50 CFR §402.02) and are used as surrogates for "reproduction, numbers, or distribution." The VSP parameter of diversity relates to all three jeopardy criteria. For example, reproduction, numbers, and distribution are all affected when genetic or life history variability is lost or constrained, resulting in reduced population resilience to environmental variation at local or landscape levels. McElhany et al. (2000) highlight that the VSP framework will include "a degree of uncertainty in much of the relevant information," and that "because of this uncertainty, management applications of VSP should employ both a precautionary approach and adaptive management."

With respect to adaptive management, NMFS expects that an adaptive management program will apply to the PA that will address uncertainties associated with the effectiveness of management actions taken to avoid jeopardy to federally listed species and destruction or adverse modification of critical habitat and meet other regulatory standards applicable to state listed species for (1) ongoing operations of the SWP and CVP and (2) habitat restoration actions that are part of the PA and/or this Opinion and CESA authorizations. The adaptive management component is expected to focus heavily on filling critical data and information gaps, enhancing the existing monitoring network, and improving quantitative modeling capability. The proposed adaptive management approach is expected to incorporate aspects that are both "active" (where managers and operations work through a process of experimentation to explore the benefits, limits, and response to management actions) and "passive" (which lacks explicit experimentation and is rather an assessment of existing and future conditions and circumstances). The adaptive management approach is also expected to identify a preliminary set of objectives that will be used to develop final objectives for this adaptive management program.

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NMFS notes the inclusion of the term "recovery" in the regulations implementing ESA section 7(a)(2) (50 CFR §402.02) (i.e., to "'jeopardize the continued existence of' means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild…"). NMFS finalized recovery plans for the listed Central Valley salmon and steelhead species in 2014 (NMFS 2014) and for the listed sDPS of green sturgeon in 2018 (NMFS 2018). These recovery plans, which include recovery objectives and criteria, also identify stressors or threats to the recovery of the species throughout their life cycles. This consultation uses the primary stressor and threat categories from the recovery plans as the basis for identification of potential stressors that could result from the proposed action and therefore could not only reduce appreciably the likelihood of survival of the species but also the likelihood of recovery of the species.

The information from recovery plans and the 2015/2016 Five-Year Status Reviews for each species represent the best scientific and commercial data available describing their respective current status, and was, therefore, incorporated into this Opinion. A technical recovery team (TRT) that assisted in the Central Valley salmonids recovery planning effort produced a "Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin" (Lindley et al. 2007). Along with assessing the current viability of the listed Central Valley salmon and steelhead species, Lindley et al. (2007) made recommendations for recovering those species. The framework was used to inform the current status of the listed Central Valley salmon and steelhead species within this Opinion. The recovery plans, status reviews, and Lindley et al. (2007) were used as the foundation to determine whether the PA reasonably would be expected to "reduce appreciably the likelihood of both the survival and recovery of a listed species…". NMFS has also applied this framework in analyzing likely effects to the to recovering the sDPS of green sturgeon, a population represented by a single spawning population, much like the Sacramento River winter-run Chinook salmon population.

Additional requirements for the analysis of the effects of an action are described in regulations (50 CFR §402). The conclusions related to "jeopardize the continued existence of" and "destruction or adverse modification" require an expansive evaluation of direct and indirect consequences of the PA, interrelated and interdependent actions, and the overall context of the impacts to the species and habitat from past, present, and future actions as well as the condition of the affected species and critical habitat (for example, see the definitions of "cumulative effects" and "effects of the action" in 50 CFR §402.02 and the requirements of 50 CFR §402.14(g)).

Recent court cases have reinforced the requirements provided in the ESA section 7 implementing regulations that NMFS must evaluate the effects of a PA within the context of the current condition of the species and critical habitat, including other factors affecting the survival and recovery of the species and the functions and value of critical habitat for the conservation of the species. In addition, the courts have directed that our risk assessments consider the effects of climate change on the species and critical habitat and our analysis of the future impacts of a proposed action. NMFS acknowledges that the effects of climate change could have notable impacts on listed species while also recognizing the challenge in quantifying those effects. Conservation of protected resources becomes more difficult when considering a changing climate, especially when accounting for the relative uncertainty of the rate and magnitude of climate-related changes and the response of organisms to those changes. Accordingly, NMFS issued general policy guidance for treatment of climate change in ESA decisions (Sobeck 2016). This guidance aligns with case law, noting the need to consider climate change in determinations and decisions despite the challenges of climate change uncertainty, and it provides policy considerations related to climate change that NMFS should use in ESA decision making, including ESA section 7 consultations.

In addition to Sobeck (2016), NMFS regional guidance (Thom 2016) further recommends use of the Representative Concentration Pathway (RCP) 8.5 scenario from the Fifth Assessment Report (AR5). Sobeck (2016) notes that "when data specific to (the RCP 8.5) pathway are not available, (NMFS) will use the best available science that is as consistent as possible with RCP 8.5." Climate change is incorporated into this analysis implicitly to an extent by the modeling results provided in the BA and additionally by qualitative evaluations that reflect more recent climate predictions applied in the biological opinion. The modeling of the PA as provided in the biological assessment characterizes a 2030 scenario of climate conditions, water demands, and build-out. In doing so, the PA uses a multi-model ensemble-informed approach to identify a best estimate of the consensus of climate projections from the third phase of the Coupled Model Intercomparison Project (CMIP3), which informed the Intergovernmental Panel on Climate Change's (IPCC) Fourth Assessment Report (AR4). These results are downscaled to a spatial resolution of approximately 12 km. This assessment report and approach results in an anticipated temperature change of +0.7 to +1.4 °C (representing the 25^{th} to 75^{th} quartile) and a precipitation change of -6% to +6%. Additionally, the approach used in for the PA characterizes 2030 sea level rise an 15 cm. However, based on results from the application of RCP 4.5 and RCP 8.5 in California's Fourth Climate Change Assessment (He et al. 2018, Pierce et al. 2018), NMFS expects that climate conditions will follow a more extreme trajectory of higher temperatures and shifted precipitation into 2030 and beyond. As provided by the assessment, NMFS assumes that temperatures would increase up to 1.9 °C between 2020-2059 and precipitation changes would range from -6% to +24% in the same period (He et al. 2018). Sea level rise is expected to range up to 15 cm in 2030 and 10-38 cm in 2050 (Pierce et al. 2018).

The October 29, 2018, Presidential Memorandum on Promoting the Reliable Supply and Delivery of Water in the West directed NMFS to complete this biological opinion within 135 days of receiving the biological assessment, and NMFS does not possess the expertise required to independently generate equivalent project modeling that uses data specific to RCP 8.5. Therefore this consultation assumes that the provided modeling represents a best-case scenario regarding climate conditions for 2030 and, to account for the differential in increased temperature, shifted precipitation, and projected sea level rise between the CMIP3 and California's Fourth Climate Change Assessment, NMFS will layer qualitative evaluations of increased climate effects onto the provided modeled data. This is consistent with guidance that "NMFS does not need to know with precision the magnitude of change over the relevant time period if the best available information allows NMFS to reasonably predict the directionality of climate change and overall extent of effects to species or its habitat" (Sobeck 2016).

Longer-term responses to climate uncertainty can be incorporated into a reinitiation trigger focused on regular assessments of adherence to the climate assumptions used in the analysis of this opinion. To address shorter-term deviation from the current predictions, NMFS expects to be able to incorporate climate uncertainty into the adaptive management actions and science plans by including monitoring of climate change effects and projections; taking management actions; and adjusting water operations, research, and monitoring in response as needed. Such adaptive management responses may include, for instance, identifying alternative locations for implementing restoration or habitat protection actions to increase habitat availability and suitability, increasing productivity of the food web, better managing predators and invasive species, or allowing species movement across environmental gradients. Adjustments to water operations associated with inflow, outflow, and exports are another example of potential adaptive responses.

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2.1.3 Overview of the Approach and Conceptual Models

NMFS uses a series of sequential activities and analyses to assess the effects of Federal actions on endangered and threatened species and designated critical habitat. These sequential activities and analyses are illustrated in Figure 2.1.3-1 for listed species and Figure 2.1.3-2 for critical habitat. The final step in the series, integrates the conclusions drawn from these activities, summarizing analyses in table format with consistent terms to facilitate the review of effects. In order for us to analyze the PA, it was first separated into components (deconstructed) for each division (as described in the BA). The first analysis uses the identified action components and interrelated and interdependent actions that resulted from the deconstruction of the action to identify environmental stressors. Specifically, the physical, chemical, or biotic aspects of the PA that are likely to have individual, interactive, or additive direct and indirect effects on the environment. As part of this step, NMFS identifies the spatial and temporal extent of both the action components and any potential stressors, recognizing that the spatial extent of the stressors may change with time. NMFS notes that the spatial extent of potential stressors may extend beyond the geographic area included in the project description (i.e., a project description of in-Delta operations may have effects that extend upstream; the spatial extent of those effects is traced as part of this analysis).

