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PRELIMINARY DRAFT TECHNICAL MEMORANDUM

Date: December 18, 2007

To: Steve Ottomoeller, URS
Maury Kruth, Bureau of Reclamation, Mid-Pacific region
Jacob McQuirk, Department of Water Resources

From: Tom Taylor and Larry Wise

RE: **Delta Mendota Canal Recirculation Feasibility Study**
Fisheries and Aquatic Ecosystems Technical Memorandum
Existing Conditions and Analytical Approach

This technical memorandum was prepared to provide information relating to the fisheries and aquatic resources that might be affected by the Delta Mendota Canal Recirculation Project and to present approaches and criteria to evaluate these potential effects. The memorandum is organized as follows:

- Section 1.0 describes the objectives of this document and provides the project background needed to understand subsequent discussions regarding the evaluation approaches and criteria.
- Section 2.0 describes the affected environment and existing conditions. Section 2.1 describes the aquatic resources that could be affected by the project, including population trends and life history information. Section 2.2 describes the different ecoregions within the project area, the regulatory requirements pertaining to them, and the values of these parameters under existing conditions.
- Section 3.0 describes the potential effects of the project on fisheries and aquatic resources in each ecoregion and the assessment approach and significance criteria that are proposed for use in the EIR/EIS for this project.
- Section 4.0 presents some fisheries issues for consideration in the development and screening of different project alternatives.
- Section 5.0 provides citations for the references used within this document.

1.0 INTRODUCTION AND BACKGROUND

1.1 Fisheries and Aquatic Ecosystems Technical Memorandum

This Fisheries and Aquatic Ecosystems Technical Memorandum (FTM) is a component of the overall DMC Recirculation Project Feasibility Study (FS) process. This document builds upon previous documents prepared as part of the FS process (described below) and incorporates these documents by reference.

The FTM was developed in collaboration with the Fisheries Technical Working Group (FTWG) comprised of representatives from the California Department of Fish and Game (CDFG), National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (FWS), California Department of Water Resources (DWR), Anadromous Fish Restoration Program (AFRP), U.S. Department of Interior, Bureau of Reclamation (Reclamation) and Reclamation's consultant team headed by URS, with ENTRIX leading the assessment of impacts to aquatic resources. The purpose of this document is to 1) describe aquatic resources within the project area that may be affected by the project, 2) describe the parameters that will be used in the evaluation of potential impacts to these resources, and 3) describe the criteria that will be used to determine whether significant impacts to these resources would be likely to occur.

This Technical Memorandum is an interim work product of the ongoing DMC Recirculation Feasibility Study and has been prepared to assist the study team in the execution of the DMC Recirculation Feasibility Study. It may be used, in whole or in part, in support of the preparation of the Feasibility Report and EIS/EIR, which will be completed later in the study process. This Technical Memorandum is not a decision document and does not represent the official position of any State or Federal agency.

In developing the approaches and criteria presented herein, it was necessary to formulate a number of assumptions in advance of actual modeling of the various alternatives. These assumptions were based on the best available information at that time. They are intended only as a starting point for the development of approaches and criteria to assessing impacts on aquatic resources. These assumptions are not intended to limit the range of potential project operations.

1.2 Background

Reclamation is evaluating the feasibility of the Delta-Mendota Canal (DMC) Recirculation Project, which involves potentially recirculating water from the Sacramento-San Joaquin River Delta (Delta) through the Central Valley Project (CVP) pumping and conveyance facilities to the San Joaquin River (SJR), upstream from Vernalis (the point at which San Joaquin River enters the Delta). DWR is cooperating with Reclamation during the feasibility investigation and is serving as lead California Environmental Quality Act (CEQA) agency for the joint federal and state Environmental Impact Statement/Environmental Impact Report (EIS/EIR).

1.3 Project Authorization

The DMC Recirculation Project FS is authorized by the CALFED Bay-Delta Authorization Act of 2004 (Public Law [PL] 108-361). Section 103(d)(2)(D)(iii) states, "The Secretary shall incorporate into the program a recirculation program to provide flow, reduce salinity concentrations in the San Joaquin River, and reduce the reliance on the New Melones Reservoir for meeting water quality and fishery flow objectives through the use of excess capacity in export pumping and conveyance facilities." State Water Resources Control Board Water Rights Decision 1641 (SWRCB 2000, as revised, hereafter D-1641), requires that Reclamation "shall prepare a Plan of Action (POA) for a recirculation analysis alternative to evaluate the feasibility and impacts of recirculating water from the Delta Mendota Canal through the Newman Wasteway . . ." The purpose of the POA will be to develop a thorough workplan for determining the feasibility of use of recirculation as a method for meeting and/or augmenting the Vernalis objectives and San Joaquin water quality objectives. Further description of these requirements is available in the

POA (Reclamation 2006) and the subsequent Initial Alternatives Information Report (IAIR) (Reclamation 2007).

1.4 Previous Project Documents

The POA, Plan of Study (POS) (Reclamation 2006) described the plan for implementing the recirculation feasibility studies and that included a long-term schedule for completing a study in compliance with D-1641. The IAIR consider a wide range of possible alternatives and narrows this range to a subset of viable alternatives. The IAIR (Reclamation 2007) includes the following:

- A description of existing and likely future water resources and related conditions in the study area as well as related problems, needs, and opportunities being addressed in the study.
- A description of related studies and programs that may interact with this project.
- Development of planning objectives to address identified problems, needs, and opportunities.
- Identification of the planning constraints, guiding principles, and criteria for the FS.
- Development of resource management measures to address planning objectives.
- Formulation and evaluation of initial project alternatives, including a "No Action" Alternative, that complies with the CALFED Record of Decision (ROD) (CALFED 2000) and do not conflict with CALFED objectives, solution principles, or policies. In addition, the plan formulation and evaluation process must comply with the federal Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&Gs) (Water Resources Council 1983).
- A description of the potential alternatives and the screening process used to identify a recommended set of initial alternatives to be further developed in the FS.
- Identification potential major future actions for the FS.

Please refer to the IAIR for a more detailed description of these elements.

1.5 Project Area

The project area (Figure 1-1) can be defined as the lower main stem of the San Joaquin River below its confluence with the Merced River and the Newman Wasteway, the areas served by the Merced, Tuolumne, and Stanislaus Rivers on the western side of the Sierra Nevada Mountains, the Newman and Westley wasteways, and the areas served by the DMC, which includes approximately 30 water agencies. The project area also includes the south Delta, which is a source of water supply for agricultural and urban uses within the Delta and conveys water for these uses to the CVP and State Water Project (SWP) exports facilities for use south of the Delta.

The DMC is on the western side of Central California's San Joaquin Valley. It runs for approximately 120 miles, beginning near Tracy at the southern edge of the Delta and terminating at the Mendota Pool on the San Joaquin River, at Mendota. The DMC is part of the federal CVP Delta export facilities, which also include the C.W. "Bill" Jones Pumping Plant (JPP) (formerly known as the Tracy Pumping Plant), the Westley, Newman, Volta and Firebaugh Wasteways, the O'Neill Pumping Plant, the O'Neill Forebay, and the SLR. The facilities and features that are likely to be used directly as part of the project include, but may not be limited to, the JPP, the DMC, the Westley or Newman Wasteway, and the San Joaquin River below its confluence with the Merced River. The project also may impact the operations of other CVP facilities, either directly or indirectly, including the San Luis Reservoir (SLR) and the New Melones Reservoir on the Stanislaus River (see Figure 1-1).

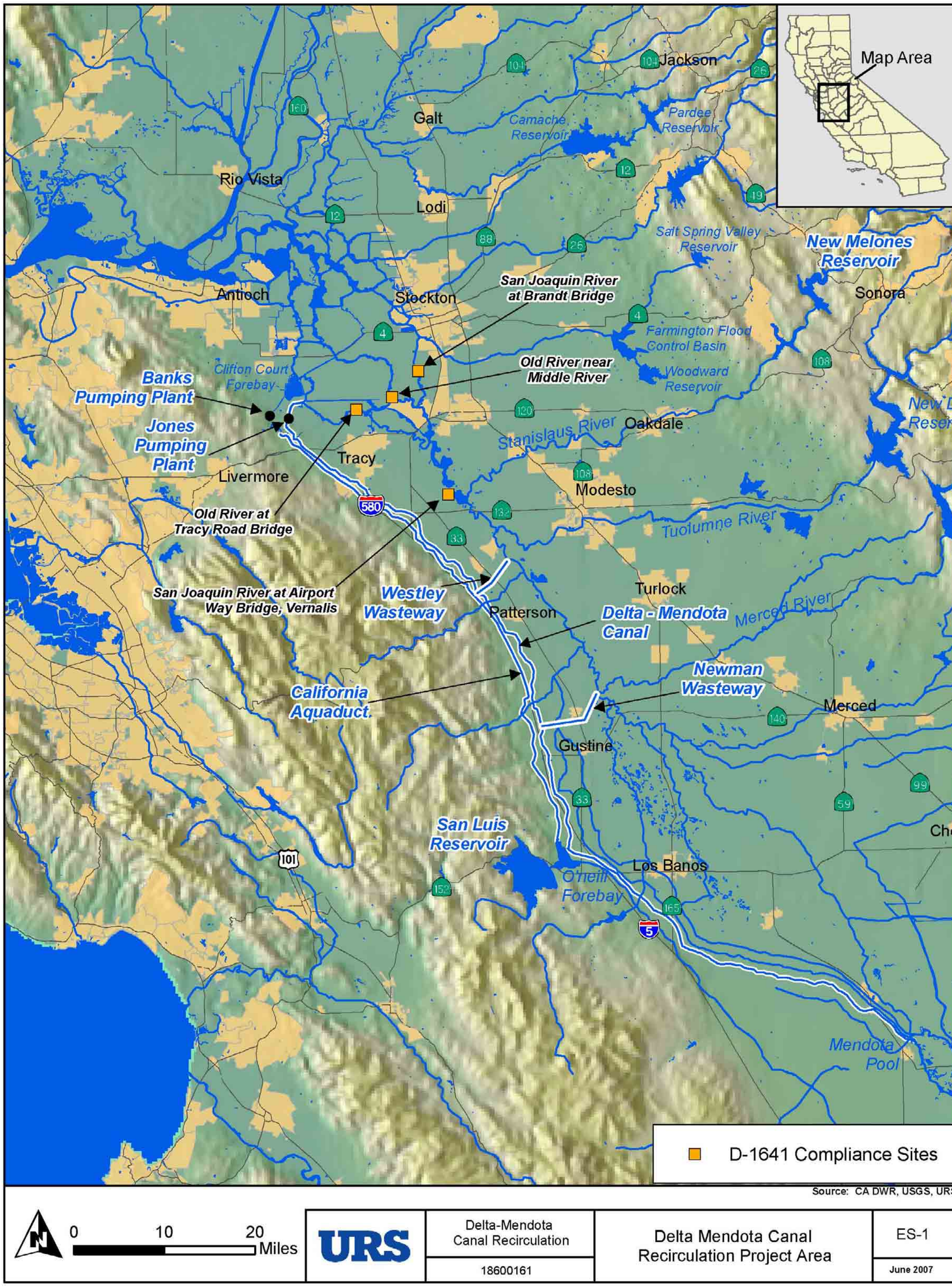

Figure 1-1 Delta-Mendota Canal Recirculation Project Area

The DMC generally runs parallel to the California Aqueduct, a state-owned facility providing primarily agricultural water to southern portions of the San Joaquin Valley and primarily urban water to southern California. State Water Project facilities that may be used for recirculation include the Harvey O. Banks Pumping Plant (BPP), California Aqueduct, and SLR.

For the assessment of impacts to aquatic resources, the project area is divided into three ecoregions: the Sacramento-San Joaquin Delta, the San Joaquin River, and tributaries to the San Joaquin River, primarily the Stanislaus River. These ecoregions have different physical conditions, biological uses, and potential project effects. Therefore, the evaluation of potential effects differs within these regions.

1.6 Alternatives to be Considered

The IAIR identified three alternatives, in addition to the No Action Alternative, to be carried forward in the planning process. Each alternative encompasses multiple variations or operational scenarios. Each variation would range from (1) achieving the objective of complying with water quality standards and flow objectives, (2) achieving the quality and flow objectives while enhancing the New Melones water supply, or (3) improving compliance with water quality and flow objectives while enhancing the New Melones water supply (Figure 1-2). The second element, discriminating among the alternatives, is the facilities that would be used to implement that alternative. Alternatives 1 and 3 (all variations) include the use of both CVP and SWP facilities, while Alternative 2 (all variations) includes the use of only CVP facilities. These alternatives are described briefly below and in detail in the IAIR (Reclamation 2007). Table 1-1 shows how the major components and priorities vary among the alternatives.

1.6.1 No Action Alternative

Under the No Action Alternative, no recirculation would be conducted. This alternative is required for analysis of environmental effects under CEQA and NEPA. The No Action Alternative is described in more detail in Section 3 of the DIAIR.

1.6.2 Alternative 1: Supplement New Melones Operation

This alternative adds recirculation to the existing operation in the basin. Recirculation would be used as an additional tool to help meet current water quality standards and flow objectives. Under this alternative, the current level of releases from New Melones for water quality and flow compliance would largely remain unchanged. BPP would be used to replace water in SLR lost due to recirculation. Variants include different JPP pumping priorities relative to other CVP obligations.

1.6.3 Alternative 2: CVP Alone

This alternative focuses the tools available to serve project goals on CVP facilities (inclusive of institutional arrangements such as wheeling). Recirculation flow would be limited to water that can be pumped at JPP. Variants include different JPP pumping priorities relative to other CVP obligations and if recirculation releases would be used prior to or after New Melones San Joaquin River releases.

1.6.4 Alternative 3: Enhance New Melones Water Supply

This alternative strives to evaluate the dual project objectives of water quality and flow compliance and the enhancement of the New Melones water supply. The difference between this alternative and Alternative 1 is that recirculation occurs prior to a New Melones release for San Joaquin River water quality and flow requirements, so New Melones would supplement recirculation only when recirculation alone could not achieve water quality and flow objectives. The evaluation of this alternative will provide insight into the amount of New Melones water supply that could be enhanced by a lesser reliance on New Melones for compliance to Delta water quality and flow requirements. BPP would be used to replace water in SLR lost due to recirculation. Variants include different JPP pumping priorities relative to other CVP obligations.

