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PROPOSED AQUATIC ECOSYSTEM ASSESSMENT METHODS

OVERVIEW AND OBJECTIVES

The major ecosystem quality objective of the CALFED Bay-Delta Program (CALFED) is to improve and increase aquatic and terrestrial habitats and improve ecological functions in the San Francisco Bay/Sacramento-San Joaquin River Delta (Bay-Delta) to support sustainable populations of diverse and valuable plant and animal species. Alternatives included in the Programmatic Environmental Impact Report/Environmental Impact Statement (EIR/EIS) are structured to meet this and other objectives (e.g., water quality, water supply reliability, and system vulnerability). The alternatives will have different effects on the aquatic ecosystem, and the impact assessment must identify differences among the alternatives (i.e., identify potential changes in the aquatic ecosystem, both beneficial and adverse, under each alternative relative to the No-Action Alternative and existing conditions baseline).

This report builds on the Fish Assessment Process Working Document (August 22, 1996) and the report Species and Assessment Variable Selection for the Fish Assessment Process for the CALFED Bay-Delta Program Programmatic EIR/EIS (September 6, 1996). The Fish Assessment Process Working Document provides a framework for identifying assessment methods by species and lifestage. The species and assessment variable selection report identifies species and assessment variables that will be included in the impact assessment for the Programmatic EIR/EIS. Information developed in those reports is used here to develop the process for selecting methods that will be included in the tools for the impact assessment.

Assessment methods are identified based on assessment variables affected by CALFED actions for each aquatic community, species selected for inclusion in the impact analysis, and constraints on the assessment criteria. Information provided by participants in the assessment process has substantially influenced selection of methods. The most important and consistently restated concern is that evaluation of differences between alternatives should be based on relationships that are clearly known, measurable, and defensible. This report reflects efforts to address this concern.

The initial focus of the work teams was on fish species. Responding to suggestions by some participants in the assessment process, the overall methodology for impact assessment has been modified to focus on the aquatic ecosystem as a whole. The aquatic ecosystem assessment methods, however, encompass cause-and-effect relationships illustrative of both overall ecosystem function and the response of individual species to changes in habitat conditions.

This report, preceding reports, and additional information provided by participants in the assessment process will be combined in a final report that describes the process leading to selection of impact assessment methods, including the selection of assessment variables, assessment criteria, and species.

AQUATIC COMMUNITIES

The aquatic ecosystem is divided into five communities based on occurrence of fish and invertebrate species (Moyle 1976) and on habitat conditions potentially affected by CALFED actions:

- **The reservoir community** occurs in Central Valley reservoirs that are lower than 1,500 feet in elevation (e.g., Shasta and Folsom Lakes, Lake Oroville).

- **The coldwater riverine community** occurs in the stream and river reaches that include chinook salmon spawning habitat (i.e., habitat that provides physical habitat needs, as defined by velocity, depth, and substrate size, and adequate water temperature for spawning and incubation).

- **The warmwater riverine community** occurs in the river reaches downstream of the coldwater riverine community and extends to the upstream edge of the Delta.

- **The estuarine community** extends from the downstream edge of the warmwater riverine community to the upstream edge of the marine community and occurs in tidally influenced habitat ranging in salinity from 0 to 10 parts per thousand (ppt).

- **The marine community** extends from the downstream edge of the estuarine community to the Golden Gate Bridge and occurs in tidally influenced habitat with salinity exceeding 10 ppt.

With the exception of the reservoir community, the geographic boundaries between these aquatic communities are not clearly defined. Under varying hydrological and meteorological conditions, the boundaries shift upstream and downstream. During wet years, the downstream boundaries of all five communities shift toward San Francisco Bay. During drier years, the downstream boundaries shift upstream toward the dams or headwaters.

The fish species that occur in each community were identified in the species and assessment variable selection report, made available to assessment team members on September 6, 1996. The coldwater riverine community encompasses fishes of the squawfish-sucker-hardhead zone, and the warmwater riverine community encompasses fishes of the deep-bodied–fishes zone.

ASSESSMENT VARIABLES

The assessment variables described below characterize aquatic habitat conditions potentially affected by CALFED actions. Change in the assessment variables affects ecological functions and species populations within the aquatic ecosystem. For each aquatic community, Tables 1 through 5 list potential CALFED actions, a brief description of the effect of CALFED actions, and affected primary and secondary assessment variables. Primary assessment variables are directly affected by CALFED actions. Secondary assessment variables are indirectly affected and change in response to primary variables.