The next step in the series of analyses starts by identifying the threatened or endangered species or designated critical habitat that are likely to be exposed to (occur in the same space and at the same time as) the potential stressors and their spatial extent. We estimate the nature of co-occurrence of individuals and effect to represent the individual exposure assessment. In this step, we identify the proportion of a population (or number of individuals when available) and age (or life stage) that are likely to be exposed to an action's effects, and the specific areas and PBFs of critical habitat that are likely to be affected. We then assess the severity of an effect based on expected impact to the individual and its continued fitness. Finally, we consider the incidence of exposure based on the activities in the description of the proposed action.

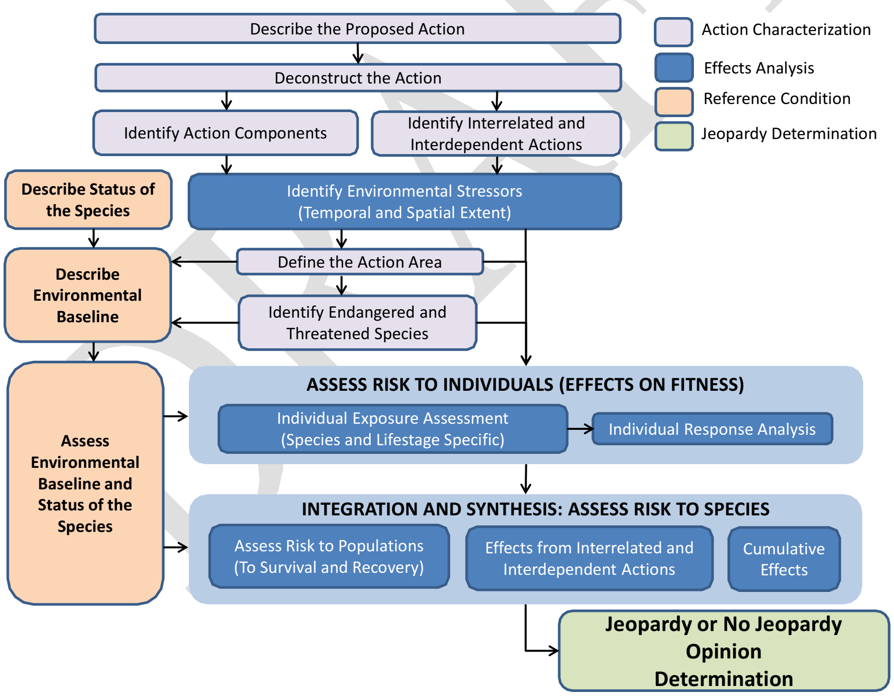

Figure 2.1.3-1. General Conceptual Model for Conducting Section 7 Analyses as Applied to Listed Species.

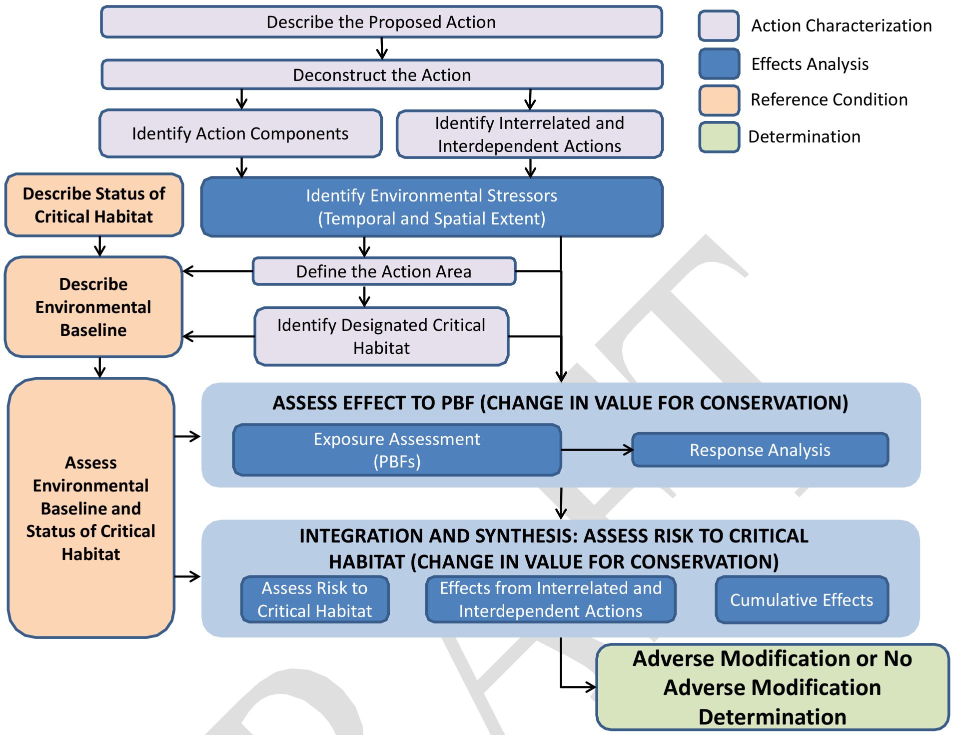

Figure 2.1.3-2. General Conceptual Model for Conducting Section 7 Analyses as Applied to Critical Habitat.

Once we identify which listed resources (i.e., endangered and threatened species and designated critical habitat) are likely to be exposed to potential stressors associated with an action and the nature of the exposure, we examine the scientific and commercial data available to determine whether and how those listed resources are likely to respond given their exposure. This represents the individual response analysis. The final steps of our series of analyses establish the risks those responses pose to listed resources, with recognition that responses of individuals may differ within and between (subwatershed) populations and among species. These steps represent our risk analysis. They are different for listed species and designated critical habitat and are discussed in the following sections.

2.1.3.1 Application of the Approach to Listed Species Analyses

Our jeopardy determinations must be based on an action's effects on the continued existence of threatened or endangered species and how those "species" have been listed (e.g., as true biological species, subspecies, or distinct population segments of vertebrate species). Because the continued existence of listed species depends on the fate of the populations that comprise them, the probability of extinction or probability of persistence of listed species depends on the probabilities of extinction and persistence of the populations that comprise the species. Similarly, the continued existence of a population is determined by the fate of the individuals that comprise it; populations grow or decline as the individuals that comprise the population live, die, grow, mature, migrate, and reproduce (or fail to do so). The approach for specific species are included below in Section 2.1.3.1.1 for salmonids and sturgeon and Section 2.1.3.1.2 for Southern Resident killer whale.

2.1.3.1.1 The Viable Salmonid Populations Framework Approach for Listed Salmonids and Southern Distinct Population Segment of Green Sturgeon

Although McElhany et al. (2000) specifically addresses viable populations of salmonids, NMFS believes that the concepts and viability parameters in McElhany et al. (2000) can also be applied to the Southern DPS of green sturgeon due to the general similarity in life cycle and freshwater/ocean use. Therefore, in this Opinion, NMFS applies McElhany et al. (2000) and the viability parameters in its characterization of the status of the species, environmental baseline, and analysis of effects of the action to the Southern DPS of green sturgeon.

Our analyses reflect these relationships. We identify the risks that actions pose to listed individuals that are likely to be exposed to effects of the actions. Our analyses then integrate the individuals' risks to identify consequences to the proportion of populations represented by the individuals (Figure 2.1.3-1). Our analyses conclude by determining the consequences of those population-level risks to the species that the populations comprise.

To measure risks to listed individuals, we use changes in the individual's "fitness" as a metric. "Fitness" can be characterized as an individual's growth rate, survival probability, annual reproductive success, or lifetime reproductive success. In particular, during the individual response analysis, we examine the scientific and commercial data available to determine if an individual's response to the effect of an action on the environment is likely to have consequences for the individual's fitness.

When individuals are expected to experience reduced fitness, we expect those reductions to also reduce the population abundance or rates of reproduction or growth rates (or to increase the variance in these rates) (Stearns 1992). Reduction in one or more of these variables is a necessary condition for increases in a population's probability of extinction, which is a necessary condition for increases in a species' probability of extinction.

If we conclude listed individuals are likely to experience reductions in their fitness, we evaluate whether those fitness reductions are likely to increase the probability of extinction of the populations those individuals represent. This can be measured using changes in population abundance, reproduction rate, diversity, spatial structure and connectivity, growth rate, or variances in these metrics. In this step of our analysis, we use the population's baseline condition (established in the Status of the Species section of this Opinion) as our point of reference. Generally, this baseline condition is a measure of how close a species is to extinction or recovery.

An important tool in this step of the assessment is a consideration of the life cycle of the species. The consequences on a population's probability of extinction as a result of impacts to different life stages are assessed within the framework of this life cycle and our current knowledge of the transition rates between life stages, the sensitivity of population growth to changes in those rates, and the uncertainty in the available estimates or information. An example of a Pacific salmonid life cycle is provided in Figure 2.1.3-3, which shows the cycle of the upstream freshwater spawning, juvenile smoltification and outmigration, ocean residence, and upstream spawning migration. Though not identical, the life history of green sturgeon is similar (i.e., spawning in upstream freshwater locations, juvenile outmigration through the riverine and estuarine areas, long ocean residence before returning to upstream spawning areas), and we take a similar approach in analyzing effects to both salmonids and sturgeon.

Various sets of data and modeling efforts are useful to consider when evaluating the transition rates between life stages and consequences on population growth as a result of variations in those rates. These data are not available for all species considered in this Opinion; however, data from surrogate species may be available for inference. Where available, information on transition rates, sensitivity of population growth rate to changes in these rates, and the relative importance of impacts to different life stages is used to inform the translation of individual effects to population-level effects.