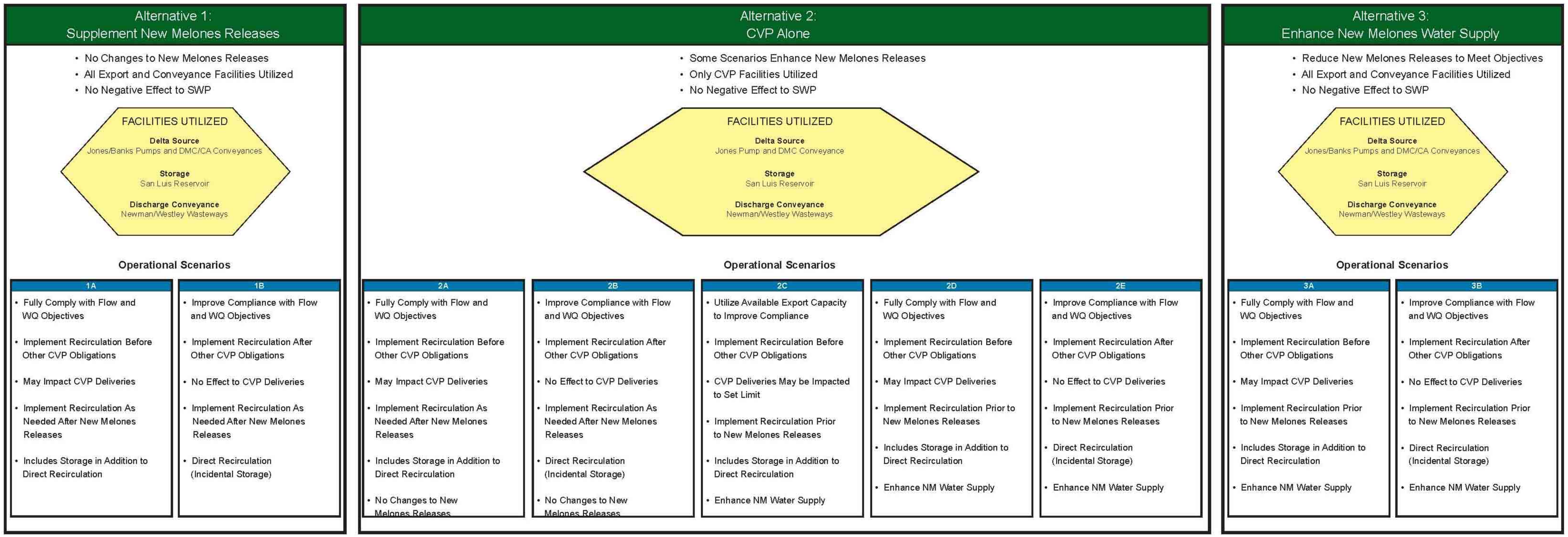

Figure 1-2 Range of Alternatives

Table 1-1
Initial Alternatives for Analysis

Alt	Delta Pumping Facilities	Delta Recirculation Pumping Priority Relative to other CVP Obligations	Conveyance	Recirculation Release Timing	Priority with Existing New Melones Delta Operation
1A	JPP/BPP	High (no SWP impact)	Newman/Westley	Real-time and stored	After
1B	JPP/BPP	Low (no SWP/CVP south of Delta impact)	Newman/Westley	Real-time	After
2A	JPP	High (no SWP impact)	Newman/Westley	Real-time and stored	After
2B	JPP	Low (no SWP/CVP south of Delta impact)	Newman/Westley	Real-time	After
2C	JPP	Medium (no SWP; some CVP south of Delta impact)	Newman/Westley	Real-time and stored	Before
2D	JPP	High (no SWP impact)	Newman/Westley	Real-time and stored	Before
2E	JPP	Low (no SWP/CVP south of Delta impact)	Newman/Westley	Real-time	Before
3A	JPP/BPP	High (no SWP impact)	Newman/Westley	Real-time and stored	Before
3B	JPP/BPP	Low (no SWP/CVP south of Delta impact)	Newman/Westley	Real-time	Before

2.0 AFFECTED ENVIRONMENT / EXISTING CONDITIONS

2.1 Aquatic Resources

The project area sustains a broad range of ecologically, commercially, and recreationally important fisheries. The Sacramento-San Joaquin ecosystem supports five fish species that are listed under the Federal and State Endangered Species Acts (ESAs), one of the largest recreational fisheries in California, and one of the largest commercial fisheries of the Pacific Coast. The fisheries provide substantial cultural, scientific, and social value. This section describes fishery-related conditions in all water bodies that may be affected by implementation of the DMC recirculation project. For the species of primary management concern in the Sacramento-San Joaquin ecosystem, the habitat associations are described in the context of the species' life stage requirements for the area of analysis and specifically described for the identified water bodies.

2.1.1 Principal Management Species

Species of primary management concern were identified based upon their legal status and ecological, commercial, and recreational significance (Table 2-1). Fish species listed under the Federal and State ESAs are both ecologically and institutionally important; some listed species are also recreationally and commercially important. Federal and State listed species within the area of analysis are:

- winter-run Chinook salmon (O*ncorhynchus tshawytscha*);
- Central Valley spring-run Chinook salmon (O. *tshawytscha)*;
- Central Valley steelhead *(O. mykiss)*;
- delta smelt (Hypomesus transpacificus); and,
- the southern DPS of North American green sturgeon (*Acipenser medirostris*).

Table 2-1
Fish Species of Primary Management Concern

Regulatory Status	Species	Location (Area of analysis)	Reason for Management Consideration(1)
ESA Listed	Winter run Chinook Salmon	Upstream and Delta areas	FE,SE
	Spring run Chinook Salmon	Upstream and Delta areas	FT,ST
	Steelhead	Upstream and Delta areas	FT, Recreation
	Delta smelt	Upstream and Delta areas	ST,FT
	Green sturgeon	Upstream and Delta areas	FT, Recreation
Species of Concern	Fall/late-fall Chinook Salmon	Upstream and Delta areas	FSC, SSC Commercial, Recreation.
	Splittail(2)	Upstream and Delta areas	SSC
	Longfin smelt	Upstream and Delta areas	SSC
None	White sturgeon	Upstream and Delta areas	Ecological, Recreation
	Striped bass	Upstream and Delta areas	Recreation
	American shad	Upstream and Delta areas	Recreation

(1) FE-federal endangered, FT-federal threatened, SE-state endangered, ST-state threatened, FC-federal candidate, FSC-federal species of concern, SSC-state special concern
(2) Splittail were previously listed as threatened, but this listing was rescinded.

Fall and late-fall run Chinook salmon are species of concern under the Federal ESA. In addition, longfin smelt have recently been proposed for listing as endangered under the federal and state ESAs (Bay Institute, et al. 2007 b, c). Petitions have also been filed to change the status of delta smelt from threatened to endangered under both the federal and state ESAs (Center for Biological Diversity et al. 2006 and Bay Institute, et al. 2007a). These petitions are currently under review by USFWS and CDFG and have not been ruled on at this time. Recreationally important species in addition to salmon and steelhead include American shad (*Alosa sapidissima*) and striped bass (*Morone saxatilis*). Several species were also identified due to their ecological significance and sensitivity to flow and temperature. These are white sturgeon (*Acipenser transmontanus*) and Sacramento splittail (*Pogonichthys macrolepidotus*), which is a California Species of Concern.

Evaluating potential impacts on fishery resources requires an understanding of both the physical habitat and the fish species' life histories and life stage-specific environmental requirements within the Project area. The following two sections provide general information regarding the life histories of species primary management concern and the water bodies (ecoregions) that would be affected by the project.

2.1.2 Population Trends

2.1.2.1 Pelagic Species in the Delta

Pelagic Organism Decline

Pelagic organism decline (POD) refers to the recent (2002- present) step decline of pelagic (occupying the water column in open water) fishes within the San Francisco estuary (Armor et al. 2005, IEP 2005, DWR and CDFG 2007, Sommer 2007). This issue has emerged as one of overwhelming concern in the Delta. While the causes of this decline are not fully understood, Delta operations and associated hydrodynamics have been identified as one of the potential causal factors. Because the DMC Recirculation project would alter Delta hydrodynamics by changing export levels and San Joaquin River inflow to the Delta and because of the POD's current importance in the management of Delta operations, it is discussed in more detail below.

The POD was announced in early 2005 as a possible change in the estuary's ability to support pelagic species and appeared to be a "step-change" from the preceding long-term decline. Four fish species are of primary concern: delta smelt, longfin smelt, young-of-year striped bass, and threadfin shad. From 2002 to present, despite moderate hydrologic conditions in the estuary which would have been expected to result in moderate increases in population sizes, the populations of these species experienced sharp declines, as indicated by the results of the annual fall midwater trawl[1] survey and confirmed through other sampling programs. Populations of each of the four species have been at or near all-time record lows since 2002. This change has persisted for a sufficiently long period to conclude that it is the result of something other than the pattern of widely variable population levels observed historically or part of the long-term decline previously observed. However, there is some disagreement whether this step decline is truly different from the long-term decline (California Bay-Delta Authority Science Program 2005).

Because these four species share a pelagic (residing primarily in open water and feeding upon zooplankton and other fishes in the water column) life stage that occurs within the Delta, and fish species with different life history patterns or in other parts of the bay have not shown similar declines over this same period, it was believed that the decline in these four species may stem from the same cause or suite of causes (DWR and CDFG 2007, Sommer 2007). To date, research has failed to identify a single factor responsible for the decline of all species or even that of a single species (Sommer 2007, Chotkowski pers. comm. 2007, Bennett 2005). POD researchers currently believe that important factors responsible for the decline may be different for each species, and that even for a single species these factors may differ between seasons and by hydrologic condition (wet and dry years) (Sommer 2007, DWR and CDFG 2007). These factors may operate cumulatively to cause the observed population declines. The POD Management Team has hypothesized that the three factors most likely to be responsible for the decline are the effects of exotic species, toxins, and water operations (DWR and CDFG 2007). The individual importance of these three potential factors is still an unresolved question. Many of the Interagency Ecological Program (IEP) studies to evaluate the causes of the POD have focused on these

[1] The fall midwater trawl is a longterm survey conducted in the fall (usually September through December) to monitor the abundance of young-of-year striped bass. Other species are caught as well, so the data set is used to evaluate the abundance of these species, as well. Many locations are surveyed from San Pablo Bay through the Delta.

factors. According to the 2005 IEP POD Synthesis (IEP 2005) and the 2007 Pelagic Fish Action Plan (DWR and CDFG 2007), these three potential causal factors are likely to work in direct and indirect ways through 'top down', 'bottom up', and habitat pathways. Top down pathways reduce the populations of pelagic species through direct mortality caused by predation, entrainment, or other factors. Bottom up pathways reduce the populations of pelagic species by reducing the productivity of the ecosystem at the lower levels of the food web, thereby reducing the amount of food available for the pelagic fish species, or through competition, which reduces the availability of the food produced. Habitat pathways are changes in the amount or quality of habitat available (Sommer 2007). These pathways are not entirely separate or distinct. For example, a change in salinity (one habitat parameter) might not affect striped bass directly, but might reduce the population of one of its prey items. Declines in the population of the prey items may then cause a subsequent reduction in striped bass survival. In this example, a change in habitat resulted in a bottom up effect on the striped bass population.

EXOTIC SPECIES

Many POD studies have been focused on the effects of introduced species. The San Francisco estuary is one of the most biologically invaded estuaries in the world. Non-native species have been introduced intentionally and unintentionally. Striped bass and threadfin shad, both POD species, were intentionally introduced. Many other introduced species are considered undesirable and some of these species are believed to adversely affect the ecosystem within the estuary. Suisun Bay and marsh have historically provided critical rearing habitat for all of the POD fish species. The productivity of this area is believed to have been reduced by the introduction of the overbite clam (*Corbula amurensis*) in the early to mid-1980s. Since the introduction of the clam, there has been a significant reduction of the phytoplankton, thereby affecting the productivity of the estuary with a corresponding reduction in zooplankton and pelagic fish production (Kimmerer 2002). Kimmerer (2002) observed that historic relationships between delta outflow and the populations of longfin smelt and striped bass have shifted since the introduction of this clam. This relationship has changed even more during the POD years (Sommer 2007). However, the distribution of *Corbula* during the POD years is similar to what it was in the 1987-1992 drought. Additionally, there has been no major decline in phytoplankton biomass or a system wide decrease in zooplankton biomass during the POD years. However, there may be a more localized decline in zooplankton biomass within Suisun Bay (DWR and CDFG 2007).

The estuary also has experienced successive waves of invasive copepod species. Copepods are zooplankton that form the food-base for many pelagic fishes. The most recently introduced copepod, *Limnoithona tetraspina*, displaced the previously dominant copepod species (*Pseudodiaptomus forbesi*) in the early 1990s. The abundance of other copepods has decreased continuously since its introduction. *Limnoithona* is believed to be a less suitable food item for fish than *Pseudodiaptomus* (Sommer 2007). Because of this, the food supply for pelagic fish may be of lesser quality than it was previously. Declines in delta smelt growth and striped bass condition factor have been observed in Suisun Bay relative to other areas in some years, which could be the result of the change in food supply.

TOXINS

Anthropogenic and environmental toxins could also have an adverse effect on fish populations (DWR and CDFG 2007). While initial histopathology data on striped bass and delta smelt indicated high frequencies of liver lesions and other signs of disease indicative of toxic effects (Armor et al. 2005), subsequent bioassay studies have shown little effect on POD species (Sommer 2007, Chotkowski pers. comm. 2007). It is unclear at this time, what the effect of toxins might be on POD species (DWR and CDFG 2007, Chotkowski 2007). Two toxins have received special attention, pyrethroid pesticides, and *Microcystis* hepatotoxins. Studies are ongoing for both, but neither has been directly linked to POD at this time.

Pyrethroid pesticides have received special attention in POD studies due to their increased use in recent years and their high toxicity to aquatic organisms. Pyrethroid use has increased over the past decade after organophosphate insecticide use declined due to increased regulation and concerns over human health effects. Although pyrethroids are readily adsorbed onto sediment, they can be mobilized during high flow events and are highly toxic to zooplankton and fish (Werner et al. 2006). Research on the effects of pyrethroids is ongoing. While it has been shown that these pesticides have the capacity to impact pelagic fish populations, a direct link to POD has yet to be demonstrated (Armor et al. 2005).

Microcystis is a colonial cyanobacteria that produces hepatotoxins that can affect fish and humans. Blooms of *Microcystis* have become larger and more widespread in recent years under summertime conditions. Reduced streamflow in the Delta is thought to promote the growth of *Microcystis* (Lehman 2006). Recent studies have found that *Microcystis* blooms generally do not co-occur with POD species, indicating that the blooms are not a primary cause of POD (Herbold et al. 2006).

WATER OPERATIONS

Water exports indirectly effect pelagic fish by changing the hydrology and salinity of the estuary. They also directly effect fish through entrainment. Hydrologic changes caused by water exports includes changes in flow magnitude and direction, especially in the South Delta, movement of water from the Sacramento River into and through the central Delta, and changes in the amount of low salinity habitat available for fish dependent upon this type of habitat. Assessment of the indirect effects of exports has largely been focused on the position of the 2 ppt salinity isopleth (X2) and the relative abundance of low salinity habitat upon which POD species, especially delta smelt, depend (USFWS 2004, NMFS 2005b). In recent years, efforts have been made to shift water diversions away from those periods believed to have the greatest impacts on fish in the Delta. However, during this period, the total amount of water exported from the Delta annually has increased substantially. The most notable changes have included a slight increase in flow down the Sacramento River since 2001, a reduction in peak San Joaquin River flows since 1999, and increased exports during June through December (DWR and CDFG 2007). Between 2001 and 2002 an increase in the salvage of delta smelt, longfin smelt, and threadfin shad was correlated with a decrease in fall mid-water trawl indices of these species (Armor et al. 2005, DWR and CDFG 2007). UC Davis researchers proposed that increased winter exports are entraining early spawning delta smelt. The early spawners tend to be the largest and most robust individuals. Increased entrainment of the most robust members of the delta smelt population may be weakening the population in concert with other factors (Bennett 2005, DWR and CDFG 2007).