INSTREAM FLOW

Instream flow includes several parameters directly related to water movement in rivers and streams. Instream flow is affected by weather, reservoir operations, diversions, tributary inflow, groundwater accretion, and drainage water accretion (i.e., discharge and nonpoint-source runoff from municipal, industrial, and agricultural sources). The effects of changes in instream flow on availability of aquatic habitat are described below under "Habitat".

FLOW. Flow is the rate of water movement past a specific point. Flow has direct and indirect effects on physical, chemical, and biological mechanisms that affect survival, growth, reproduction, and migration of fish and other aquatic organisms.

TRANSPORT. Transport is the time required for a mass (e.g., water, particles) to move between two specific points and is a function of stream morphology, flow, distance, physical properties of the particles, and (in the case of living organisms) behavior.

DELTA FLOW

Delta flow includes several parameters directly related to movement of water in the Bay-Delta estuary. Delta flow is affected by weather; tides; tributary inflow, including effects of upstream reservoir operations; diversions; flow division to Delta channels, including the effects of barriers and channel morphology; drainage water accretion (i.e., discharge and nonpoint- source runoff from municipal, industrial, and agricultural sources); and potential discharge from future in-Delta water storage facilities.

NET FLOW. Net flow is the rate of water movement past a specific point, not including tidal flow. Net flow in a Delta channel is a function of inflow, diversion, and flow divisions (including the effects of barriers) within the Delta. Commonly calculated net flows include Delta inflow, San Joaquin River flow past Jersey Point, and Delta outflow.

TIDAL FLOW. Tidal flow is the average channel flow attributable to ebb or flood tides not including net flow. In addition to the direct effects all flow has on fish and other aquatic organisms, tidal flow affects water surface elevation, tidal excursion (i.e., movement of a mass upstream and downstream with the flood and ebb tides), and tidal prism (i.e., the volume of water that moves past a location as the result of a change in tidal stage).

TRANSPORT. Transport is the time required for a mass to move between two specific points and is a function of channel morphology, net and tidal flow, distance, physical properties of the particles, and (in the case of living organisms) behavior.

RESERVOIR ELEVATION

Reservoir elevation refers to water surface elevation at a specific time and the change in elevation over time. Reservoir elevation is a function of reservoir inflow, outflow, and morphology. The primary effects of variable reservoir elevation on fish are through changes in reservoir productivity, habitat availability, habitat quality, and water quality.

TEMPERATURE

Water temperature refers specifically to the temperature of water in stream channels, including water released from storage reservoirs. Temperature does not include discharge of cooling water from electrical generation plants or other facilities. Effects of changes in temperature may be presented in percent survival of a species and as change in habitat availability; temperature habitat relationships are discussed under "Habitat".

ESTUARINE SALINITY

Estuarine salinity is presented as concentrations, electrical conductivity units, and geographical location. Estuarine salinity is a function of the mixing of ocean salinity with freshwater inflow and does not include land-derived salinity, which is discussed under "Water Quality". Delta outflow, tidal flow, and estuary morphology affect the distribution of salinity in the estuary. The effects of changes in estuarine salinity on habitat availability are discussed under "Habitat".

SEDIMENT MOVEMENT

Sediment movement refers to both deposition and erosion of bottom and lateral substrates. Sediment movement includes natural (e.g., water and wind erosion and deposition) and human-induced processes (e.g., dredging, dredge disposal, levee construction, and boat wakes). Sediment movement may be represented by changes in channel width, length, depth, or area or sediment

composition of substrates (e.g., percent fines). Suspended sediment is not discussed in this category but is discussed under "Water Quality" (i.e., transparency).

DIVERSION IMPACTS

Diversion impacts refer to all losses and mortality of fish and other aquatic organisms attributable to consumptive and nonconsumptive diversions. Diversion impacts are primarily a function of physical and biological factors. Diversion effects may be presented as percentage of flow diverted, percentage of a species population lost, or number of fish (e.g., fish impinged, abraded, entrained, disoriented, or lost to predation). Fish screen efficiency, salvage operations, predator removal, and other activities affect the level of diversion losses. Diversion effects on channel flow and streamflow are not included in this category but are addressed under "Flow".

BARRIERS

Barriers are any structures that impede the movement or reduce the survival of fish and other aquatic organisms that must pass over, around, or through the barriers. Barriers include dams, temporary physical obstructions of rock and other materials, gated structures, acoustical barriers, electrical barriers, air-bubble barriers, and louvered barriers. Barriers may affect fish movement without affecting net flow. The effects of barriers on fish movement are a function of physical and biological factors. Barriers are sometimes associated with diversions and the effects of barriers and diversions may be difficult to separate. Effects of barriers on channel flow patterns in the Delta and Suisun Bay are not included in this category but are covered under "Flow". Barriers to fish movement that are attributable to salinity or dissolved oxygen are discussed under "Water Quality".