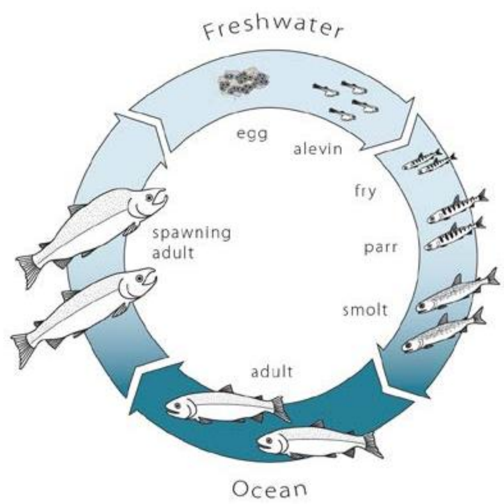

Figure 2.1.3-3. Conceptual Diagram of the Life Cycle of a Pacific Salmonid (NMFS 2016).

In addition, we recognize that populations may be vulnerable to small changes in life stage transition rates. Small reductions across multiple life stages can be sufficient to cause the extirpation of a population. This is illustrated in Figure 2.1.3-4 for two hypothetical scenarios with different transition rates (numbers included are for explanatory purposes only and do not reflect either observed or expected survival or production rates). For two adult salmon (a spawning pair) that produce 2,000 eggs that then experience a 20 percent survival rate to the juvenile stage, a 10 percent survival to smoltification, and a 5 percent survival over several years at sea, two adult salmon will return to spawn again. However, if the survivorship is reduced to 18 percent at the juvenile stage, 8 percent at the smolt stage, and 4 percent at the sea stage, then only one adult salmon will return, leading to eventual extirpation if the trend continues.

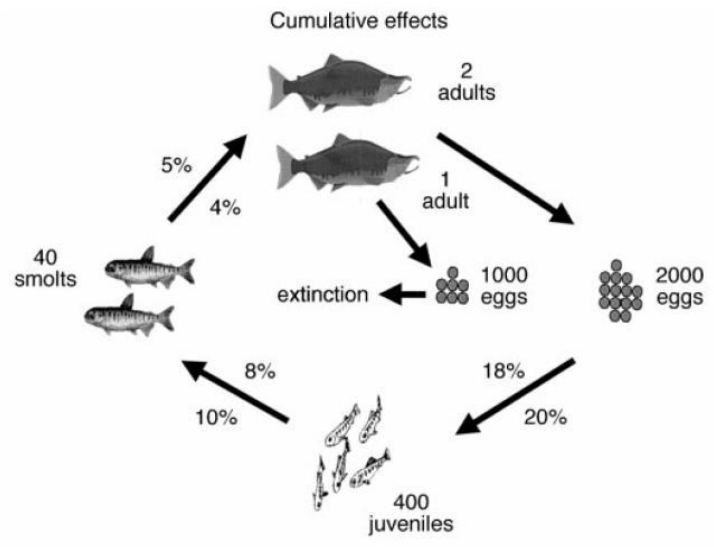

Figure 2.1.3-4. Illustration of Population Vulnerability to Small Changes in Transition Rates (Naiman and Turner 2000).

The section 7 consultation process requires assessment of the effects of several stressors to the species. The effects of these stressors require conceptual understanding of both the species' use of the area and the effects of the stressors on the species. NMFS closely considered the conceptual models of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP) (Williams 2010) and the Salmon and Sturgeon Assessment of Indicators by Life stage (SAIL) (Heublein et al. 2017, Johnson et al. 2017) when identifying and evaluating the effects of activities associated with the PA. These models identify the effects of stressors such as increased temperature, toxins, changes in flow, minor and major diversions, the site of action, and the life stage affected. These stressors and their effects are reflected in the structure and evaluations of the effects analysis.

Our assessment next determines if changes in population viability are likely to be sufficient to reduce the viability of the species the population comprises. In this assessment, we use the species' status (established in the Status of the Species section of this Opinion) as our point of reference. We also use our knowledge of the population structure of the species (e.g., from the relevant recovery plan) to assess the consequences of the increase in extinction risk to one or more of those populations. Our Status of the Species section discusses the available information on the structure and diversity of the populations that comprise the listed species and any available guidance on the role of those populations in the recovery of the species, noting that an action that is helping to implement recovery actions or strategies is less likely to jeopardize the continued existence of the species. We consider that recovery objectives and strategies are described in recovery plans and inform our analyses on likelihood of the proposed action to reduce appreciably the likelihood of species recovery. An example of structure and diversity information used in this assessment is provided in Figure 2.1.3-5 for CV spring-run Chinook salmon. This figure illustrates the historic distribution and structure of the species and notes those populations that have been extirpated. This information provides a sense of existing and lost diversity and structure within the species, which are important considerations when evaluating the recovery consequences of extinction risk or effects to current or potential habitat.

Figure 2.1.3-5. Current and Historical Distribution of the Central Valley Spring-run Chinook Salmon Evolutionarily Significant Unit.

Box 1: An example of the determination of effects to individuals of a species.

The first steps in evaluating the potential impacts a project may have on an individual fish would entail: (1) identifying the seasonal periodicity and life history traits and biological requirements of listed salmonids and sturgeon within the action area. Understanding the spatial and temporal occurrence of these fish is a key step in evaluating how they are affected by current human activities and natural phenomena; (2) identifying the main variables that define riverine or estuarine characteristics that may change as the result of project implementation; (3) determining the extent of change in each variable in terms of time, space, magnitude, duration, and frequency; (4) determining if individual listed species will be exposed to potential changes in these variables; (5) evaluating how the changed characteristic would affect the individual fish in terms of the fish's growth, survival, and/or reproductive success; (6) and determining the proportion of a population affected.

As an example, riverine characteristics may include flow, water quality, vegetation, channel morphology, hydrology, neighboring channel hydrodynamics, and connectivity among upstream and downstream processes. Each of these main habitat characteristics is defined by several attributes (e.g., water quality includes water temperature, dissolved oxygen, ammonia concentrations, turbidity). The degree to which the proposed project may change attributes of each habitat characteristic will be evaluated quantitatively and/or qualitatively in the context of its spatial and temporal relevance. Not all of the riverine characteristics and associated attributes identified above may be affected by project implementation to a degree where meaningful qualitative or quantitative evaluations can be conducted. That is, if differences in flow with and without the proposed project implementation are not sufficient to influence neighboring channel hydrodynamics, then these hydrodynamics will not be evaluated in detail either quantitatively or qualitatively. The changed nature of each attribute will then be compared to the attribute's known or estimated habitat requirements for each fish species and life stage. For example, if water temperature modeling results demonstrate that water temperatures during the winter-run Chinook salmon spawning season (mid-April through mid-August) would be warmer with implementation of the proposed project, then the extent of warming and associated impact would be assessed in consideration of the water temperature ranges required for successful winter-run Chinook salmon spawning.

NMFS will then evaluate how the proposed project's effects on riverine characteristics may affect the growth, survival, and reproductive success of individual fish. For example, all of these metrics may be affected if the proposed project results in increased water temperatures during multiple life stages. Individual fish growth also may be affected by reduced availability, quantity, and quality of habitats (e.g., floodplains, channel margins, intertidal marshes). Survival of an individual fish may be affected by suboptimal water quality, increased predation risk associated with non-native predatory habitats and physical structures, impeded passage, and susceptibility to disease. Reproductive success of individual fish may be affected by impeded or delayed passage to natal streams; suboptimal water quality (e.g., temperature), which can increase susceptibility to disease; and reduced quantity and quality of spawning habitats. Instream flow studies (e.g., instream flow incremental methodology studies) available in the literature, which describe the relationship between spawning habitat availability and flow, will be used to assess proposed project-related effects on reproductive success. All factors associated with the proposed project that affect individual fish growth, survival, or reproductive success will be identified during the exposure analyses.

We use a set of tables to collect and evaluate the available information on the expected effects of each component action of the PA. These tables identify the stressor effect mechanism and the exposure, response, and risk posed to individuals and proportion of the species.

Table 2.1.3-1 outlines the basic set of information we evaluated, and Box 1 offers an example of the conceptual thought behind the information in the table. We categorize the effects to individuals on the basis of the severity of the predicted response and resulting fitness consequence within life stages.

Table 2.1.3-1. Example of Information Used to Identify Effects of the Components of the Proposed Action to Listed Species.

Stressor	Life Stage (Location)	Life Stage Timing (Work Window Intersection)	Individual Response and Rationale of Effect	Severity of Stressor	Proportion of Population Exposed	Frequency of Exposure	Magnitude of Effect	Weight of Evidence	Expected Change in Fitness

As Table 2.1.3-1 shows, for each response to an action, we assign a relative magnitude of effect (high, medium, or low). This is a qualitative assessment of the likelihood of a fitness consequence occurring that allows for incorporation of some aspects of uncertainty (for instance, an infrequent but documented presence of a small number of individuals at a particular time). It is based on assessment of the severity of the stressor, the proportion of the population exposed, and the frequency of exposure. Severity is categorized as lethal, sublethal, or minor. The proportion of the population exposed (for the fish species) is characterized similarly as in NMFS (2009) as large (70 percent or more exposed), medium (more than 2 percent, but less than 70 percent exposed), and small (exposure not expected to exceed 2 percent). We note that this includes intra-annual exposure (i.e., exposure of the same cohort to a stressor multiple times in a year). The frequency of exposure is categorized as high (very frequent; occurring in 75 percent or more years), medium (moderately frequent; occurring in 25-75 percent of years), and low (infrequent; occurring in fewer than 25 percent of years). Table 2.1.3-2 shows combinations of severity, proportion, and frequency that result in the various magnitudes of effect.