Salvage rates have been used as an index of the relative impacts of entrainment on pelagic fish populations. Salvage is not a direct measurement of entrainment effects, since the number of fish salvaged is only a small fraction of the fish lost to entrainment and fish smaller than about 20 mm are not adequately represented in salvage. It also does not account directly for fish lost to predation before they reach the pumps, or fish that have been displaced from more favorable to less favorable habitats by the changes in current patterns caused by the pumps. While predation on fish entering Clifton Court forebay is accounted for in salvage calculations, additional predation may occur on the approaches to this facility. It is accepted, however, that salvage provides an index of the number of fish entrained into the pumps. To the extent that salvage and these other sources of loss are proportionate to pumping, the salvage index provides a useful tool to assess the relative magnitude of these losses. In order to understand the effects of exports and entrainment on pelagic fish populations, POD researchers are studying correlations between decreasing fall midwater trawl indices, stock-recruitment relationships, and increasing exports. Some models have indicated that exports explain less than two percent of the variability in population sizes as determined from the fall midwater trawl data (Chotkowski pers. comm. 2007). These models, however, are still in development.

HABITAT QUALITY

Fall habitat quality has also been hypothesized to be related to POD. Feyrer et al. (2007) point to an overall reduction in habitat quality coincident with long-term declines in delta smelt, striped bass, and threadfin shad. The specific factors relating to fish abundance were water clarity (Secchi disk depth, which is an indicator of turbidity) and specific conductance (related to salinity) for delta smelt and striped bass, and specific conductance and temperature for threadfin shad. These factors were selected for analysis because this information was collected consistently in association with the fall midwater trawl sampling program. However, specific mechanisms linking physical habitat quality to the abundance of these species remain unclear and tools for evaluating this hypothesis are still under development.

Additionally, numerous other water quality and habitat parameters that were not evaluated could also coincide with changes in the abundance of these species. Within the context of this project, turbidity within the Delta is not expected to change substantially and is not being modeled. Electrical conductivity (EC) and water source fraction (the amount of water from various sources, i.e. the Sacramento River, the San Joaquin River, the bay, east side streams, etc.), are the water quality parameters that will be modeled within the Delta.

UNCERTAINTIES

While there has been a substantial amount of research into the potential causes of POD, the amount of scientific uncertainty associated with the cause and effect relationships is large. None of these hypotheses, including those from the POD management team, have received widespread acceptance from the scientific community or even the principal investigators conducting POD studies (Sommer 2007, Chotkowski pers. comm. 2007). None of the POD hypotheses have been published in peer reviewed literature. The California Bay-Delta Authority Science Program Review Panel (2005) suggested that IEP solicit increased participation and peer review by the academic community as POD concepts and hypotheses are developed. This step is being taken. Thoroughly testing these hypotheses will require years of additional research. It is likely that several of these potential causal factors contribute cumulatively to the POD, with different factors operating at different times of year or under different hydrologic conditions and on different species. The specific mechanisms and the magnitude of the effects of each element remain to be determined. Further refinement, modeling, and testing is ongoing, and it is unclear when and if these mechanisms can be verified.

Because of the urgency of the POD crisis, particularly with regard to delta smelt, management actions are being undertaken to try to maintain these species, even in the face of these uncertainties.

2.1.2.2 Salmon, Sturgeon, and Splittail Population Trends

Salmonids

The four runs of Chinook salmon: fall, late-fall, winter, and spring, as well as Central Valley steelhead, have all experienced long term declines over the past several decades. Within the past decade some stocks have declined while others have stabilized or even improved, creating a complex current situation in regards to Central Valley salmonids. The heavy influence of hatchery stocks among all of these runs further complicates the overall assessment of current species status. Fall-run returns have improved over the past decade but the population has become heavily dependant on hatchery production, leaving managers uncertain of the overall sustainability of wild populations (Williams 2006). The late-fall run is included in the Central Valley fall run ESU and has received very little attention in terms of research and monitoring. As a result, the population trajectory of this run, and the factors governing it, remain unclear (Williams 2006). The winter-run remains a small population with limited habitat downstream of Keswick dam. The population has grown in recent years but remains far from recovery (NMFS 2004a, Williams 2006). Spring-run population in Sacramento River tributary streams such as Butte Creek have grown in recent years while stocks in the mainstem Sacramento River have declined (Williams 2006). Overall, the spring-run has shown broad fluctuations in abundance (NMFS 2004a). Wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries with other much smaller populations in the lower Sacramento and San Joaquin basins. Data on Central Valley steelhead are limited but the DPS is thought to be highly fragmented and suffering a continued decline corresponding with declining habitat conditions throughout the Central Valley (NMFS 2004a).

Sturgeon

Although the San Francisco Bay-Delta population of white sturgeon was seen as a success story after recovering from historical over-fishing (Moyle 2002), in the past few years the population may have suffered another decline (CDFG 2006). The recent decline and the reasons for it are currently the subject of research. Green sturgeon as a species have benefited from a decline in fishing pressure on them. While the larger west coast population may be robust (S.P. Cramer 2002), the Bay-Delta population may be experiencing a long-term decline in productivity (NMFS 2005e).

Splittail

Sacramento splittail are obligate floodplain spawners (Moyle and Crain 2007). High fecundity and multiple breeding year classes make their populations resilient under wet conditions when floodplain spawning habitat is available (Moyle et. al 2004). Splittail reached their lowest numbers after a series of drought years but have recovered in recent years due to favorable hydrologic conditions and improved habitat access.

2.1.3 Species Descriptions

2.1.3.1 Species Associated with POD

Delta Smelt – Threatened

The delta smelt was listed as threatened by USFWS effective April 5, 1993 (USFWS 1993, 58 FR 12854 12864), and by CDFG on December 9, 1993. The Sacramento-San Joaquin Delta Native Fishes Recovery Plan was completed in 1996 (USFWS 1996). A consortium of conservation groups has petitioned the USFWS and the California Fish and Game Commission to change its status to endangered under the federal and California ESA (Center for Biological Diversity et al. 2006 and Bay Institute et al. 2007). These petitions are under consideration.

Critical habitat for delta smelt is defined by the USFWS (USFWS 1994, 59 FR 65256-65279) as:

> *"Areas and all water and all submerged lands below ordinary high water and the entire water column bounded by and contained in Suisun Bay (including the contiguous Grizzly and Honker Bays); the length of Goodyear, Suisun, Cutoff, First Mallard (Spring Branch), and Montezuma Sloughs; and the existing contiguous waters contained within the Delta."*

Delta smelt are a euryhaline fish (capable of tolerating a wide range of salinities). They are endemic (found only in) to the upper San Francisco Estuary, principally the Delta and Suisun Bay. They occur in the Delta primarily below Isleton on the Sacramento River side and below Mossdale on the San Joaquin River side. They are found seasonally throughout Suisun Bay and in small numbers in larger sloughs of Suisun Marsh. They move into sloughs and channels of the western Delta (e.g. Lindsey Slough) when spawning. During high-outflow periods they may be washed into San Pablo Bay, but they do not establish permanent populations there (EA Engineering, Science, and Technology 1999).

During winter and spring (November through March), delta smelt migrate upstream from the brackish-water estuarine areas to spawn (Figure 2-1).[2] They spawn from January through June in shallow, fresh, or slightly brackish tidally influenced backwater sloughs and channel edgewaters with temperatures of 45° to 59°F (DWR and Reclamation 2005). Eggs are demersal and adhesive. Larvae hatch from 10 to 14 days (Wang 1986) and are planktonic (float with water currents) as they are transported and dispersed downstream into the low-salinity areas within the western Delta and Suisun Bay (Moyle 2002).

The lifespan of delta smelt typically does not last more than one year, although a few individuals live to spawn in their second year. Most adult smelt die after spawning in the early spring. Delta smelt inhabit open surface waters and shoal areas within the western Delta and Suisun Bay for the majority of their one-year life span (USFWS 1994, 59 FR 65256-65279). Their abundance fluctuates substantially within and among years due to the short life span. Delta smelt abundance is reduced during unusually dry years with exceptionally low outflows (e.g., 1987 through 1991) and unusually wet years with exceptionally high outflows (e.g., 1982 and 1986). Other factors thought to affect the abundance and distribution in the Bay-Delta include entrainment, effects of non-native species on the zooplankton community, and pollution. Results of recent CDFG summer tow-net surveys, 20 mm larval surveys, and the fall mid-water trawl

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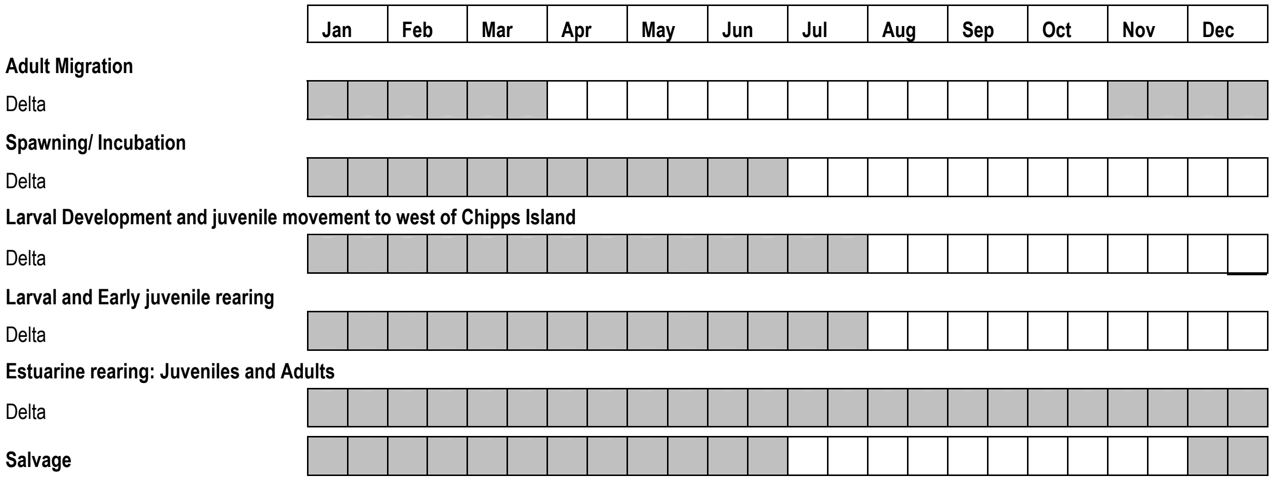
[2] Figure 2-1 and the similar figures that follow show the times of year when the lifestage indicated on the left would be expected to be present in the ecoregion indicated. These periodicities were developed in collaboration with the FTWG based on information from a variety of sources, including unpublished data provided by the FTWG members.

surveys indicate that delta smelt abundance and geographic distribution has not shown any significant signs of recovery to pre-1982 levels (USFWS 2004), and has been at or near all time lows since 2002 (Sommer 2007).



Source: FTWG

Figure 2-1 Timing of Life History Stages for Delta Smelt

The availability of rearing habitat for delta smelt is closely tied to the locations of the low salinity zone and X2. In general, adult abundance tends to be highest when X2 is located in Suisun Bay in the spring (Bennett 2005). However, this trend is complicated by a switch in the relationship of X2 to habitat quality after the decline of the delta smelt began in the early 1980's. Kimmerer (2002) reported that, prior to 1982, smelt abundance was higher when X2 was further east. After 1982, this pattern was reversed. This trend reversal is thought to be due to the decline in habitat quality in the central Delta over time (Bennett 2005).

Longfin Smelt – Proposed for listing

Longfin smelt is not currently listed under the Federal Endangered Species Act. The species is listed under the California Endangered Species Act as a species of special concern. They are one of the species associated with the POD and were previously petitioned for listing in 1993, which the USFWS denied. Environmental groups have petitioned the USFWS and CDFG to list the species as endangered in a petition filed in August 2007, citing their population decline over the last 20 years (Bay Institute, et al. 2007 b,c).

Longfin smelt are euryhaline species that live primarily in the San Francisco Bay and the Delta, but can sometimes be found in the ocean off the Golden Gate. They are most abundant in San Pablo and Suisun bays (Moyle 2002). They spend the early summer in San Pablo and San Francisco bays, generally moving into Suisun Bay in August. Longfin smelt appear to spawn in the Delta, downstream of Rio Vista (Moyle et al. 1995). Most spawning is from January through May (Figure 2-2) in water temperatures from 44.6 to 58.1°F (Moyle 2002). Longfin smelt eggs are adhesive and are probably deposited on rocks or aquatic plants during spawning. Newly hatched longfin smelt are swept downstream into more brackish parts of the estuary. The majority of adults die after spawning. Longfin smelt survival is thought to correspond with strong Delta outflow required to transport longfin smelt young to more suitable rearing habitat in Suisun and San Pablo bays (Moyle 2002).

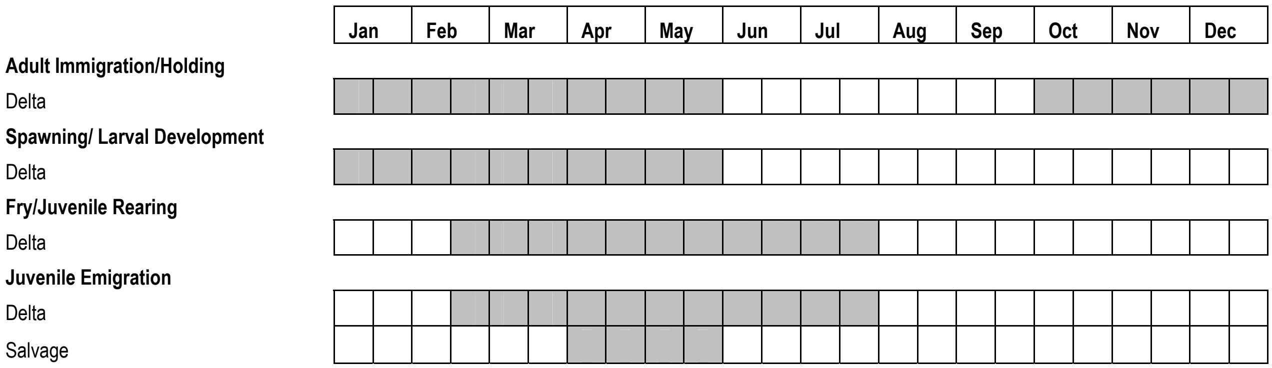


Figure 2-2 Timing of Life History Stages for Longfin Smelt

Striped Bass – No legal status

Striped bass are an introduced species supporting recreational fisheries in the Delta and Central Valley rivers. They are not listed under either federal or state ESAs, but young-of-year striped bass are associated with the POD.

Striped bass are widespread along the Pacific coast. Adult striped bass spend summer in the Bay, Delta, and major rivers and may move into the ocean outside the Golden Gate in some years. In the fall, they begin moving inland to the Delta and the rivers. However, they may be found in all of these areas throughout the year. Detailed discussions of the life history and habitat requirements of striped bass in the Delta are reported by CDFG (Fry 1973, Turner and Kelly 1966).

Striped bass begin spawning in the spring when water temperatures reach 59°F. Most spawning occurs from April to June (Figure 2-3) when temperatures are from 59 to 65°F (Wang 1986). Spawning occurs in areas of moderate to swift currents. The current suspends the eggs and larvae while they develop to prevent mortality (DWR and Reclamation 2005). Important spawning areas occur in the Delta on the San Joaquin River from the Antioch Bridge to Middle River (Fry 1973), especially during years of low flow (Moyle 2002). Successful spawning occurs in the San Joaquin River, upstream from the Delta, during years of high flow, when the large volume of runoff dilutes irrigation return water. Embryos and larvae from the Sacramento River are carried into the Delta and Suisun Bay. In the San Joaquin River outflow is balanced by tidal current, so that embryos and larvae stay suspended in the same general area in which spawning took place.