HABITAT

Habitat has physical, chemical, and biological attributes that may be important to survival of aquatic species. As defined here, habitat refers to availability of area, depth, or distance that possesses characteristics representative of a species' need or other ecological function (e.g., wetted area, length of wetted perimeter, or weighted usable area).

PHYSICAL HABITAT. Physical habitat, both spawning and rearing, possesses attributes that may be important to species survival. Physical habitat represents potential availability and is not necessarily representative of actual availability. Actual habitat availability depends on flow, temperature, estuarine salinity, and other variables included under other categories described below.

EFFECT OF FLOW ON HABITAT. The effects of flow on habitat availability may be presented as "weighted usable area" (e.g., acres, square feet). Weighted usable area is a function of flow and habitat preference or use by a species (e.g., preferred ranges of velocity, depth, and substrate). Depth and wetted area may also indicate aspects of habitat availability related to flow.

EFFECT OF WATER TEMPERATURE ON HABITAT. The effects of water temperature on habitat availability may be presented in length, volume, or area that meet specific temperature needs for a species or lifestage that potentially occurs in the habitat.

EFFECT OF ESTUARINE SALINITY ON HABITAT. The effects of estuarine salinity on habitat may be presented as area, volume, or distance. The habitat must meet specific salinity needs for a species, life stage, or aquatic community (e.g., acres of optimal salinity habitat).

EFFECT OF RESERVOIR ELEVATION ON HABITAT. Both falling and rising water surface elevations affect spawning and rearing habitat for reservoir fishes. The effects of changes in reservoir elevation on habitat availability may be presented as area, depth, or distance (e.g., wetted area, length of wetted perimeter, or weighted usable area).

WATER QUALITY

Water quality is a broad category of chemical, physical, and biological characteristics of water that are influenced by human activities and that affect survival of fish and other aquatic organisms. Water quality is influenced by municipal and industrial discharge, agricultural and urban runoff, direct application of pesticides, and dredging or filling operations. Accretion of groundwater in streamflow may also affect water quality by altering dissolved oxygen levels and water temperature and introducing nutrients and toxicants.

AGRICULTURAL SALINITY. Agricultural salinity originates from dissolved salts in agricultural runoff. In the San Joaquin River, agricultural salinity has periodically created a barrier to migration and spawning for some species.

THERMAL POLLUTION. Electrical generation plants, sewage treatment plants, and other facilities discharge water at temperatures that may exceed the temperature of receiving water. The increased temperature may affect the survival of fish and other aquatic species present in the receiving water.

DISSOLVED OXYGEN. Low dissolved oxygen levels have periodically created a barrier to migration of chinook salmon in the lower San Joaquin River. Low dissolved oxygen levels result primarily from the discharge of organic material (e.g., treated sewage) to Delta channels. Either supersaturation or reduced levels of dissolved oxygen is generally not a major factor affecting aquatic species in the Sacramento-San Joaquin River system or in the Bay-Delta.

NUTRIENTS. Inorganic nutrients enter the aquatic ecosystem primarily through agricultural runoff and sewage discharge. Nutrient input can contribute to noxious phytoplankton blooms and to reduced levels of dissolved oxygen. As described above, low dissolved oxygen levels can adversely affect fish migration and survival.

TOXICANTS. Toxicants reduce the survival of fish and other aquatic organisms through acute and chronic effects. Toxicants include pesticides, metals, and other chemicals that enter the aquatic ecosystem through agricultural runoff, direct application (e.g., water weed control), industrial discharge, dredging, mine drainage, sewage discharge, and urban runoff.

TRANSPARENCY. Transparency is the ability of light to penetrate water (i.e., water clarity). Changes in transparency can reduce survival and growth of fish (especially larval fish) and other aquatic organisms, reduce primary productivity, and adversely affect habitat suitability. Transparency is a function of particulate (including sediment, algae, and other organic particles) and dissolved materials. Natural (e.g., flow- and wind-driven mixing and erosion, decomposing vegetation, and algal populations) and human-induced processes (e.g., dredging, dredge disposal, sewage discharge, and boat wakes) affect transparency.

FISHING

Fishing includes commercial fishing, sport fishing, and illegal fishing activities that cause or contribute to the death of individuals in a species population.

ARTIFICIAL PRODUCTION

Artificial production is the human-aided production of a species in facilities isolated to some degree from the natural ecosystem (e.g., fish hatcheries, rearing pens). The produced individuals are released to supplement wild populations and provide fishing opportunities.