Table 2.1.3-2 Categories of Effect Magnitude

A - Severity of Stressor (Lethal/ Sublethal/ Minor)	B - Proportion of Population Exposed (Large/ Medium/ Small)	C - Frequency of Exposure (High/ Medium/ Low)	Resulting Magnitude of Effect – Combination of A, B, and C
Lethal	Large or Medium	High, Medium, or Low	High
Sublethal	Large	High	High
Lethal	Small	High or Medium	Medium
Sublethal	Large	Medium or Low	Medium
Sublethal	Medium	High or Medium	Medium
Sublethal	Small	High	Medium

A - Severity of Stressor (Lethal/ Sublethal/ Minor)	B - Proportion of Population Exposed (Large/ Medium/ Small)	C - Frequency of Exposure (High/ Medium/ Low)	Resulting Magnitude of Effect – Combination of A, B, and C
Minor	Large	High or Medium	Medium
Minor	Medium	High	Medium
Lethal	Small	Low	Low
Sublethal	Medium	Low	Low
Sublethal	Small	Medium or Low	Low
Minor	Small	Low	Low
Minor	Medium or Small	Medium or Low	Low
Minor	Small	High, Medium, or Low	Low

The weight of evidence for stressor effect identified in

Table 2.1.3-1 is based on the best available scientific information and is categorized based on the characteristics of the analytical method, with modifications to include statistical power of analytical methods. Weights are defined as follows:

- High: Supported by multiple scientific and technical publications, especially if conducted on the species within the area of effect, quantitative data, and/or modeled results; high power in interpretation of analytical results
- Medium: Evidence between high and low definitions
- Low: One study, or unpublished data, or scientific hypotheses that have been articulated but not tested; low power in interpretation of analytical results

A key consideration in this assessment is the strategy of the NMFS recovery plan that "every extant population be viewed as necessary for the recovery of the ESUs and DPS," and that "wherever possible, the status of extant populations should be improved" (NMFS 2014). Noted recovery actions include (but are not limited to) reintroduction of populations into key watersheds, completion of landscape-scale restoration throughout the Delta, restoring flows throughout the Sacramento and San Joaquin river basins and the Delta, reducing the biological impacts of exporting water through the CVP and SWP facilities, and meeting established water quality criteria. Several of these recovery actions could be affected by the PA and, therefore, could contribute to either recovery or jeopardy. In following the recommendations of the recovery plan to also advocate that uncertainty be resolved in favor of the species, NMFS considers that an expected appreciable reduction in any population's viability due to implementation of the PA would also appreciably reduce the likelihood of survival and recovery of the population's diversity group and the ESU/DPS. Therefore, this assumption in our analysis of effects is consistent with the principle of institutionalized caution.

There are, however, other considerations. We look to various factors to determine if the reduction in the population's viability or its capacity to become viable would also appreciably reduce the likelihood of survival and recovery of the diversity group and ESU/DPS. Examples of these factors include the timing, duration, and magnitude of the reduction and the permanent or temporary nature of the reduction. A PA could adversely affect a population without appreciably reducing the likelihood of survival of the species.

Table 2.1.3-3 presents the basic set of outcomes associated with acceptance or rejection of the propositions used when evaluating effects of the PA. These follow a logical path and hierarchical structure that is used to organize the jeopardy risk assessment. This table is populated using results from

Table 2.1.3-1 as completed for all stressors. For each step in Table 2.1.3-3, the stressor result that supports the true or false determination will be identified, with documentation of the magnitude of effect and weight of evidence, to allow clear disclosure of potential for uncertainty. While the approach cannot remove the uncertainty, it can allow a determination to be made based on a methodological approach of the magnitude of effect and weight of evidence.

Table 2.1.3-3. Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Listed Species.

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	The proposed action is not likely to produce stressors that have direct or indirect adverse effects on the environment	True	End
		False	Go to B
B	Listed individuals are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect consequences of the proposed action	True	NLAA
		False	Go to C
C	Listed individuals are not likely to respond upon being exposed to one or more of the stressors produced by the proposed action	True	NLAA
		False	Go to D
D	Any responses are not likely to constitute "take" or reduce the fitness of the individuals that have been exposed	True	NLAA
		False	Go to E
E	Any reductions in individual fitness are not likely to reduce the viability of the populations those individuals represent	True	NLJ
		False	Go to F
F	Any reductions in the viability of the exposed populations are not likely to reduce the viability of the species	True	NLJ
		False	LJ

Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and not likely/likely to jeopardize (NLJ/LJ).

In order to assess the survival and recovery of any species, a guiding framework that includes the most appropriate biological and demographic parameters is required. This has been generally defined above. For Pacific salmonids, McElhany et al. (2000) defines a VSP as an independent population that has a negligible probability of extinction over a 100-year timeframe. The VSP concept provides specific guidance for estimating the viability of populations and larger-scale groupings of Pacific salmonids such as at the ESU or DPS level.

Four VSP parameters form the key to evaluating population and ESU/DPS viability: (1) abundance; (2) productivity (i.e., population growth rate); (3) population spatial structure; and (4) diversity (McElhany et al. 2000). These four parameters and their associated attributes are presented in Figure 2.1.3-6.

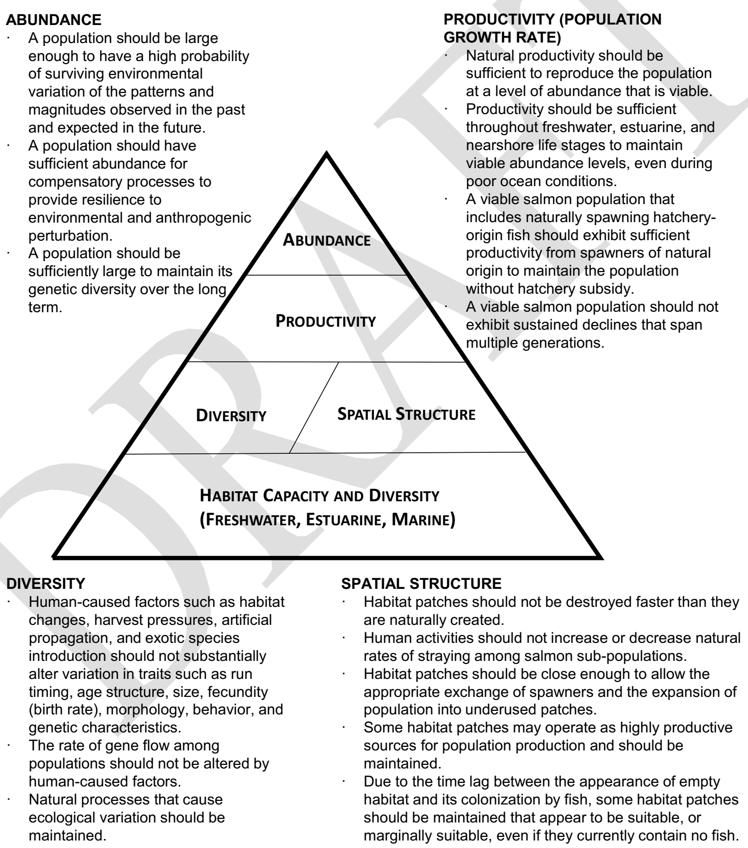

Figure 2.1.3-6. Viable Salmonid Population Parameters and Their Attributes (from McElhany et al. 2000).

In addition to the four key parameters, the quality, quantity, and diversity of the habitat (habitat capacity and diversity) available to the species in each of its three main habitat types (freshwater, estuarine, and marine environments) is a foundation to VSP. Salmonids cannot persist in the wild and withstand natural environmental variations in limited or degraded habitats. Therefore, the condition and capacity of the ecosystem upon which the population (and species) depends play a critical role in the viability of the population or species. Without sufficient space, including accessible and diverse areas the species can utilize to weather variation in their environment, the population and species cannot be resilient to chance environmental variations and localized catastrophes. Salmonids have evolved a wide variety of life history strategies designed to take advantage of varying environmental conditions. Loss or impairment of the species' ability to use these adaptations increases their risk of extinction.

Recent research shows that a diversity of life histories among populations contributes to the maintenance of multiple and diverse salmonid stocks fluctuating independently of each other, which in turn reduces species extinction risk and long-term variation in regional abundances (Hilborn et al. 2003; Schindler et al. 2010; Yates et al. 2012; Satterthwaite and Carlson 2015). Such variance buffering of complex ecological systems has been described as a portfolio effect (Schindler et al. 2010), borrowing on concepts from financial portfolio theory (Markowitz 1952; Koellner and Schmitz 2006; Satterthwaite and Carlson 2015).