Striped bass abundance appears closely related to juvenile survival especially during the first few months of life. During this period, striped bass are very vulnerable to entrainment and flow conditions due to their planktonic nature. Flow affects suitability of currents necessary to transport embryos and larvae to nursery areas in the Delta (Fry 1973, Moyle 2002).

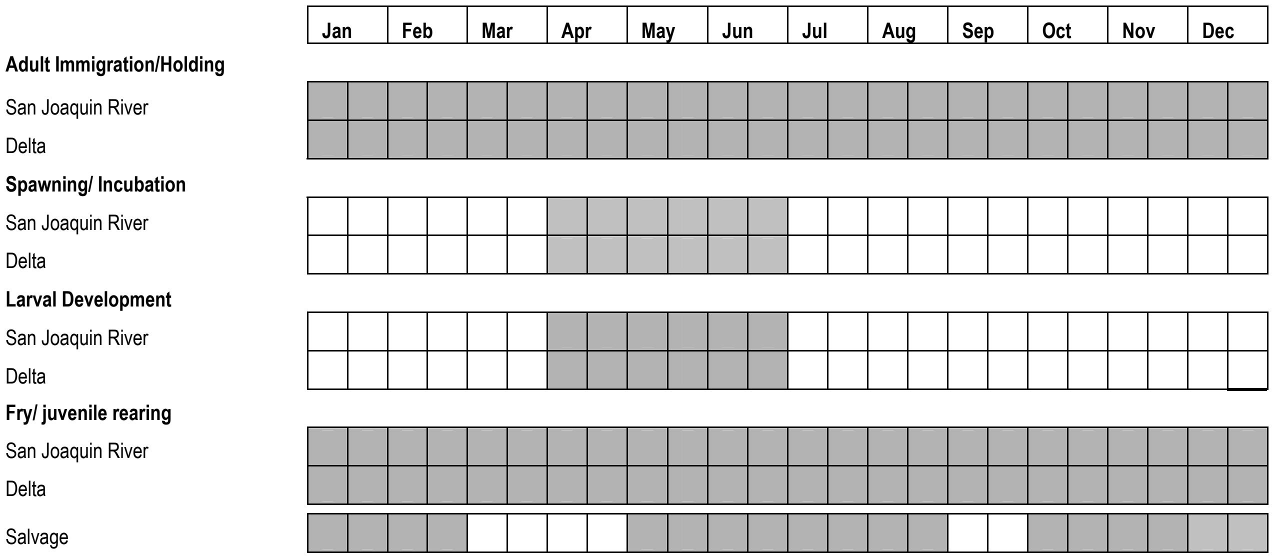


Figure 2-3 Timing of Life History Stages for Striped Bass

Threadfin Shad – No Legal Status

Threadfin shad were introduced to California as forage fish to improve growth rate of game fishes. Like striped bass, they are not listed, but are one of the species associated with the POD.

Threadfin shad are found in open waters of reservoir, lakes, and large ponds as well as sluggish backwaters of rivers. They prefer warmer waters and do not tolerate sudden drop in temperature or prolonged periods of cold water. The Delta population experiences heavy die-offs every winter when the water temperature cools to 43 to 46°F (Moyle 2002).

Spawning can occur from April through August (Figure 2-4), peaking in June and July when water temperature exceed 68°F. The embryos hatch in 3-6 days and larvae immediately assume a planktonic existence. The duration of this planktonic life stage is suspected to be 2 or 3 weeks depending on temperature (Moyle 2002). The larvae metamorphose into juveniles at about 2 cm TL. Juveniles form dense schools and in estuaries are found in water of all salinities, although they are most abundant in fresh water.

In the Delta, threadfin shad are a major item in the diet of striped bass and other piscivorous fishes. Their numbers in the Delta have gradually declined since the late 1970s, reflecting a general decline of planktonic fishes in the estuary (Moyle 2002, Sommer 2007).

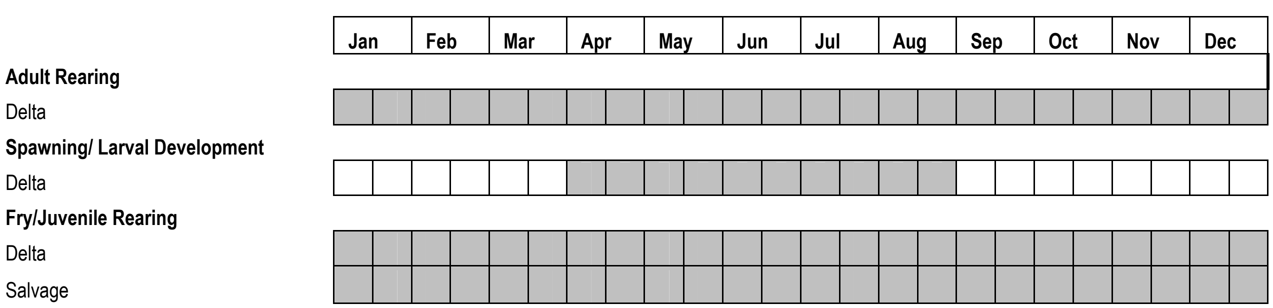


Figure 2-4 Timing of Life History Stages for Threadfin Shad

2.1.3.2 Salmonids

Chinook Salmon

Chinook salmon are anadromous fish, which spawn in freshwater and grow to adulthood in the ocean. Four runs of Chinook salmon pass through the Delta.[3] The runs are recognized and named for the timing of their entry into the freshwater environment: 1) fall-run; 2) late-fall-run; 3) winter-run; and 4) spring-run (Hallock and Fry 1967, Healey 1991). The life history and habitat requirements of Chinook salmon have been well documented (e.g., Myers et al. 1998, Healey 1991, Moyle 2002, and Reiser and Bjornn 1979). In the descriptions that follow, the freshwater period of their lives is divided below into four general life stages: adult upstream migration (immigration), spawning (including incubation and emergence), freshwater rearing, and downstream migration of juveniles/smolts (emigration). The timing of these life history events, egg development upon adult entry to freshwater, and the duration of freshwater rearing differ among the four runs.

Chinook salmon of some race and lifestages are generally present within areas of analysis throughout the year, although water temperatures may be quite stressful during the warmer months. The relative number and distribution of the various life stages changes throughout the year depending upon the temporal and spatial distribution of the runs. Each of the four runs of Chinook salmon rear in the Delta for variable periods of time, although some fish may simply migrate through the Delta and so may be present for only a short time. The San Joaquin River (defined herein as upstream of the head of Old River) and its tributaries support fall run Chinook salmon. The San Joaquin River is used primarily as a migration corridor during immigration and emigration, although some limited rearing may occur during emigration. All spawning occurs on the tributaries to the San Joaquin River (Merced, Tuolumne, and Stanislaus Rivers), as does most rearing.

Chinook salmon populations of all runs have been impacted by the construction of dams and diversions on rivers and streams. Over 80 percent of their holding and spawning habitat is no longer accessible (Moyle 2002). Other threats include entrainment of juveniles in diversions, loss and degradation of floodplain and estuarine rearing habitat, exploitation, non-native fish predators, non-native fish and invertebrates causing ecological alterations, competition with hatchery-reared salmon, disease, pollution, siltation (e.g., from mining, logging, grazing), loss of riparian woodland that provides shade and large woody debris, and natural factors such as drought.

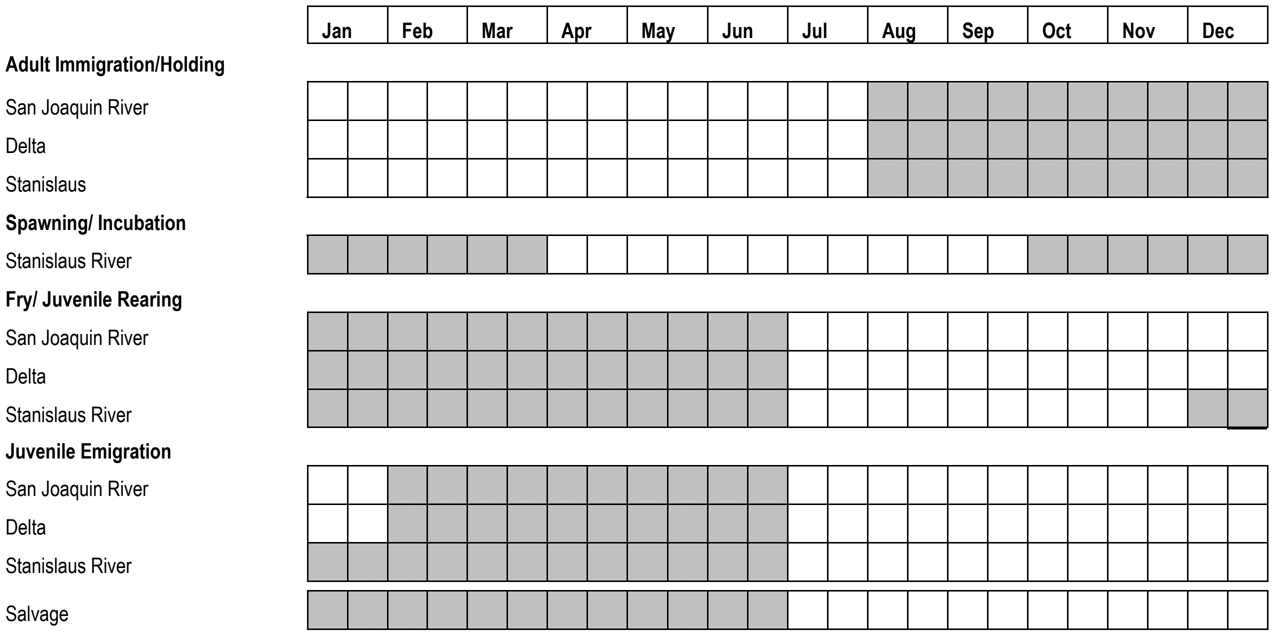
Fall Run Chinook Salmon - Species of Concern

The Central Valley fall-run Chinook salmon evolutionarily significant unit (ESU) was classified as a Species of Concern on April 15, 2004, (NMFS 2004b, 69 FR 19975). The ESU includes all naturally spawned populations of fall- and late fall-run Chinook salmon in the Sacramento and San Joaquin River Basins and their tributaries east of Carquinez Strait, California (NMFS 1999, 64 FR 50394).[3]

The fall run is the largest run of Chinook salmon. Fall run support significant commercial and recreational fisheries along the Pacific Coast and in the area of analysis.

Fall-run Chinook salmon are already sexually maturing as they enter the freshwater environment and are typically ready to spawn within days once they reach their spawning areas. Adult Chinook salmon annually migrate upstream through the Delta from August through December (Figure 2-5). The spawning peak occurs upstream of the Delta from October through March, depending upon the spawning location (FTWG). More than 90 percent of the entire run has entered all the rivers by the end of November and migration and spawning can continue into December. Fall-run Chinook salmon migrate downstream through the Delta between February and June (FTWG). The Delta is considered to be the major rearing area for fall-run juveniles from the fry to smolt life stages.

[3] Note that NMFS did not find fall and late fall run Chinook salmon to be distinct ESUs.



Source: FTWG

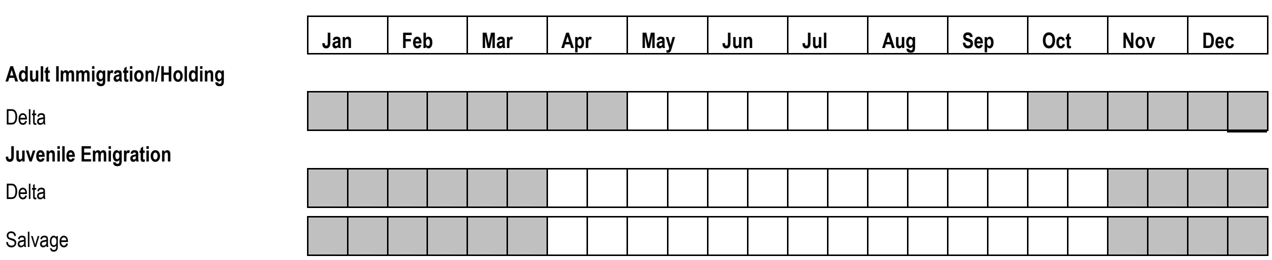
Figure 2-5 Timing of Life History States for Fall Run Chinook Salmon

Late Fall Run Chinook Salmon- Species of Concern

The Central Valley late fall-run Chinook salmon ESU was classified as a Species of Concern on April 15, 2004, (NMFS 2004b, 69 FR 19975). The ESU includes all naturally spawned populations of fall- and late fall-run Chinook salmon in the Sacramento and San Joaquin River Basins and their tributaries east of Carquinez Strait, California (NMFS 1999, 64 FR 50394).

Late fall-run Chinook salmon would occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries. They are not believed to use the San Joaquin River or its tributaries.

Adult immigration of late-fall-run Chinook salmon through the Delta generally begins in October, peaks in December, and ends in April (Moyle 2002) during a period of typically high, fluctuating flows (Figure 2-6). Spawning occurs upstream of the Delta from January to March, although it may extend into April in dry years. Late-fall-run juveniles emigrate from their spawning and rearing areas to the Delta from October through March (FTWG). The majority of emigrating juveniles are smolt-sized by the time they reach the lower Sacramento River and Delta, typically from November through January. Occurrence of late-fall-run juveniles in the lower river appears to coincide with the first storms. However, the later the first storm occurs, the fewer late-fall-run juveniles that successfully migrate to the Delta (Snider and Titus 2000a, b). Some rearing may occur in the Delta during emigration.



Source: FTWG

Figure 2-6 Timing of Life History Stages for Late Fall Run Chinook Salmon

Winter-Run Chinook Salmon – Endangered

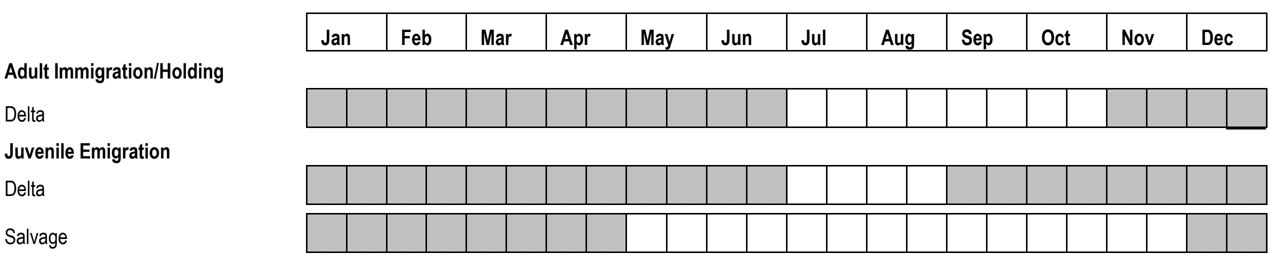
Winter-run Chinook salmon were listed as endangered on January 4, 1994 (NMFS 1994, 59 FR 440). This status was reaffirmed on June 28, 2005 (NMFS 2005c, 70 FR 37160). The ESU includes all naturally spawned populations of winter-run Chinook salmon in the Sacramento River and its tributaries in California. Critical habitat for winter-run Chinook salmon was established effective July 16, 1993 (NMFS 1993, 57 FR 36626). The critical habitat designation includes the Sacramento River from Keswick Dam to Chipps Island, and all waters between Chipps Island and the Golden Gate Bridge and to the north of the San Francisco/Oakland Bay Bridge.