SPECIES INTERACTIONS

Species interactions are a broad range of biological factors potentially affecting the survival of fish and other aquatic organisms. Effects of human activities on species interactions are usually indirect, although direct effects also occur (e.g., introduction of exotic species). Species interactions, however, may change substantially in response to other changes in the assessment variables discussed above.

PREDATION. Predation occurs naturally; however, fish and other aquatic organisms that are already stressed by other factors (e.g., elevated water temperature and turbulence created by barriers) may be more susceptible to predation, and the prey population may be sensitive to additional mortality. Predation may also increase with the introduction of exotic predators (e.g., striped bass and largemouth bass).

COMPETITION. Competition occurs when the use of a resource (e.g., food or habitat) by one individual reduces the availability of the same resource for another individual. Competition occurs within a species population and between species. As with predation, fish already stressed by other

factors (e.g., elevated water temperature, reduced water velocity) may be less able to compete for limited resources, and species survival could decline. The introduction of exotic species with resource needs similar to native species may increase competition for limited resources.

FOOD AVAILABILITY. Food availability refers to the density of food items available. Food availability may be affected by the assessment variables discussed previously (e.g., flow, estuarine salinity, temperature, water quality, and habitat). Introduced species may reduce food availability for species with similar food preferences (i.e., competition).

DISEASE. Disease refers to fungi, bacteria, viruses, and other pathogens that may limit species population abundance. The pathogens may be natural or introduced, and the effects may vary depending on interactions with other assessment variables.

EXOTIC PLANTS. Introduction of exotic plants to aquatic habitats may affect species population abundance through modification of habitat (e.g., change in substrate, water circulation, and water quality) and through changes in species interactions (e.g., food availability, predation, and competition).

SPECIES SELECTED FOR INCLUSION IN THE IMPACT ASSESSMENT

A representative group of species that occur in the aquatic ecosystem was selected based on species importance and species response to the assessment variables potentially affected by CALFED actions. The methods applied to select species was described in the information provided on September 6, 1996. Including the three species added during the meeting on September 13, 1996 (i.e., tule perch, starry flounder, and Pacific herring), 25 species were selected for inclusion in the impact analysis, 18 species of fish and seven species or groups of invertebrates (Table 6).

Species were selected from each of the five aquatic communities. Species were considered important if they support sport or commercial fisheries, are listed under the federal or California Endangered Species Acts, or the species has a significant ecological role. Species response to assessment variables could include affects on survival, growth, reproduction, and migration; population abundance and distribution; and habitat availability. If the response of two or more species is similar, the analysis of the response of one species was assumed to adequately represent the response of the other species for the purpose of the Phase II programmatic evaluations.

CONSTRAINTS ON ASSESSMENT CRITERIA

Assessment criteria provide a measure of the effect of CALFED actions on habitat conditions, ecological functions, and species populations. Assessment criteria may include the assessment variables previously described (i.e., secondary variables that change in response to

primary variables) or some measure of response to changes in the assessment variables (e.g., survival and abundance). Assessment criteria must meet all of the following constraints to be considered for inclusion in the impact assessment for the Programmatic EIR/EIS. A "No" response to evaluation against any of the three constraints results in the criterion being dropped from further consideration.

- **Constraint 1: Measurable.** The assessment criteria must be measurable and must illustrate the extent and nature of differences between alternatives. The relationship between a change in an assessment variable and the assessment criteria (i.e., the response) must be known and supportable with available information.

- **Constraint 2: Accuracy and Precision.** The assessment criteria should be quantifiable within appropriate accuracy and precision (i.e., sufficiently sensitive to measure differences between alternatives). The measurement error must be lower than the range of differences among alternatives.

- **Constraint 3: Importance.** The assessment criteria must make it possible to identify and not falsely imply important differences and similarities between alternatives. The assessment criteria must be sensitive to substantial effects on ecological functions or abundance and distribution of species populations. The criteria must also indicate effects on the potential to meet ecosystem restoration objectives of the CALFED Program and of other ongoing aquatic ecosystem restoration programs (e.g., Central Valley Project Improvement Act, endangered and threatened species recovery plans).

METHODS SELECTED FOR INCLUSION IN THE IMPACT ASSESSMENT

Assessment methods are listed in Tables 7 through 11 for the assessment variables and species identified in the preceding sections. Methods may be included among the tools used for the impact assessment in the Programmatic EIR/EIS if the assessment criteria meet all three constraints identified above. The methods are generally specific to a species and life stage, but also encompass cause and effect relationships illustrative of ecosystem function.

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