California's Central Valley salmon portfolio has weakened over time (Carlson and Satterthwaite 2011, Herbold et al. 2018). The foundation for this "portfolio effect" of spreading risk across populations can be found at the within-population scale (Greene 2009; Bolnick et al. 2011). For example, juvenile Chinook salmon leave their natal rivers at different sizes, ages, and times of the year, and this life history variation is believed to contribute to population resilience (Beechie et al. 2006; Lindley et al. 2009; Miller et al. 2010; Satterthwaite et al. 2014; Sturrock et al. 2015). Life history diversity promotes salmonid population resiliency, thereby reducing a species' extinction risk. Thus, preserving and restoring life history diversity is an integral goal of many salmonid conservation programs (Ruckelshaus et al. 2002). It is increasingly recognized that strengthening a salmon population's resilience to environmental variability (including climate change) will require expanding habitat opportunities to allow a population to express and maintain its full suite of life history strategies (Bottom et al. 2011; Herbold et al. 2018; Munsch et al. 2019).

As presented in NMFS (2014), criteria for VSP are based upon measures of the VSP parameters that reasonably predict extinction risk and reflect processes important to populations. Abundance is critical because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (i.e., population growth rate) provides information on important demographic processes. Genotypic and phenotypic diversity are important because they allow species to use a wide array of environments, respond to short-term changes in the environment, and adapt to long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats and can affect overall extinction risk and evolutionary processes that may alter a population's ability to respond to environmental change. However, each of these parameters, and the criteria that can be developed from them, must be sensitive to the uncertainty of estimates, levels, and processes (McElhany et al. 2000).

The VSP concept also identifies guidelines describing a viable ESU/DPS. The viability of an ESU or DPS depends on the number of populations within the ESU or DPS, their individual status, their spatial arrangement with respect to each other and to sources of potential catastrophes, and diversity of the populations and their habitat (Lindley et al. 2007). Guidelines describing what constitutes a viable ESU are presented in detail in McElhany et al. (2000). More specific recommendations of the characteristics describing a viable Central Valley salmonid population are found in Table 1 of Lindley et al. (2007). The effects of the PA are analyzed with consideration for the diversity and spatial structure of the salmonid populations. Because the effects of the PA are experienced at locations where individual populations (e.g., Mill Creek spring-run Chinook salmon and Butte Creek spring-run Chinook salmon) come together, the effects to individual populations are not differentiated in the effects analysis. For spring-run Chinook salmon, all Sacramento River basin populations are analyzed as a single unit. Effects are separately analyzed for San Joaquin River basin spring-run. This includes both spring-running fish and fish with the experimental population designation, because individuals of the experimental population do not carry exemptions from take prohibition when outside of the designated experimental population area, or in an area of overlap with individuals that are not part of the experimental population (50 CFR 222.501(a)). Steelhead populations are similarly analyzed in the effects analysis based on basin of origin. However, the impacts to the diversity and spatial structure provided by the individual populations will be evaluated when the VSP approach is applied in the integration and synthesis for the ESU/DPS.

We nest the VSP concept within the hierarchy of the individual-population-diversity group-ESU/DPS relationships to evaluate the potential impact of the PA. For the species, the conceptual model is based on a bottom-up hierarchical organization of individual fish at the life stage scale, population, diversity group (if applicable), and ESU/DPS (Figure 2.1.3-7). The viability of a species (e.g., ESU) is dependent on the viability of the population(s) or diversity groups that compose that species and the spatial distribution of those groups or populations; the viability of a diversity group is dependent on the viability of the population(s) that compose that group and the spatial distribution of those population(s); and the viability of the population is dependent on the four VSP parameters and on the fitness and survival of individuals at the life stage scale. The anadromous salmonid life cycle (see Figure 2.1.3-3) includes the following life stages and behaviors, which are evaluated for potential effects resulting from the PA:

- Adult immigration and holding
- Spawning, embryo incubation
- Juvenile rearing and downstream movement[3]
- Smolt outmigration

[3] The juvenile rearing and downstream movement life stage is intended to include fry emergence and fry and fingerling rearing, which occurs both in natal streams and as these fish are moving downstream through migratory corridors at a pre-smolt stage. The distinction between juveniles and smolts is made because smolts have colder thermal requirements than juveniles that are not undergoing osmoregulatory physiological transformations.

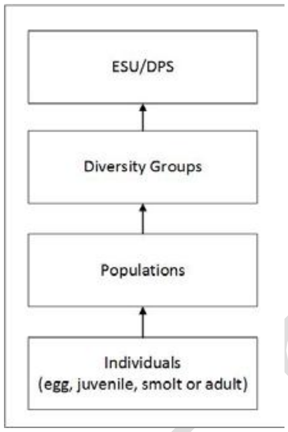

Figure 2.1.3-7. Conceptual Model of the Hierarchical Structure that is Used to Organize the Jeopardy Risk Assessment for Anadromous Salmonids.

2.1.3.1.2 Approach Specific to Southern Resident Killer Whales

The Overview of the Approach and Models Used (Section 2.1.3) and Application of the Approach to Listed Species Analysis (Section 2.1.3.1) described above also apply to NMFS' approach for Southern Resident killer whales (Southern Residents). As appropriate, we use NMFS WCR Guidance (NMFS 2013) on how to identify key components and characterize the potential effects of the PA on Southern Residents in this consultation. The Southern Resident DPS is a single population. The population is composed of three pods, or groups of related matrilines, that belong to one clan of a common but older maternal heritage (NMFS 2008). The Southern Resident population is sufficiently small that the relative fitness of all individuals from each pod can influence the survival and recovery of the DPS. Southern Residents are known to prefer Chinook salmon as their primary prey (Ford and Ellis 2006; Hanson et al. 2010), and Southern Resident population dynamics have previously been correlated with the abundance of Chinook populations over a broad scale throughout their range (Ward et al. 2013). Prior sections have discussed the analytical approach to assessing impacts to ESA-listed Chinook salmon. Similarly, an accompanying analysis of impacts to non-ESA-listed Chinook salmon will be performed to support assessment of effects on Southern Resident killer whale prey base. This analysis of effects to Southern Residents relies on the expected impacts of the PA on the abundance and availability of Chinook salmon for prey and how any expected changes in prey availability will affect the fitness, and ultimately the abundance, reproduction, and distribution, of the Southern Resident DPS.

2.1.3.2 Application of the Approach to Critical Habitat Analyses

The basis of the destruction or adverse modification analysis is to evaluate whether the PA affects the quantity or quality of the PBFs in the designated critical habitat for a listed species and, especially in the case of unoccupied habitat, whether the PA has any impacts to the critical habitat itself. Specifically, NMFS will conclude that a PA is likely to destroy or adversely modify the designated critical habitat for the ESU/DPS, if the action results in a direct or indirect alteration of the quantity or quality of the essential PBFs of designated critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species (81 FR 7214; 7216; February 11, 2016) (Note that the concept of primary constituent elements has been replaced by the statutory term "physical or biological features" as of February 2016 (81 FR 7414; February 11, 2016). NMFS bases critical habitat analysis on the affected areas and functions of critical habitat essential for the conservation of the species, and not on how individuals of the species will respond to changes in habitat quantity and quality. If an area encompassed in a critical habitat designation is likely to be exposed to the direct or indirect consequences of the PA on the natural environment, NMFS asks if PBFs included in the designation that give the designated critical habitat value for the conservation of the species are likely to respond to that exposure. In particular, NMFS is concerned about responses that are sufficient to reduce the quantity or quality of those PBFs or capacity of that habitat to develop those features over time.

To conduct this analysis, NMFS follows the basic exposure-response-risk analytical steps described in Figure 2.1.3-2 and applies a set of reasoning and decision-making questions designed to aid in this determination. These questions follow a similar logic path and hierarchical approach to the elements and areas within a critical habitat designation.

Table 2.1.3-4 outlines the reasoning and decision-making steps in the determination of effects of the PA on designated critical habitat. Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Table 2.1.3-5 includes the collection of information used to evaluate the effects of components of the PA on critical habitat.

Table 2.1.3-4. Reasoning and Decision-making Steps for Analyzing the Effects of the Proposed Action on Designated Critical Habitat.

Step	Apply the Available Evidence to Determine if…	True/False	Action
A	The proposed action is not likely to produce stressors that have direct or indirect adverse effects on the environment	True	End
		False	Go to B
B	Areas of designated critical habitat are not likely to be exposed to one or more of those stressors or one or more of the direct or indirect effects of the proposed action	True	NLAA
		False	Go to C
C	The quantity or quality of any physical or biological features of critical habitat or capacity of that habitat to develop those features over time are not likely to be reduced upon being exposed to one or more of the stressors produced by the proposed action	True	NLAA
		False	Go to D
D	Any reductions in the quantity or quality of one or more physical or biological features of critical habitat or capacity of that habitat to develop	True	NLAA

Step	Apply the Available Evidence to Determine if…	True/False	Action
	those features over time are not likely to reduce the value of critical habitat for the conservation of the species in the exposed area	False	Go to E
E	Any reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are not likely to appreciably diminish the overall value of critical habitat for the conservation of the species	True	No D/AD MOD
		False	D/AD MOD

Acronyms and abbreviations in the action column refer to not likely to adversely affect (NLAA) and destruction or adverse modification of critical habitat (D/AD MOD).