Winter-run Chinook salmon are unique to the Sacramento River system. Winter-run Chinook salmon do not use the San Joaquin River or its tributaries. These fish would occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries.

Adult winter-run Chinook salmon immigration occurs from November through June (FTWG) with a peak during the period extending from January through April (USFWS 1995a) (Figure 2-7). Winter-run Chinook salmon primarily spawn in the mainstem Sacramento River above Red Bluff Diversion Dam from late-April to September, with the peak generally occurring from late June to early July.

Most winter-run Chinook salmon fry only rear for a short period in the upper Sacramento River above Red Bluff Diversion Dam. They use the Sacramento River from about Red Bluff to the Delta for rearing and emigration and may be present in this area from September through June (FTWG). Winter-run Chinook salmon fry may rear for some time in the Delta as well.

The primary threat to winter-run Chinook salmon is the loss and degradation of spawning habitat. Winter-run Chinook salmon are further threatened by having only one small, extant population dependent on artificially created environmental conditions. These fish are further subject to inadequately screened water diversions, predation at artificial structures, non-native species, pollution, adverse flow conditions, high summer water temperatures, unsustainable harvest rates, passage problems at various structures, and vulnerability to drought (Good et al. 2005).



Sources: FTWG

Figure 2-7 Timing of Life History Stages for Winter-Run Chinook Salmon

Spring-Run Chinook Salmon – Threatened

On June 28, 2005, NMFS issued its final decision to retain the status of CV spring-run Chinook salmon as threatened (NMFS 2005c, 70 FR 37160). Designated critical habitat for Central Valley spring-run Chinook salmon ESU includes 1,158 miles of stream habitat in the Sacramento River basin and 254 square miles of estuary habitat in the San Francisco-San Pablo-Suisun Bay complex (NMFS 2005b, 70 FR 52488).

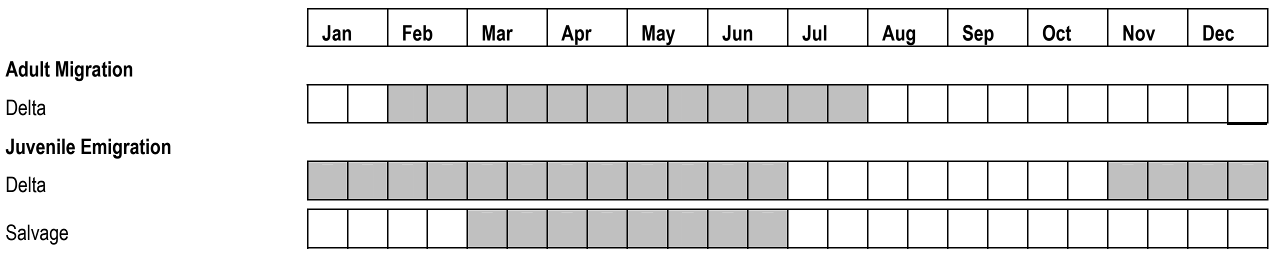
Spring Chinook salmon are not believed to use the San Joaquin River or its tributaries. These fish would occur in the Delta during migration to and from spawning and rearing habitat in the Sacramento River and its tributaries.

Historically, the San Joaquin River supported a large run of spring-run fish. This run was extirpated by development throughout the watershed. A few spring-run Chinook have been observed in the San Joaquin River tributaries (Moyle 2002). These fish are believed to be strays from the Sacramento River

Basin. The initial phases of an effort to re-establish a spring-run on the San Joaquin River below Friant Dam are currently underway. The success of this effort remains to be seen.

Spring-run Chinook enter the Delta as sexually immature adults from February through July; peak migration is during April-May (FTWG) (Figure 2-8). The adults typically mature in cool, deep pools in rivers upstream of the valley floor during the summer and spawn in suitable habitat adjacent to these areas from August through December, peaking in mid-September (FTWG, Moyle 2002). Juvenile spring-run Chinook can rear for several months to over a year before emigrating. Most spring-run juveniles emigrate as smolts, although some portion of an annual year-class may emigrate as fry. Emigration timing varies among the tributaries of origin, and can occur during the period extending from November through June (NMFS 2004a, FTWG).

The major threats to spring-run Chinook salmon include loss of historical spawning habitat, and the degradation and modification of rearing and migration habitats: reduced instream flow during spring-run migration periods, unscreened or inadequately screened water diversions, predation by nonnative species, and high water temperatures (Good et al. 2005).



Source: FTWG

Figure 2-8 Timing of Life History Stages for Spring-Run Chinook Salmon

Steelhead - Threatened

The Central Valley steelhead evolutionarily significant unit (ESU) was listed as threatened on March 19, 1998, including all naturally spawned populations of steelhead in the Sacramento and San Joaquin Rivers and their tributaries, including the Sacramento-San Joaquin Delta (NMFS 1998, 63 FR 13347). Steelhead from San Francisco and San Pablo Bays and their tributaries are excluded from this listing. On June 28, 2005, NMFS issued its final decision to retain the status of Central Valley steelhead as threatened (NMFS 2005c, 70 FR 37160). In 2006, the listing was reaffirmed but the ESU was redesignated as a distinct population segment (DPS). Critical habitat was designated for the Central Valley steelhead DPS on September 2, 2005 (NMFS 2005d, 70 FR 52488). Central Valley steelhead were well-distributed historically throughout the Sacramento and San Joaquin Rivers (Busby et al. 1996). Existing wild steelhead stocks in the Central Valley are mostly confined to the upper Sacramento River and its tributaries. Until recently, Central Valley steelhead were thought to be extirpated from the San Joaquin River system. However, recent monitoring has detected small self-sustaining populations of steelhead in the Stanislaus, and other streams previously thought to be devoid of steelhead (McEwan 2001). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers, indicating that steelhead are widespread, throughout accessible streams and rivers in the Central Valley (Good et al. 2005).

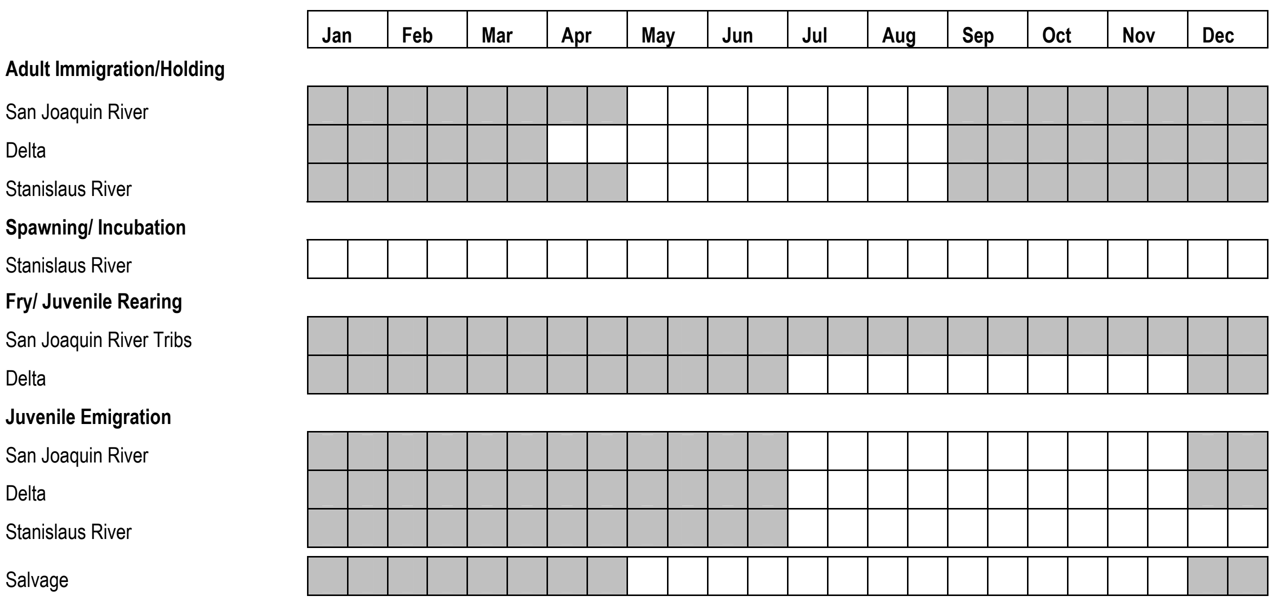
The entire population of the Central Valley steelhead DPS must pass through the Delta as adults migrating upstream and juveniles emigrating out to the ocean. Juvenile steelhead likely use the Delta for rearing. Adult Central Valley steelhead migrating into the San Joaquin River and its tributaries use the Western edge of the Delta, whereas adults of these species entering the Sacramento River system to spawn use the northern and central Delta for a migration pathway.

Adult steelhead immigrate from September to March (Figure 2-9); peak migration typically occurs in January and February (Moyle 2002). Adult immigration in the San Joaquin River generally occurs until

April. Steelhead generally spawn January through May. No spawning occurs in the Delta or the San Joaquin River, but does occur in the Merced, Tuolumne, and Stanislaus Rivers.

Steelhead juveniles rear in Central Valley streams for one to two years. Optimal temperatures for fry and juvenile rearing are reported to range from 55°F to 65°F (NMFS 2004a), although steelhead have been observed to grow to smolt size where summer-fall temperatures exceed 65°F (Titus, pers. comm. 2005). Steelhead can begin emigrating in the late fall, but the primary period of steelhead emigration occurs from December through May (Snider and Titus 2000a, b and NMFS 2004a). When emigrating Central Valley steelhead use the lower reaches of the Sacramento River and the Delta for rearing and as a migration corridor to the ocean. Some may utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas.

Steelhead populations have been most significantly impacted by the construction of dams that block access to headwaters of the mainstem Sacramento and San Joaquin rivers and all the major tributaries (McEwan and Jackson 1996). Other threats include low and inadequate river flows due to excessive diversions, elevated water temperatures, unscreened or poorly screened diversions, and predation by exotic species.



Source: FTWG

Figure 2-9 Timing of Life History Stages for Steelhead

2.1.3.3 Sturgeon

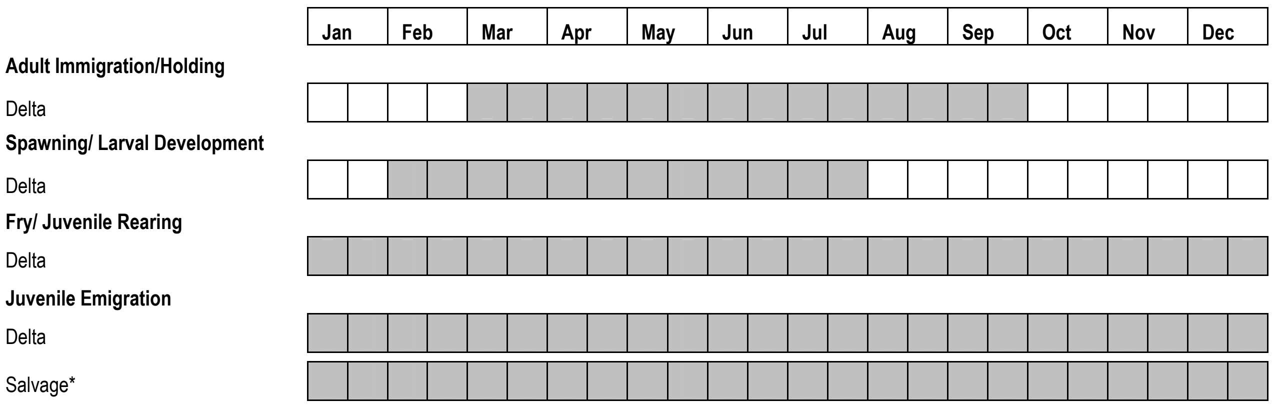
Green Sturgeon – Threatened

On June 6, 2006, the Southern DPS (consisting of coastal and Central Valley populations south of Eel River) of green sturgeon were listed as threatened (NMFS 2006, 71 FR 17757). Critical habitat has not yet been designated for this DPS.

The green sturgeon is an anadromous, native fish that occurs in low numbers in the Bay/Delta system (Moyle 2002). Adults tend to be more marine-oriented than the more common white sturgeon. In freshwater, green sturgeon use the Sacramento River and its major tributaries, but migrate through and may forage and rear in the Delta. They are not believed to use the San Joaquin River or its tributaries (NMFS 2006, 71 FR 17757).

Adults begin their upstream migration in March (FTWG), and enter the Sacramento River until the end of September (FTWG) (Figure 2-10). Spawning occurs upstream of the Delta from February through July, with peak activity believed to occur from April to June (FTWG, Moyle et al. 1995). Green sturgeon spawning occurs predominately in the upper Sacramento River (NMFS 2002). Juvenile green sturgeon spend 1 to 3 years in freshwater prior to emigrating to the ocean (NMFS 2005e).

Green sturgeon population threats include vulnerability due to concentration of spawning habitat, smaller population size, lack of population data, potentially growth-limiting and lethal temperatures tolerances, harvest concerns, loss of spawning habitat, entrainment by water projects, and influence of toxic material and exotic species. (NMFS 2002).



Source: FTWG
*Salvage periodicity for sturgeon is not a useful criteria for analysis due to very low numbers.

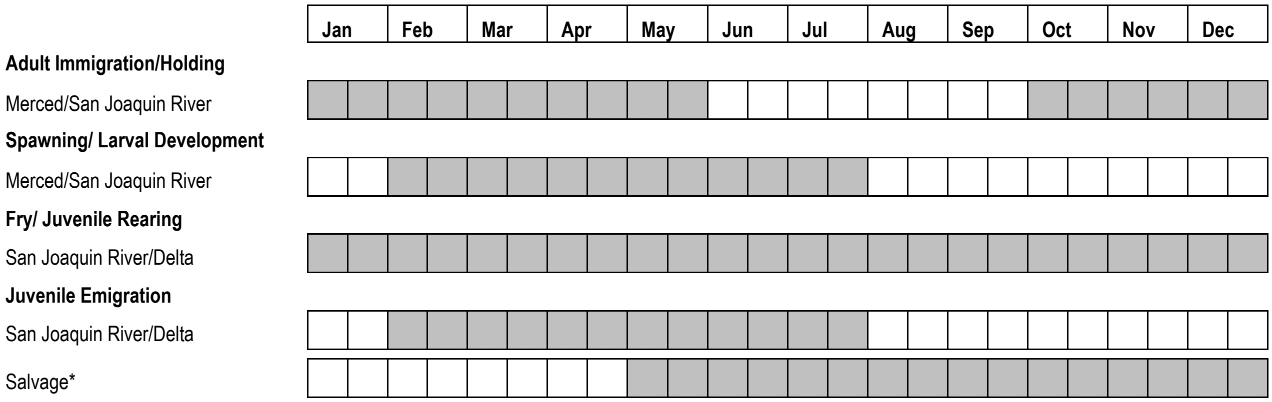
Figure 2-10 Timing of Life History Stages for Green Sturgeon

White Sturgeon – No Legal Status

White sturgeon occur in the Delta and its tributary rivers, including both the Sacramento and San Joaquin Rivers and their larger tributaries. Some individuals may also migrate out into the Pacific Ocean. Most California white sturgeon are found in the San Francisco Bay estuary. This species is not listed under federal or state ESAs, although its populations have declined over historic levels.