Table 2.1.3-5. Example of Information Used to Identify Effects of the Components of the Proposed Action to Critical Habitat.

Action Component	Location of Effect	Physical and Biological Features Affected	Response and Rationale of Effect	Magnitude	Weight of Evidence	Expected Change in PBF Supporting the Life History Needs of the Species

Tables 2-3 and 2-4 allow us to determine the expected consequences of the action on PBFs, sort or rank the magnitude of those consequences, and determine whether areas of critical habitat are exposed to additive effects of the PA and the environmental baseline. We recognize that the value of critical habitat for the conservation of the species is a dynamic property that changes over time in response to changes in land use patterns, climate (at several spatial scales), ecological processes, changes in the dynamics of biotic components of the habitat, etc. For these reasons, some areas of critical habitat might respond to an exposure when others do not. We also consider how the physical and biological features of designated critical habitat are likely to respond to any interactions with and synergisms between cumulative effects of pre-existing stressors and proposed stressors.

At the heart of the analysis is the basic premise that the value of an overall critical habitat designation for the conservation of the species is the sum of the values of the components that comprise the habitat. For example, the value of listed salmonid critical habitat for the conservation of the species is determined by the value of the watersheds or other areas that make up the designated area. In turn, the value of the watersheds or other areas is based on the quantity or quality of PBFs of critical habitat or capacity of that habitat to develop those features over time in that area. Specifically, NMFS will conclude that a Federal action is likely to "destroy or adversely modify" designated critical habitat if the action results in a direct or indirect alteration of the quantity or quality of the essential PBFs of designated critical habitat, or that precludes or significantly delays the capacity of that habitat to develop those features over time, and if the effect of the alteration is to appreciably diminish the value of critical habitat for the conservation of the species. NMFS may consider other kinds of impacts to designated critical habitat. For example, some areas that are currently in a degraded condition may have been designated as critical habitat for their potential to develop or improve and eventually provide the needed ecological functions to support species' recovery. Under these circumstances, NMFS may conclude that an action is likely to "destroy or adversely modify" the designated critical habitat if the action alters it or prevents it from improving over time relative to its pre-action condition.

Therefore, reductions in the quantity or quality of any PBFs of critical habitat or capacity of that habitat to develop those features over time may reduce the value of the exposed area (e.g., watersheds) for the conservation of the species, which in turn may reduce the value of the overall critical habitat designation for the conservation of the species.

There are, however, other considerations. We look to various factors to determine if the reduction in the quantity or quality of any PBFs of critical habitat or capacity of that habitat to develop those features over time would affect the value of the critical habitat for the conservation of the species. Examples of these factors include the following:

- The timing, duration, and magnitude of the reduction
- The permanent or temporary nature of the reduction

We use the current value for the conservation of the species of those areas of designated critical habitat that occur in the action area as our point of reference for our assessment of effects of the PA on designated critical habitat. For example, if the critical habitat in the action area has limited current value or potential value for the conservation of listed species, then that limited value is our point of reference for our assessment of the consequences of the effects of the PA on the value of the overall critical habitat designation for the conservation of the species. In addition, we must determine whether reductions in the value of critical habitat for the conservation of the species in the exposed area of critical habitat are likely to *appreciably diminish* the overall value of critical habitat for the conservation of the species. A PA could adversely affect critical habitat in an action area without appreciably diminishing the value of critical habitat for the conservation of the species.

2.1.3.3 Characterization of the Environmental Baseline

ESA regulations define the environmental baseline as "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). The environmental baseline provides a description of the conditions during the time period associated with the effects of the proposed action. The "effects of the action" include the direct and indirect effects of the PA and of interrelated or interdependent actions "that will be added to the environmental baseline" in the integration and synthesis, which is the subsequent section of and opinion (50 CFR §402.02). Consistent with these definitions, in *National Wildlife Federation v. National Marine Fisheries Service,* 524 F.3d 917, 929 (9th Cir. 2008), regarding NMFS' consultation on the effects of operating hydropower dams on the Columbia River, the Ninth Circuit Court of Appeals noted, "The 2004 BiOp initially evaluated the effects of the PA as compared to the reference operation, rather than focusing its analysis on whether the action effects, when added to the underlying baseline conditions, would tip the species into jeopardy." The court concluded that NMFS needed to consider the effects of the action in the context of the degraded baseline conditions when NMFS determined whether the PA would not jeopardize the continued existence of listed species. *Id*. at 929-31.

In the Environmental Baseline section (Section 2.4), we summarize the past and present impacts leading to the current status of the species in the action area, including the effects of CVP and SWP operations to date. The Environmental Baseline section also describes the exposure to non-project stressors that are expected to occur in the future (e.g., climate change), or extend into the future, affecting listed species and their critical habitats. Therefore, as illustrated in

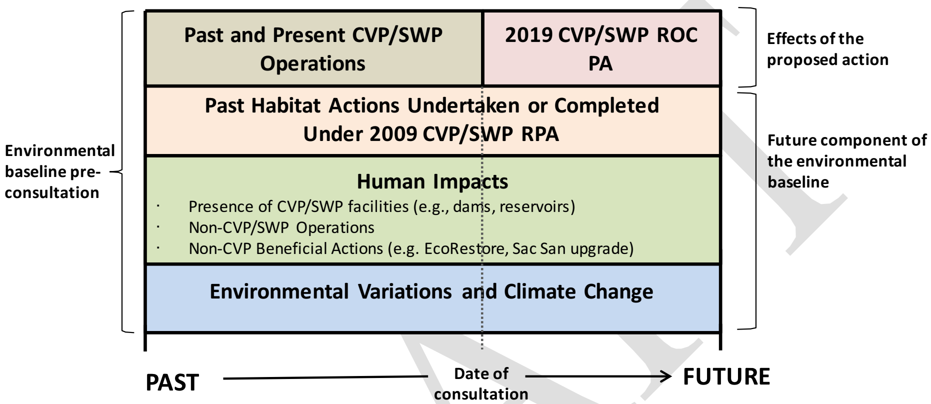

Figure 2.1.3-8, the pre-consultation environmental baseline characterizes the effects of the combination of natural environmental variation, human impacts, including those associated with past and current operations of the CVP and SWP, and past habitat actions undertaken or completed under the 2008 USFWS and 2009 NMFS biological opinions on the CVP and SWP operations. Note that the figure blocks are illustrative of general categories of components of aggregation of effects in the analysis. The figure does not denote relative intensity of effect or whether impacts are positive or negative; temporal variability of effect/impact is not depicted.

Implicit in both these definitions of environmental baseline and effects of the action is a need to anticipate future effects, including the future component of the environmental baseline. Future effects of Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to environmental variations, are future components of the environmental baseline, to which effects of the proposed project are added in the integration and synthesis section. In accordance with NMFS guidance (Sobeck 2016), climate change is included along with environmental variations in order to best characterize the future condition that the species will encounter.

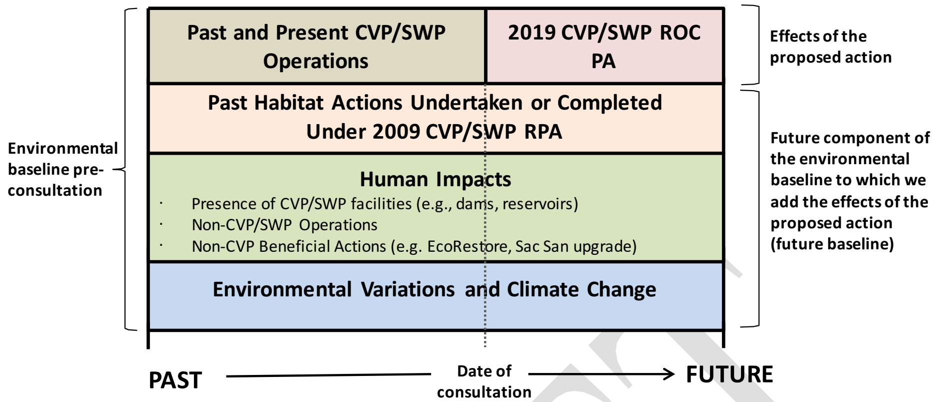

Figure 2.1.3-8. A Conceptual Model of the Effects of the Proposed Action Added on Top of the Future Component of the Environmental Baseline. Figure blocks are illustrative of general categories of components. Figure does not denote relative intensity of effect or whether impacts are positive or negative; temporal variability of effect/impact is not depicted.

To consider the effects of the action in the context of environmental baseline conditions, the analysis considers future effects of Federal projects that have undergone consultation and of contemporaneous State and private actions, as well as future changes due to natural processes, along with the effects of the proposed project. Given the timeline of the PA and because it includes an ongoing action (i.e., ongoing delivery of water), we analyze the entire suite of project effects along with environmental baseline conditions in the future, which captures anticipated effects of non-project processes and activities. As presented in the project description of the BA, the PA includes operations of the CVP and SWP in the future. Therefore,

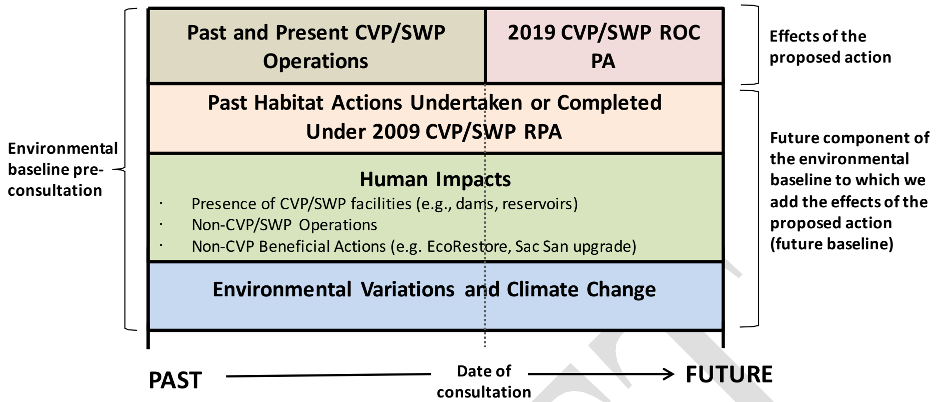

Figure 2.1.3-8 illustrates that the integrated analysis of effects of the PA in the future will include effects of past actions governed by components of the 2009 NMFS biological opinion along with effects of actions included in the biological opinion issued by NMFS for this PA.

2.1.4 Evidence Available for the Analysis

The primary source of initial project-related information was the biological assessment for the Reinitiation of Consultation on the Coordinated Long-Term Operation of the Central Valley Project and State Water Project, multi-agency meetings with the action agency to discuss project details and clarifications, and supplemental notes and data files. However, to conduct the consultation analyses, NMFS considered current literature and published information to provide a foundation for the analysis and represent evidence or absence of adverse consequences. In addition to a thorough review of up-to-date literature and publications, the following provides a list of resources that we considered in the development of our analyses:

- Final rules listing the species in this Opinion as threatened or endangered
- Final rules designating critical habitat for the CV salmon and steelhead species, CCC steelhead, and sDPS of green sturgeon
- Final rule describing the use of surrogates in ITSs (80 FR 26832; May 11, 2015)
- Final rule defining destruction or adverse modification of critical habitat (81 FR 7214; February 11, 2016)
- Final rule defining physical and biological features as replacements for primary constituent elements (81 FR 7414; February 11, 2016)
- 2016 5-year Status Review: Summary and Evaluation of Sacramento River Winter-run Chinook Salmon ESU
- 2016 5-year Status Review: Summary and Evaluation of CV Spring-run Chinook Salmon ESU
- 2016 5-year Status Review: Summary and Evaluation of CCV Steelhead DPS
- 2016 5-year Status Review: Summary and Evaluation of CCC Steelhead
- 2015 5-year Status Review: Summary and Evaluation of sDPS Green Sturgeon
- 2016 5-year Status Review: Summary and Evaluation of Southern Resident Killer Whale

Commented [CM4]: TO BE FINALIZED AFTER ALL "SUPPLEMENTAL" BA MATERIALS AND FINAL BA ARE RECEIVED.

- NMFS 2009 biological opinion on CVP and SWP operations and 2011 amendments to the reasonable and prudent alternative
- 2014 NMFS Recovery Plan for CV salmonids
- 2016 NMFS Recovery Plan for CCC steelhead
- 2018 NMFS Recovery Plan for sDPS of green sturgeon
- 2008 NMFS Recovery Plan for Southern Resident killer whale
- Past independent reviews (i.e., CVP and SWP biological opinions, CVP/SWP operations biological opinion annual reviews)
- Information included in Collaborative Science and Adaptive Management Program processes
- NMFS Selected Science Review for the Reinitiation Effort (Byrne 2018)

2.1.4.1 Primary Analytical Models

Commented [CM5]: PENDING FINALIZATION OF METHODS.

This text and associated figure will be finalized towards end of BiOp drafting to reflect the methods use. Generally, the existing text is accurate.

The Project BA includes a suite of models used in the analysis of the effects of the operations of the PA. NMFS used these model results along with results from additional analytical methods. Figure 2.1.4-1 provides a schematic of how information and results flow between the models; models specific to this Opinion are denoted with an asterisk (*). Fundamental models used in the BA and/or Opinion include the following:

- CalSimII: A hydrological planning scenario tool that provides monthly average flows for the entire SWP and CVP system based on an 82-year record (1922-2003).
- DSM2-HYDRO: One-dimensional hydraulic model used to predict flow rate, stage, and water velocity in the Delta and Suisun Marsh and used to support routing and hydrodynamic analyses.
- HEC-5Q: Uses CalSimII flow and climatic model output to predict monthly water temperature on the Trinity, Feather, American, and Stanislaus River basins and upstream reservoirs.
- Reclamation Egg Mortality Model*/SacSalMort*: Temperature-exposure mortality criteria for three life stages (pre-spawned eggs, fertilized eggs, and pre-emergent fry) are used along with the spawning distribution data and output from the river temperature models to compute percentage of salmon spawning losses.
- SALMOD*: Predicts effects of flows on habitat suitability and quantity for all races of Chinook salmon in the Sacramento River.
- DPM*: Simulates migration and mortality of Chinook salmon smolts entering the Delta from the Sacramento, Mokelumne, and San Joaquin rivers through a simplified Delta channel network, and provides quantitative estimates of relative Chinook salmon smolt survival through the Delta to Chipps Island.
- IOS*: A stochastic life cycle model for winter-run Chinook salmon the Sacramento River.
- Salvage-Density Analysis*: A model of entrainment into the south Delta facilities as a function of flow based on historical salvage data.
- NMFS-Southwest Fisheries Science Center Temperature Dependent Egg Mortality Model (Martin et al. 2017): A temperature-dependent mortality model for Chinook

salmon embryos that accounts for the effect of flow and dissolved oxygen on the thermal tolerance of developing eggs.
- Sacramento River Winter-run Chinook Salmon Life Cycle Model*: A state-space and spatially explicit life cycle model of eggs, fry, smolts, juveniles in the ocean, and mature adults that includes density-dependent movement among habitats.
- Anderson Egg Mortality Model: Models for managing the Sacramento River temperature during the incubation of winter-run Chinook salmon which characterize temperature-and density-dependent mortality from egg through fry survival.
- Weighted Usable Area*: A computation of the surface area of physical habitat available weighted by its suitability according to studies assessing suitability of physical and (at times) chemical factors such as substrate particle size, water depth, flow velocity, and dissolved oxygen.
- Floodplain Inundation*: Analysis of flow results to determine suitable area based on floodplain hydraulic modeling studies that informed relationships between floodplain flow and suitable area.
- Delta Salmonid Travel Time (Perry and Pope 2018): Pending.

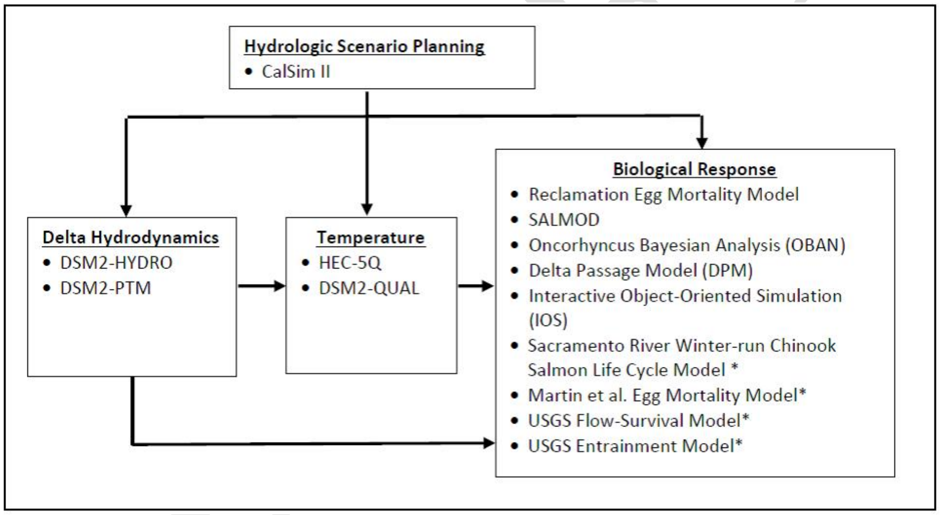

Figure 2.1.4-1. Main Models Used in the Analysis of Operations in the Biological Opinion and Their Information Flow with Respect to Each Other.

Though salmon life cycle modeling was not used in the previous biological opinion on system-wide water project operations in the Central Valley (i.e., NMFS 2009), NMFS has recognized the need to better integrate life cycle models into their assessments of the effects of water operations on the listed anadromous fish species. Peer reviews (Cummins et al. 2008; Anderson et al. 2009; National Research Council 2010) recommended increased use of life cycle modeling as part of the consultation analyses and provided general recommendations on how NMFS should proceed with further incorporating life cycle modeling into ongoing analyses (Rose et al. 2011).

Commented [CM6]: THIS IS FIGURE FROM CWF. WILL REVISE FIGURE AFTER FINAL DETERMINATION OF METHODS USED.