Migration of mature adult white sturgeon begins in October and continues into May (Figure 2-11). Most spawning occurs in the Sacramento River from February through July, peaking in March and April (Kohlhorst 1976). About 10 percent of the adult population (Kohlhorst et al. 1991) migrates into the San Joaquin River, occurring from Mossdale to the mouth of the Merced River (October through May). Spawning migration may begin several months prior to the spawning period (Kohlhorst 1976; Moyle 2002). Spawning and larval development occurs in the San Joaquin and Merced Rivers between February and July (FTWG).

White sturgeon typically complete their life cycle within the Delta and its major tributaries, the Sacramento and San Joaquin rivers. Few fish enter the ocean, but some that do so make coastal migrations extending at least as far as the Columbia River Basin (Moyle 2002). During most of the year, adults are concentrated in San Pablo and Suisun bays, where they feed principally on bottom dwelling invertebrates.



Source: FTWG

*Salvage periodicity for sturgeon is not a useful criteria for analysis due to very low numbers

Figure 2-11 Timing of Life History Stages for White Sturgeon

2.1.3.4 Other Species of Concern

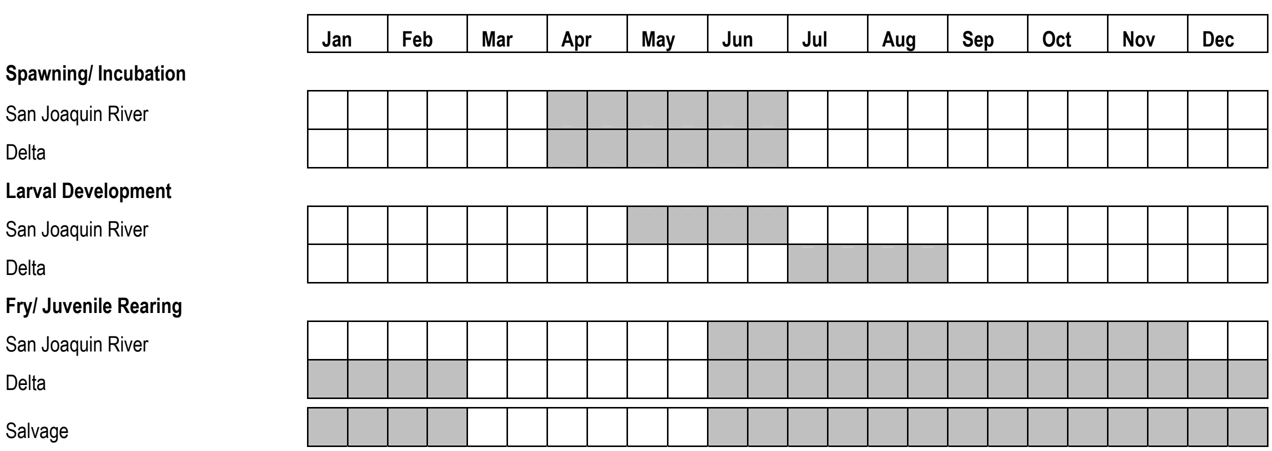
American Shad – No Legal Status

American shad are an introduced, anadromous species that supports recreational fisheries in the Delta and Central Valley rivers. This species is not listed under the federal or state ESA, nor are they a species of concern beyond their recreational importance.

American shad occur in the Sacramento River, its major tributaries, the San Joaquin River, and the Delta.

Adult American shad are abundant in the Delta in spring during their upstream migration between April through June (CDFG 1986) (Figure 2-12). Many shad spawn in the rivers tributary to the Sacramento River above the Delta. Water temperature strongly influences the timing of spawning. Juvenile shad are found north of the Delta on the Sacramento River and to a lesser extend in the south Delta (Moyle 2002). This life stage is extremely vulnerable to entrainment in agricultural diversions in the Delta, power plant cooling water diversions and pumps in the South Delta (Moyle 2002). They migrate downstream to reach the ocean in fall, but sometimes migrate as early as late June when outflows are high.

American shad population declines in recent years are likely caused by the increased diversion of water from the rivers and the Delta, combined with changing conditions in the ocean. Pesticides and other factors may also be contributing to their decline (Moyle, 2002).



Source: FTWG

Figure 2-12 Timing of Life History Stages for American Shad

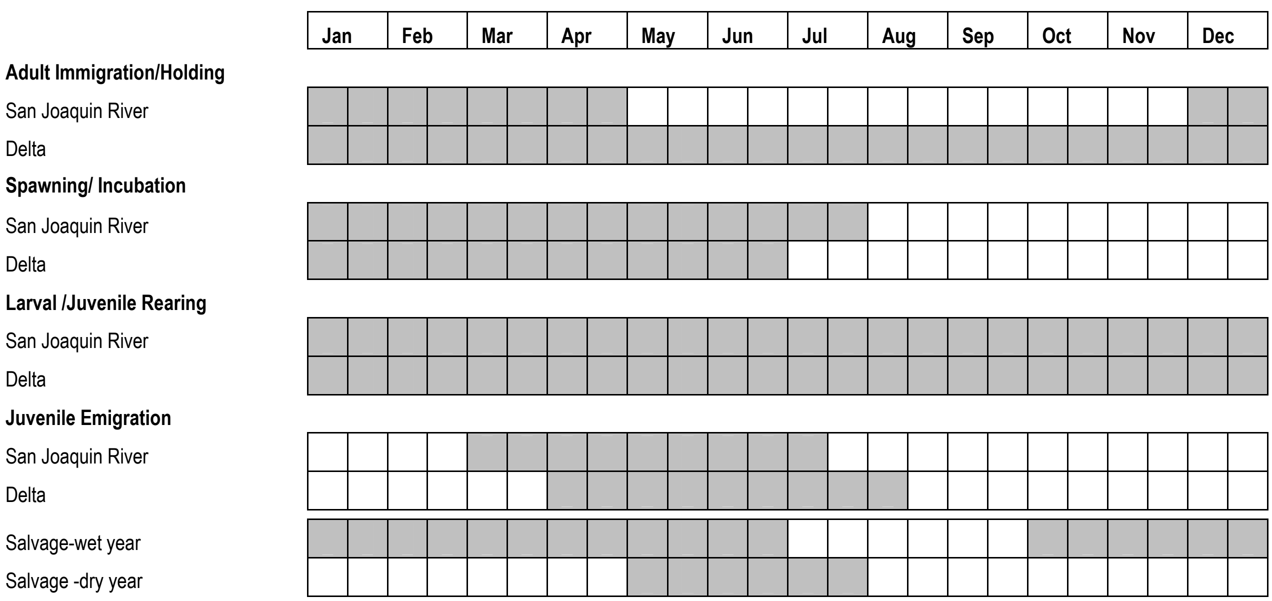
Splittail – California Species of Concern

The Sacramento splittail was federally listed as threatened on February 8, 1999 (USFWS 1999, , 64 FR 5963), and delisted on September 22, 2003 (USFWS 2003, , 68 FR 55139). The splittail is listed as a species of special concern under the California ESA (Moyle et al. 1995).

Splittail, a euryhaline non-game fish, are largely confined to the Delta, Suisun Bay, Suisun Marsh, Napa River, Petaluma River, and other parts of the San Francisco estuary (Moyle 2002). In the Delta, they are most abundant in the north and west portions when populations are low.

Splittail can exist within a wide range of habitat conditions (Moyle et al. 2004). Conditions important to maintaining viable splittail populations includes availability of floodplains for successful spawning, with migration corridors from spawning to rearing grounds, and abundant high-quality brackish water rearing habitat (Moyle et al 2004).

The timing of splittail upstream movements and spawning corresponds to the historical spring, high-flow period. Timing and location of spawning varies among years depending upon the timing and magnitude of winter and spring runoff. Adult splittail migrate upstream to freshwater areas to spawn between December and April (FTWG, Figure 2-13). Spawning occurs in seasonally inundated floodplains in January through June, or even through July in the San Joaquin River at water temperatures from 57°F to 66°F (Moyle 2002 and DWR and Reclamation 2005). Splittail prefer to spawn over flooded vegetation or beds of aquatic plants. Larval splittail are commonly found in shallow, vegetated areas near spawning habitat. Larvae eventually move into deeper and more open-water habitat as they grow and become juveniles (DWR and Reclamation 2005). Developing juveniles migrate downstream to shallow, brackish water year-round rearing grounds from March through August.



Source: FTWG

Figure 2-13 Timing of Life History Stages for Sacramento Splittail

Sacramento splittail populations have been reduced due to loss and modification of riverine spawning and rearing habitat and changes in hydrology. Flood control processes have created artificial hydrologic conditions that may act to reduce the regularity of flooding in floodplain habitat, such as the Cosumnes floodplain and Yolo Bypass. Juvenile splittail are thought to begin migrating downstream with increasing water temperatures; however, artificially constructed channels in the watershed are often too deep to sufficiently warm the water. Other threats to the population include variations in climate, introduction of non-native predators and competitors, toxic substances, and angler harvest (Moyle 2002).

2.2 Project Ecoregions

For the assessment of impacts to aquatic resources, the project area is divided into three ecoregions: the Sacramento-San Joaquin Delta, the San Joaquin River, and tributaries to the San Joaquin River. These ecoregions have different physical conditions, biological uses, and potential project effects and therefore the evaluation of potential effects differs within these regions.

2.2.1 Sacramento-San Joaquin Delta

San Francisco Bay and the Sacramento-San Joaquin Delta (Bay Delta) make up the largest estuary on the west coast (USEPA 1993). The Delta covers over 75 square miles of tidally influenced river channels and sloughs, separated by levied islands that surround the confluence of the Sacramento and San Joaquin rivers. The legal boundaries for Sacramento-San Joaquin Delta (Delta) is the triangular-shaped area defined by Collinsville in the west, Freeport on the Sacramento River and Vernalis on the San Joaquin River (Figure 2-14). The northern Delta is dominated by Sacramento River water that is relatively low in salinity; the San Joaquin River and the south Delta are relatively higher in salinity. The southern Delta is dominated by inflows from the San Joaquin River and tidal influence. The western end of the Delta is dominated by ocean tides that enter through the Golden Gate and transit San Francisco Bay, San Pablo Bay, Carquinez Straits, Suisun Bay, and Honker Bay. The central or interior Delta is comprised of interconnecting channels that convey tidal flows and river inflows into and out of the Delta.

The southern Delta is bounded by the San Joaquin River on the north and east and by Old River on the south. Flow through the southern Delta is strongly influenced by San Joaquin River flows, riparian pumping and various discharges, exports at the CVP and SWP pumps, and the operation of temporary barriers in Old River, Middle River, and Grant Line Canal. The hydrodynamic conditions in the southern Delta strongly effect both the entrainment risk of numerous species at the pumps and habitat conditions.

The Delta supports one or more life stages of a diverse assemblage of anadromous, freshwater, euryhaline, and saltwater species (USEPA 1993). Portions of the estuary have been identified as critical habitat under the ESA for spring-and winter-run Chinook salmon, Central Valley steelhead and delta smelt and Essential Fish Habitat under the Magnusen Act for commercially important fish species. It provides spawning or nursery habitat for more than 40 fish species, including delta smelt, Sacramento splittail, American shad, white sturgeon, and striped bass. The Delta is a migration corridor and provides seasonal rearing habitat for Chinook salmon and steelhead. Species such as green sturgeon utilize the Delta as a migratory corridor, juvenile nursery, and adult foraging habitat. Longfin smelt spawn in the Delta estuary and rear in Suisun Bay and San Pablo Bay. Delta smelt complete their entire life cycle in the Delta and Suisun Bay.

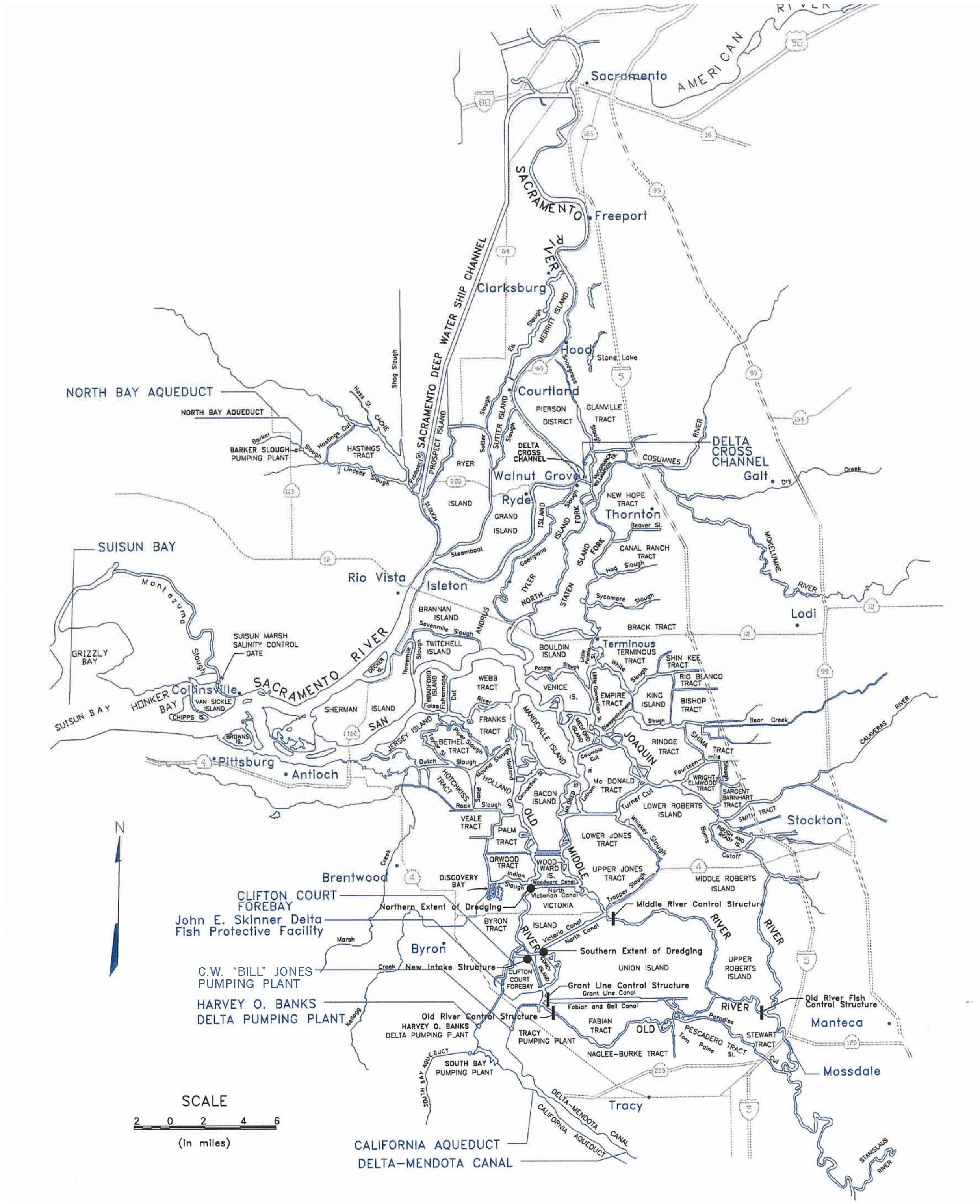


Figure 2-14 Sacramento-San Joaquin Delta

2.2.1.1 Hydrodynamics

Flows in the Delta are influenced by the water management upstream and within the Delta. Water developments have altered the timing and magnitude of river flows into the Delta, affecting the timing and location of salinity gradients. These changes affect a variety of parameters that are used to govern operation of the Delta and many others that influence fish habitat and their populations. Regulatory requirements include, but are not limited to, Delta outflow, X2 (the 2 ppt isocline) location, and Export/inflow (E/I) ratios. In addition, negative flows in Old and Middle rivers have been used as a management tool to protect delta smelt. Another factor affecting fish in the Delta and subject to take limits described in the NMFS and USFWS Biological Opinions on the Operating Criteria and Plan (OCAP)(Reclamation 2004), is fish entrainment and loss at the Banks and Jones pumping plants.