Expected to be added:
Floodplain inundation
WUA analysis
Anderson egg mortality model
Perry and Pope
Reclamtion Egg Morality Model (will be renamed SacSalMort)

Expected to be removed:
USGS Flow-survival model
OBAN
DSM2-PTM
DSM2-QUAL

In response, NMFS has developed a life cycle modeling framework for CV Chinook salmon that is used in this Opinion to allow better evaluation of how complex and interacting management actions affect salmon populations. Specifically, the analyses include results from a model framework developed by the NMFS Southwest Fisheries Science Center to describe salmon population dynamics given water management, habitat restoration, and climate change scenarios (Hendrix et al. 2014; Hendrix et al. 2016). The framework relies upon standard Central Valley physical (i.e., CalSimII, DSM2, HEC-RAS) and chemical (i.e., temperature models, DSM2-QUAL) models to provide a characterization of abiotic conditions for a given scenario. A stage-structured population dynamics model of Chinook salmon links the habitat information to density-dependent stage transitions. These transitions describe the movement, survival, and reproduction that drive the dynamics of salmon populations.

The physical models applied in the BA and relied upon in this Opinion are generalized and simplified representations of a complex water resources system. The models are not predictive models of actual operations, and, therefore, the results cannot be considered as absolute and within a quantifiable confidence interval. For instance, CalSim II is a monthly planning model; it is not calibrated and cannot be used in a real-time predictive manner. CalSim II results are intended to be used in a comparative manner, which allows for assessing the changes in the CVP and SWP system operations and resulting incremental effects between two scenarios. This and any subsequent models that use CalSimII results require caution when used to characterize absolute conditions or conditions on a sub-monthly time step.

Though the results of the analytical tools require a more comparative analysis, the analysis for section 7 consultation requires that the effects of the project be evaluated in the aggregate. Therefore, NMFS used the results of the analysis in the exposure-risk-response framework along with knowledge of the species status and environmental baseline to evaluate the overall conditions that fish experience. The quantitative results of the analytical methods are used to inform this evaluation as much as possible, though, given the limitations of many of the models to comparative analyses, this assessment does rely on a qualitative analysis and application of results.

2.1.4.2 Critical Assumptions in the Analysis

To address the uncertainties identified above related to the PA and the analysis provided in the BA, NMFS established a set of key assumptions required to address existing data gaps in the BA that are critical to our analysis of effects. General assumptions that were made in filling those data gaps include the following:

- Species presence data are an accurate description of when and where a proportion of a particular species can be expected to occur in a particular area. While real-time monitoring in any given year may provide an opportunity to fine-tune short-term presence information, the available data that characterize both the bulk of presence and the tails (that is, smaller proportion) of presence are considered the best information for informing exposure and risk.

- The characterization of future conditions incorporated into the PA and biological opinion analysis is applicable throughout operations until a subsequent consultation on the CVP and SWP is completed. The PA and biological opinion analyses characterize climate conditions, water demands, and build-out as predicted for approximately 2030.

- Real-time operations and adaptive management will be designed to incorporate uncertainty and allow action within reasonable timeframes for those activities given opportunities or scenarios to address uncertainties.

Commented [CM7]: PROJECT'S APPROACH TO AM IS NOT YET DEFINED.

- The project, as characterized in the modeling provided by the BA, does not simulate short-term real-time operations, especially those that are dependent on biological triggers. Because the modeling analysis is based on comparative long-term scenario planning tools, it is not able to emulate the daily operations that would be implemented to manage to biological, water quality, and other constraints. NMFS has analyzed the effects of the project as characterized by an initial approach to operations as identified by the operational criteria of the PA and completed auxiliary analyses when possible to evaluate the effects of real-time operations that are within the operational criteria identified in the PA.

- Results that include confidence intervals to characterize uncertainty are viewed in totality, considering the range of results over the intervals and not simply mean or median values.

- Exposure of a few individuals to a stressor, as indicated by the species presence, does not result in no adverse effect. Exposure of a small number of individuals may still result in incidental take of those individuals, however few, and this incidental take should not be ignored. If the magnitude of effect to those individuals is low, it will be stated as such.

Many of the methods described above focus the analyses on particular aspects of the action or affected species. Key to the overall assessment, however, is an integration of the effects of the PA with each other and with the baseline set of stressors to which the species and critical habitat are also exposed. In addition, the final steps of the analysis require a consideration of the effects of the action within the context of the baseline condition of the species and critical habitat. That is, following the hierarchical approaches outlined above, NMFS combines the effects of the action to determine whether the action is likely to appreciably reduce the likelihood of both the survival and recovery of the species or likely to result in the destruction or adverse modification of critical habitat. Because not all components of the PA were presented with the specificity required to analyze a particular outcome of effect, NMFS' determination is based on a collection of site-specific and framework-level action components. This can explain and result in different conclusions in the biological assessment compared to the biological opinion.

2.1.5 Integrating the Effects

The preceding discussions describe the various quantitative and qualitative models, decision frameworks, and ecological foundations for the analyses presented in this Opinion. The purpose of these various methods and tools is to provide a transparent and repeatable mechanism for conducting analyses to determine whether the PA is likely to jeopardize the continued existence of the listed species or result in the destruction or adverse modification of designated critical habitat.

Many methods described above focus the analyses on particular aspects of the action or affected species. Key to the overall assessment, however, is integration and synthesis which consists of: (1) Reviewing the status of the species and critical habitat; and (2) adding the effects of the action, the environmental baseline, and cumulative effects to assess the risk that the proposed action poses to species and critical habitat (Figure 2.1.3-1 and Figure 2.1.3-2). That is, following the hierarchical approaches outlined above, NMFS integrates the effects of the action with the baseline condition as the foundation to determine whether the action is reasonably expected to appreciably reduce the likelihood of both the survival and recovery of listed species in the wild and whether the action is likely to appreciably diminish the value of designated critical habitat for the conservation of the species.

2.1.6 Presentation of the Analysis in this Opinion

Biological opinions are constructed around several basic sections that represent specific requirements placed on the analysis by the ESA and implementing regulations. These sections contain different portions of the overall analytical approach described here. This section is intended as a basic guide to the other sections of this Opinion and the analyses that can be found in each section. Every step of the analytical approach described above is presented in this Opinion in either detail or summary form.

Description of the Proposed Action—This section summarizes the proposed Federal action and any interrelated or interdependent actions. This description is the first step in the analysis where we consider the various elements of the action and determine the stressors expected to result from those elements. The nature, timing, duration, and location of those stressors define the action area and provide the basis for our exposure analyses.

Range-wide Status of the Species and Critical Habitat—This section provides the baseline condition for the species and critical habitat at the listing and designation scale. For example, NMFS evaluates the current viability of each salmonid ESU/DPS given its exposure to human activities and natural phenomena such as variations in climate and ocean conditions, throughout its geographic distribution. These baseline conditions form the basis for determining whether the PA is likely to jeopardize the continued existence of the species or result in the destruction or adverse modification of critical habitat. Other key analyses presented in this section include critical information on the biological and ecological requirements of the species and critical habitat and the impacts to species and critical habitat from existing stressors.

Environmental Baseline—This section provides the baseline condition for the species and critical habitat within the action area. By regulation, 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 on the species and critical habitat. This section will also include anticipated effects of climate change on the species and critical habitat within the action area. In this Opinion, some analysis may be contained within the

Status of the Species and Critical Habitat section, due to the large size of the action area (which entirely or almost entirely encompasses the freshwater geographic ranges of some listed fish species). This section also summarizes the impacts from stressors that will be ongoing in the same areas and times as the effects of the PA. This information forms part of the foundation of our exposure, response, and risk analyses.

Effects of the Proposed Action—This section details the results of the exposure, response, and risk analyses NMFS conducted for effects of the PA on individuals and proportion of the listed species population and PBFs and value for the conservation of the species of critical habitat within the action area. This will include the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action, that will be added to the environmental baseline (50 CFR §402.02). Indirect effects are those that are caused by the PA and are later in time, but still are reasonably certain to occur. Discussion of results will include identification of uncertainties associated with analytical methods or interpretation and will highlight instances of application of the precautionary principle to give the benefit of the doubt to the species. In the case of the PA, climate change effects as modeled for a 2030 climate scenario will be incorporated into the analysis by explicit modeling and additional qualitative evaluations to better incorporate more recent climate projections.

Cumulative Effects—This section summarizes the impacts of future non-Federal actions reasonably certain to occur within the action area, as required by regulation. Similar to the rest of the analysis, if cumulative effects are expected, NMFS determines the exposure, response, and risk posed to individuals of the species and features of critical habitat. Future Federal actions that are unrelated to the PA are not considered in this section because they require separate consultation pursuant to section 7 of the ESA.

Integration and Synthesis of Effects—Section 2.7, Integration and Synthesis, is the final step in our assessment of the risk posed to species and critical habitat as a result of implementing the PA. In this section, we add the effects of the action to the environmental baseline and the cumulative effects, taking into account the status of the species and critical habitat, to formulate NMFS' Opinion as to whether the PA is likely to: (1) reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing its reproduction, numbers, or distribution; or (2) appreciably diminish the value of designated critical habitat for the conservation of the species. Discussion will include identification of uncertainties associated with the integration of effects and will highlight instances of application of the precautionary principle to give the benefit of the doubt to the species.