Delta Outflow

Delta outflow is an estimate of net downstream flow, calculated as the difference between inflow and the sum of estimated in-Delta consumptive uses and exports through the CVP and SWP pumps (defined in D-1641). Delta outflow is an important factor influencing fish habitat and fish populations, as it influences salinity gradients and other water quality parameters. The volume of the Estuary's fresh water supply has been increasingly depleted each year, due to upstream diversions, in-Delta use, and Delta exports.

D-1641 contains Delta outflow compliance criteria under the water quality objectives for fish and wildlife beneficial uses for Net Delta Outflow (NDO)(see Table 2-2). Delta Outflow requirements range from 3,000 to 8,000 cfs, depending on month and water year type. This requirement is based on a three-day running average. CALSIM II outputs are monthly means. Delta outflow is frequently greater than these requirements because of other operational requirements within the Delta, such as maintenance of X2 location or E/I ratio.

Table 2-2
Delta Outflow Requirements Under D-1641[1] (cfs)

Water Year Type	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Wet	4500[2]	7100[3]	7100[3]	7100[3]	7100[3]	7100[3]	8000	4000	3000	4000	4500	4500
Above normal	4500[2]	7100[3]	7100[3]	7100[3]	7100[3]	7100[3]	8000	4000	3000	4000	4500	4500
Below normal	4500[2]	7100[3]	7100[3]	7100[3]	7100[3]	7100[3]	6500	4000	3000	4000	4500	4500
Dry	4500[2]	7100[3]	7100[3]	7100[3]	7100[3]	7100[3]	5000	3500	3000	4000	4500	4500
Critical	4500[2]	7100[3]	7100[3]	7100[3]	7100[3]	7100[3]	4000	3000	3000	3000	3500	3500

[1]Based on net Delta outflow index
[2]Increased to 6,000 cfs if the eight rivers index for December exceeds 800 TAF
[3]Calculated as a 3-day running average and dependent on EC at Collinsville and the eight rivers index and the Sacramento river index in may.

Average daily Net Delta Outflow by month and water year type for water years 1997 and 2007 are presented in Table 2-3. This recent period of record was used, because of the significant changes in Delta operations that have occurred in recent years. Delta outflows is highest during the late winter and early spring, and lowest in August and September. Average Delta flows range from about 5,700 to over 130,000 cfs during wet years (Table 2-3). In dry years, average flows range from about 4,000 to 33,600 cfs. The total range (not averaged) of outflow for 2000 to 2006, irrespective of water year type (last row of Table 2-3), is about 9,600 to over 183,000 cfs during the wet season (February through May) and from approximately 3,100 to 8,900 cfs during August through October, when flows are lowest.

Table 2-3
Average Delta Outflow (cfs) by Water Year types Between 1997 and 2007

Water Year Type	Oct	Nov	Dec	Jan	Feb)	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	5710	8036	40070	130931	107437	75202	78861	53200	36219	15391	10758	9871
Above Normal	8269	13719	28854	29781	96406	78467	31371	22098	11244	9793	5977	4703
Below Normal	4184	7331	28885	51440	29622	15761	22029	41877	11719	9631	6874	3447
Dry	4757	6524	18183	28683	33639	32208	15333	11816	6810	5875	4041	4302
Critically Dry	-	-	-	-	-	-	-	-	-	-	-	-
2000-2006 WY Avg	4184-8508	4742-8205	5996-47943	15211-156265	12029-94092	15761-124121	11892-183031	9612-82004	5651-37105	4645-12044	3153-8914	3447-8610

Export/Import Ratio

State Water Board Decision 1641, limits the ratio of the water exported by the combined SWP/CVP pumps to the total inflow to the Delta (E/I ratio) to be less than 65 percent from July through January, or 35 percent from February through June. Exceptions to the 35 percent requirement are allowed in February under some circumstances. Lower E/I ratios are presumed to be beneficial to fish (NMFS 2005d, 70 FR 52488-52627, USFWS 2004), in that a smaller proportion of the total flow is being diverted, and thus presumably a smaller proportion of the fish are subjected to the adverse effects of the pumps. Statistical relationships between E/I and biological productivity or population indices have not been developed. Furthermore, substantially different conditions could be present in the Delta at the same E/I ratio (e.g. 1,000 cfs exports with 10,000 cfs inflow versus 10,000 cfs exports with 100,000 cfs inflow). In discussions with biologists knowledgeable regarding Delta operations (V. Poage USFWS and J. White-CDFG personal communication, August 24, 2007), no biologically meaningful thresholds or specific amount of change in E/I could be identified as significance criteria. For these reasons, changes in E/I ratios were not used in the evaluation of Project alternatives. Flexibility in the E/I standard is provided in the Bay-Delta Water Quality Control Plan and pumping above the E/I standard is a tool for the EWA to obtain water. This tool has not been used in recent years, and will not be used in modeling runs for this project.

Under Baseline conditions, the E/I ratio rarely exceeds the regulatory limits and approach them most closely in below normal and drier years (Table 2-4).

Table 2-4
Average E/I Ratio (Expressed as a Percentage) by Water Year Types Between 1997 and 2007

Water Year Type	Oct	Nov	Dec	Jan	Feb)	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	56%	55%	35%	14%	12%	11%	10%	8%	21%	36%	42%	48%
Above Normal	50%	39%	19%	27%	10%	10%	14%	12%	28%	41%	52%	59%
Below Normal	48%	50%	29%	17%	27%	41%	20%	6%	40%	43%	52%	63%
Dry	52%	55%	38%	32%	34%	28%	20%	10%	27%	47%	56%	55%
Critically Dry	-	-	-	-	-	-	-	-	-	-	-	-
2000-2006 WY Avg	40-61%	21-61%	4-53%	1-43%	1-42%	2-41%	1-24%	4-17%	6-40	18-50%	26-59%	27-63%

X2 Location

Salinity is an important habitat factor in the estuary. Estuarine species characteristically have optimal salinity ranges, and their abundance may be affected by the amount of habitat available within the species' optimal salinity range (Kimmerer 2002). This is described in further detail in Section 3.2.1.1. Because the salinity field in the estuary is largely controlled by freshwater outflows, the level of outflow may determine the available area of optimal salinity habitat for different species (Hieb and Baxter 1993; Unger 1994 as cited in DWR and Reclamation 1996, Kimmerer 2002, DWR and Reclamation 2005). X2, the location of the 2 ppt isopleths, is an indicator of the salinity gradient in the Bay-Delta, and is measured in terms of river kilometers (rkm) upstream of the Golden Gate. Lower values of X2 indicate that X2 is further west, while higher values indicate X2 is further east.

Under D-1641 Water Quality Objectives, X2 is to be west of the confluence of the Sacramento and San Joaquin Rivers at rkm 81 in January, June and July, and west of Chipps Island (rkm 74) during February through May. SWP and CVP operations are managed to comply with these criteria.

Average X2 location (Table 2-5) by water year type from the 1996 through 2006 water years fell between rkm 52 and rkm 87, as measured upstream from the Golden Gate. X2 is generally furthest west in February through May and furthest east in August through November. X2 is generally further west in wetter conditions and further east in drier conditions.

Table 2-5
Estimated Average Location of X2 (rkm) by
Water Year Type and Month under Existing Conditions (1996-2006)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	84.6	83.0	75.1	59.5	53.8	54.7	56.4	58.9	61.8	69.1	74.8	77.7
Above Normal	79.0	78.5	70.7	71.2	59.1	52.0	60.1	64.4	71.6	76.3	79.7	84.4
Below Normal	86.7	84.5	79.6	62.5	62.3	68.5	71.0	62.7	69.1	76.7	78.7	85.7
Dry	87.8	84.7	77.9	69.7	70.7	65.4	70.7	73.5	79.0	81.4	85.0	87.1
Critically Dry	-	-	-	-	-	-	-	-	-	-	-	-
2000-2006 WY Avg	83-88	81-86	74-84	54-80	54-74	52-72	45-74	48-76	57-81	68-83	75-88	78-88

2.2.1.2 Entrainment

As described previously, export operations of the SWP and CVP affect fish survival within the Delta, both directly and indirectly (USFWS 2005). An unknown fraction of the fish entrained by the pumps are lost, but both entrainment and loss are assumed to be proportional to salvage. Relative entrainment numbers do not necessarily represent changes in population size, however, as fish distribution within the Delta varies widely within and among water year types. This is described in detail in Section 3.2.1.3

Table 2-6 presents the estimated annual average entrainment index calculated for Existing Conditions for all years and for wetter and drier hydrologic conditions. These values will differ from actual salvage numbers, which is not reported on a monthly basis. The entrainment index is equal to the volume of water pumped by export facilities multiplied by the average salvage density for each species (see Section 3.2.1.3). These numbers serve as a basis for comparison to evaluate the effect of the action alternatives on fish salvage and entrainment. For most species, more fish are entrained in wetter conditions than in drier conditions, which is consistent with the amount of water diverted during these two hydrologic conditions. The entrainment index for longfin smelt and threadfin shad is considerably greater in drier conditions than in wetter conditions. Drier conditions result in these species being brought into closer proximity to the pumps. The entrainment indices are highest for most native Delta species from February through April and again in September. For salmonids, entrainment indices are highest in September through March with peak monthly values varying by species. The entrainment indices do not necessarily represent relative population impacts, as fish distribution varies widely by water year type.

Table 2-6
Entrainment at SWP and CVP Combined for Existing Conditions

WY Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep	Annual Total
Delta Smelt															
Wet	3,052	2,166	879	363	25,887	43,512	2,108	8	3	0	4	643	252	37,960	116,837
Above Normal	2,895	1,897	875	400	14,672	30,171	1,977	8	3	0	4	600	145	25,255	78,902
Below Normal	1,851	1,700	1,721	1,027	31,629	22,309	1,192	0	0	9	101	486	417	73,568	136,010
Dry	1,923	1,531	1,378	666	24,751	17,250	1,099	0	0	10	105	497	296	54,394	103,900
Critically Dry	1,486	1,243	1,089	401	14,284	10,695	897	0	0	7	87	395	199	30,001	60,784
Striped Bass															
Wet	105,144	48,402	11,139	1,789	112,193	2,322,072	1,015,021	166,496	33,439	27,841	78,606	68,967	1,235	163,024	4,155,368
Above Normal	100,741	42,568	11,261	1,999	63,144	1,720,679	919,986	157,231	32,177	27,302	79,223	64,318	714	108,675	3,330,018
Below Normal	32,791	37,123	34,036	7,095	105,061	2,097,606	504,203	31,943	22,327	123,815	209,257	56,185	2,571	250,500	3,514,513
Dry	32,602	33,375	28,750	4,802	82,936	1,711,073	491,733	27,200	18,189	130,364	216,056	57,711	1,924	206,760	3,043,475
Critically Dry	27,694	27,048	23,247	3,067	53,870	1,103,590	335,514	18,899	14,991	99,720	142,841	45,740	1,447	116,075	2,013,743
Longfin Smelt															
Wet	78	27	13	13,946	663	52	42	11	0	0	0	20	10,846	901	26,599
Above Normal	74	25	12	10,218	355	36	40	10	0	0	0	18	6,137	609	17,534
Below Normal	79	35	323	12,850	24,478	1,055	1	0	0	11	6	15	4,773	56,674	100,300
Dry	78	32	281	8,621	19,124	805	1	0	0	12	6	15	3,530	40,985	73,490
Critically Dry	67	27	230	5,443	10,781	494	1	0	0	9	4	12	2,592	22,518	42,178
Threadfin Shad															
Wet	403,695	231,704	13,061	8,565	3,639	225,441	730,490	1,145,928	578,916	475,831	398,824	381,098	6,067	4,624	4,607,883
Above Normal	392,180	216,331	13,469	8,886	1,851	161,268	651,773	1,067,989	561,553	453,389	401,884	357,547	3,491	3,177	4,294,788
Below Normal	364,051	170,003	31,197	14,435	1,415	351,763	2,247,953	821,616	302,487	991,077	535,013	261,874	5,086	3,266	6,101,236
Dry	349,090	149,428	26,004	9,862	1,104	289,753	2,142,216	718,844	248,300	1,040,874	556,408	264,068	3,858	2,327	5,802,136
Critically Dry	319,490	118,910	20,912	6,379	613	188,160	1,576,997	531,586	203,774	871,852	434,473	212,070	2,978	1,275	4,489,469
Fall-run Chinook Salmon															
Wet	5,219	18,918	3,743	7,650	32,340	18,137	324	62	335	39	127	199	5,761	48,310	141,164
Above Normal	5,078	16,920	3,632	6,434	18,592	13,101	291	59	313	38	128	186	3,278	32,016	100,066
Below Normal	87	90	2,562	17,511	19,410	542	2	21	0	223	132	241	8,024	44,217	93,062
Dry	86	81	2,005	10,760	15,079	440	2	19	0	235	138	247	5,401	29,431	63,924
Critically Dry	74	66	1,569	5,947	7,793	282	1	15	0	178	109	196	3,163	15,924	35,317

Table 2-7
Entrainment at SWP and CVP Combined for Existing Conditions (continued)

WY Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep	Annual Total
Late Fall-run Chinook Salmon															
Wet	1,862	33	0	1	0	4	0	4	5	19	55	932	0	0	2,915
Above Normal	1,761	29	0	1	0	4	0	4	4	19	56	868	0	0	2,746
Below Normal	422	10	14	10	0	0	0	0	0	7	38	685	5	0	1,191
Dry	446	9	11	6	0	0	0	0	0	7	39	706	3	0	1,227
Critically Dry	332	7	9	3	0	0	0	0	0	5	27	558	2	0	943
Winter -run Chinook Salmon															
Wet	8,699	2,194	1,998	312	7	1	0	0	0	0	0	1,073	239	9	14,532
Above Normal	8,211	1,872	1,879	247	4	1	0	0	0	0	0	999	135	6	13,354
Below Normal	2,614	4,096	7,666	446	14	0	0	0	0	0	0	2,017	187	32	17,072
Dry	2,777	3,774	5,865	285	11	0	0	0	0	0	0	2,062	131	20	14,925
Critically Dry	2,041	3,118	4,539	168	5	0	0	0	0	0	0	1,640	85	11	11,607
Spring-run Chinook Salmon															
Wet	7	150	8,054	36,280	12,336	2,835	0	0	3	7	0	0	27,557	18,420	105,649
Above Normal	7	130	7,766	29,476	7,090	1,989	0	0	3	7	0	0	15,656	12,209	74,333
Below Normal	7	3	3,244	17,455	3,980	7	0	0	0	0	0	0	7,818	9,062	41,576
Dry	7	3	2,522	10,842	3,091	6	0	0	0	0	0	0	5,314	6,015	27,800
Critically Dry	6	2	1,966	6,101	1,593	4	0	0	0	0	0	0	3,196	3,252	16,120
Steelhead															
Wet	9,326	15,980	5,926	2,008	720	342	117	2	0	56	63	361	1,468	1,037	37,406
Above Normal	8,922	13,982	5,818	1,884	403	250	93	2	0	56	63	338	840	693	33,344
Below Normal	2,427	11,878	14,199	1,923	311	126	65	0	0	4	93	190	754	716	32,686
Dry	2,535	10,755	11,375	1,265	243	105	60	0	0	5	96	196	544	502	27,681
Critically Dry	1,937	8,765	8,993	777	132	69	49	0	0	3	65	155	378	274	21,597
Splittail															
Wet	5,972	2,733	2,347	2,742	53,279	903,266	223,203	5,135	699	423	177	272	1,998	68,606	1,270,852
Above Normal	5,699	2,397	2,254	2,601	27,373	710,624	190,335	4,785	671	409	179	254	1,143	46,989	995,713
Below Normal	1,170	1,251	2,124	2,046	141	3,410	429	68	91	171	110	307	927	341	12,586
Dry	1,220	1,157	1,648	1,264	112	2,916	428	61	74	180	114	315	627	298	10,414
Critically Dry	935	958	1,285	705	77	1,942	270	46	61	138	75	250	372	168	7,282

Table 2-8
Entrainment at SWP and CVP Combined for Existing Conditions (continued)

WY Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr 1-15	Apr 16-30	May 1-15	May 16-31	Jun	Jul	Aug	Sep	Annual Total
American Shad															
Wet	88,893	10,688	859	763	1,463	56,608	441,595	283,395	91,075	159,424	285,668	162,950	589	2,261	1,586,231
Above Normal	85,292	9,395	817	575	864	38,820	399,655	266,214	86,091	152,940	287,878	152,662	334	1,488	1,483,025
Below Normal	37,424	6,379	981	542	41	10,369	209,409	86,978	37,125	144,452	270,324	154,992	224	93	959,333
Dry	37,868	5,785	770	349	32	7,830	199,112	79,674	29,993	151,798	280,811	157,384	158	64	951,628
Critically Dry	30,990	4,721	604	208	17	4,764	147,629	64,735	24,839	124,592	213,949	125,764	104	35	742,951

2.2.2 San Joaquin River

The San Joaquin River area of analysis is focused primarily on the San Joaquin River between the confluence of the Newman Wasteway with the San Joaquin River (just upstream of the confluence of the Merced River) downstream to where the San Joaquin River flows into the Delta, at the head of Old River. Details regarding the facilities and water bodies within the San Joaquin River Area of analysis and the fisheries resources they support are described in section 3.1.1.1 of the IAIR.

The reaches considered for this analysis are:

- Newman Wasteway Confluence to Merced River Confluence (River Miles 119 to 118).
- Merced River Confluence to Tuolumne River Confluence (River Miles 118 to 86).
- Tuolumne River Confluence to Stanislaus River Confluence (River Miles 86 to 80).
- Stanislaus River Confluence to Old River (River Miles 80 to 54).

The lower reaches of the San Joaquin River from the Merced River to Vernalis are used by anadromous salmonids for immigration, seasonal rearing, and outmigration. Spawning habitat is not available in this reach for salmonids due to substrate, water temperature and water quality conditions. This 43-mile reach includes the confluence of the Stanislaus, Tuolumne and Merced rivers, the main tributaries to the San Joaquin River entering from the eastern side of the valley. Flows in the San Joaquin River at Vernalis are influenced by the operations of dams on the tributary rivers, as well as releases from Mendota Pool on the San Joaquin River. The maximum flows are less than historical levels.

2.2.2.1 Flow

Flows in the San Joaquin River between the mouth of Merced River and Mendota Pool are controlled by spill or releases from Mendota Pool, and agricultural diversions and return flows within the reach. Releases from Friant Dam to the San Joaquin River are currently made to meet downstream water rights and for flood control purposes. These releases do not always influence flows downstream of Mendota Pool. Releases from Mendota Pool are made to meet water delivery contracts. These flows are not intended to provide continuous flow into the project area, although some flow does persist this far downstream.

Minimum instream flow requirements for the San Joaquin River at Vernalis are established by SWRCB D-1641 from February to June by water year class (SWRCB 2000) (Table 2-9).

Table 2-9
Required San Joaquin River Flow (cfs) at Vernalis

Water Year Type	February-June Flow
Critical	710-1140
Dry	1420-2280
Below Normal	1420-2280
Above Normal	2130-3420
Wet	2130-3420

Since 1999, a 31-day pulse flow has occurred in the Lower San Joaquin River as part of the Vernalis Adaptive Management Plan (VAMP) (Table 2-10). The VAMP is a 12 year experiment to evaluate relationships between San Joaquin River flow, CVP and SWP exports and the configuration of South Delta barriers on salmon outmigration and survival from the San Joaquin River and through the Delta. The VAMP is a condition within D-1641, and the amount of flow and allocation of contributions from the upstream dams is worked out each year by the San Joaquin River Group Authority (SJRGA) and Reclamation.

Table 2-10 Minimum Monthly Average Flow Rate (cfs) During The VAMP Pulse Flows (April 15 to May 15) As Measured at Vernalis by Water Year Type (Based on 60-20-20 Hydrologic Classification)	
Water Year Type	**Vernalis Flow**
Wet	7,330 or 8,620 cfs
Above Normal	5,730 or 7,020 cfs
Below Normal	4,620 or 5,480 cfs
Dry	4,020 or 4,880 cfs

There are three USGS gaging stations on the San Joaquin River within the project area. From downstream to upstream, these are located near Vernalis, Crows Landing, and Newman. More than 60 years of data were available for the Vernalis and Newman gages, but only the last 10 years for the Crows Landing gage. Flows increase at more downstream locations due to inflow from the Merced, Tuolumne, and Stanislaus Rivers, as well as various smaller tributaries and agricultural runoff. Flows are highest during the late winter and early spring, and lowest in August and September.

At Vernalis, average flows during wet years range from about 2,100 to over 16,200 cfs (Table 2-11). In critically dry years, average flows range from about 720 to 1,800 cfs. In more recent years, 2000 to 2006, flows have ranged from about 1,900 to nearly 28,000 cfs during the wet season (February through May) and from approximately 1,100 to 3,700 cfs during August through October, when flows are lowest.

Table 2-11
Average Flow (cfs) by Water Year Type- 1924, 1930-2006 (USGS 11303500)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	2270	2124	4201	8719	13447	15333	16035	16208	13646	5659	2587	3140
Above Normal	3130	3391	5610	6624	8967	8056	7207	8811	6827	2230	1372	1669
Below Normal	1660	1860	2641	2775	2962	2943	2429	3424	3399	957	768	1006
Dry	2492	2603	2850	2871	2741	2295	1802	1751	1439	930	921	1141
Critically Dry	1805	1588	1703	1637	1576	1623	1337	1201	955	722	721	798
2000-2006 WY Avg	1705-2826	1632-2526	1503-3521	1792-13170	1879-7559	2134-12100	2598-27940	2625-26050	1404-15690	1147-5547	1116-3697	1121-3316

Average flows at Crows Landing (Table 2-12) range from 890 to over 10,000 cfs during wet water years. In drier years (Below Normal and Dry), they range between 320 and approximately 1,200 cfs, based upon the ten years of available data for this location.

Table 2-12
Average Flow (cfs) by Water Year Type between 1996 and 2006 (USGS 11274550)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	1135	886	1667	7267	10016	5578	7516	6820	5564	2701	1142	1110
Above Normal	1468	1053	1120	1262	3208	3159	1809	1366	707	622	623	593
Below Normal	631	817	1067	993	878	1088	941	1017	509	451	431	326
Dry	824	965	836	1008	990	1245	911	1064	502	451	457	369
Critically Dry	-	-	-	-	-	-	-	-	-	-	-	-
2000-2006 WY Avg	631-1063	731-1106	687-1280	888-4076	804-3507	870-4470	706-16350	937-13680	454-9240	403-2285	408-1294	326-1217

At Newman (Table 2-13), average flows ranged from 690 to 7,900 cfs during wet years. In critically dry years, flows ranged from 240 to 640 cfs. In more recent years (2000-2006), flows have ranged from about

700 to 16,600 cfs during the wet season (February through May) and from 280 to 1,150 cfs during August through October, when flows are lowest.

Table 2-13
Average Flow (cfs) by Water Year Type between 1944 and 2006 (USGS 11274000)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	688	715	1548	4561	6575	6940	7875	7074	5392	2316	926	1134
Above Normal	1459	1308	2342	2988	3537	2517	1673	2137	1373	606	479	549
Below Normal	338	367	679	877	1039	970	620	811	1012	308	293	333
Dry	633	585	725	910	841	801	594	620	387	314	336	410
Critically Dry	509	463	434	520	635	642	491	396	309	273	288	242
2000-2006 WY Avg	566-924	703-975	541-1318	692-3921	802-3212	869-4199	709-16610	912-13350	374-8852	317-1992	341-1159	282-1105

2.2.2.2 Water Quality

There are general water quality requirements for the San Joaquin River at Vernalis, which have been established by a set of SWRCB decisions. SWRCB D-1422 conditions New Melones Reservoir to be operated to maintain average monthly level total dissolved solids (TDS) that should not exceed an average of 500 parts per million (ppm) for all months in the San Joaquin River at Vernalis. Historically, releases have been made from New Melones Reservoir to maintain compliance with objectives. Reclamation has not always been able to meet this objective when water supply is limited. In the past, when sufficient water supplies were not able to meet the water quality standards for the entire year, the emphasis was to use the available water during the irrigation season, generally from April through September. Therefore, SWRCB D-1641 modified the water quality objective contained in the 1995 Bay-Delta Water Quality Control Plan to distinguish between the irrigation and non-irrigation seasons (SWRCB 2000) (Table 2-14). The revised criterion is the average monthly electrical conductivity (EC) at Vernalis:

Table 2-14
State Water Resources Control Board Water Quality Standards

Season	EC (ms/cm)	TDS (ppm)
Irrigation (April-August)	0.7	455
Non-Irrigation (September-March)	1.0	650

2.2.3 Stanislaus River

The DMC Recirculation project may affect flow and water temperature and quality on the Stanislaus River downstream of New Melones Reservoir.

2.2.3.1 Flows

The Stanislaus River is governed by several different regulations and agreements. New Melones Reservoir is operated in an attempt to balance multiple objectives including fishery flow requirements, water supply, water quality, San Joaquin River water quality, and inflow to the Delta. Section 3.1.1.12 of the IAIR (Reclamation 2007) provides additional detail on the various regulations and agreements. The 1997 New Melones Interim Plan of Operations (IPO) allocates water to serve four purposes: fishery, water quality, Bay-Delta flow, and water supply (Table 2-15).

Table 2-15
New Melones Interim Plan of Operation Allocations (1,000 AF)

New Melones Storage Plus Inflow		Fishery		Vernalis Water Quality		Bay-Delta		CVP Contractors	
From	To	From	To	From	To	From	To	From	To
0	1,400	0	98	0	70	0	0	0	0
1,400	2,000	98	125	70	80	0	0	0	0
2,000	2,500	125	345	80	175	0	0	0	59
2,500	3,000	345	467	175	250	75	75	90	90
3,000	6,000	467	467	250	250	75	75	90	90

Required releases to the Stanislaus River below Goodwin Dam (a re-regulation dam, just downstream of New Melones) include: (1) releases up to the amount of the fishery account are debited from the annual fishery allocation; (2) releases up to the amount of the D-1641 Bay-Delta flow requirement, excluding the amount of fishery release, are debited from the annual Bay-Delta flow allocation, and (3) releases up to the amount of the Vernalis water quality requirement, excluding the amount of fishery and Bay-Delta flow allocations, are debited from the annual Vernalis water quality allocation.

Depending on the fishery allocation under the New Melones IPO, the fishery release volume at Goodwin Dam is managed under the base and pulse flow schedules shown in Table 2-16.

Table 2-16
Stanislaus River Minimum and Pulse Flow Schedules

Annual Fishery Allocation – (1000 AF)	0	98.4	243.3	253.8	310.3	410.2	466.8
Minimum Flow Schedules (cfs)							
January	0	125	250	275	300	350	400
February	0	125	250	275	300	350	400
March	0	125	250	275	300	350	400
April	0	250	300	300	900	1500	1500
May	0	250	300	300	900	1500	1500
June	0	0	200	200	250	800	1500
July	0	0	200	200	250	300	300
August	0	0	200	200	250	300	300
September	0	0	200	200	250	300	300
October	0	110	200	250	250	350	350
November	0	200	250	275	300	350	400
December	0	200	250	275	300	350	400
Pulse Flow Schedules (cfs)							
April 15–May 16	0	500	1500	1500	1500	1500	1500

Additional releases are made to the Stanislaus River below Goodwin Dam, if necessary, to meet SWRCB's D-1422 dissolved oxygen content objective. D-1422 requires that water be released from New Melones to maintain the dissolved oxygen concentration in the Stanislaus River at a value of at least 7 mg/L as measured near Ripon. Releases from Goodwin Dam to the Stanislaus River (except for flood control) do not exceed 1,500 cfs.

Releases are also made from New Melones to meet D-1641 standards for the San Joaquin River at Vernalis for EC, flow, and VAMP, as described in previous sections. These releases are made from New Melones, as required, but are limited by the allocation determined by the New Melones IPO.

There are two USGS gaging stations on the Stanislaus within the project area. From downstream to upstream, these are located near Ripon and Knights Ferry (below Goodwin Dam). Sixty-five years of hydrologic data were available at Ripon and 22 years at Knights Ferry. Flows generally increase from the upstream location to the downstream location due to inflow from small tributaries and agricultural runoff. However, the data from the two stations also differ because of the difference period of record.

Flows are highest during the late winter and early spring, and lowest in August and September. Near Ripon, average flows during wet years range from about 360 to over 3,300 cfs (Table 2-17). In critically dry years, average flows range from about 230 to 545 cfs. From 2000 to 2006, average flows have ranged from about 280 to over 4,500 cfs.

Table 2-17
Average Flow by Water Year Type between 1941 and 2006 (USGS 11303000)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	359	361	994	1898	2057	2390	2711	3343	2376	903	598	586
Above Normal	647	1064	1847	2000	2077	1825	1515	2283	1257	335	293	324
Below Normal	262	344	543	660	646	707	955	1800	1391	267	184	186
Dry	453	384	583	585	426	444	575	623	429	358	310	219
Critically Dry	376	338	298	235	254	544	485	446	402	351	300	269
2000-2006 WY Avg	335-591	308-421	307-1154	309-4178	321-1696	337-3115	366-4537	834-4130	550-1839	325-1267	304-1199	278-1158

Below Goodwin dam, average flows during wetter years range from about 300 to over 2,000 cfs (Table 2-18). In drier years, average flows range from around 220 to about 800 cfs. From 2000 to 2006, average flows have ranged from about 180 to close to 4,500 cfs.

Table 2-18
Average Flow by Water Year Type between 1984 and 2006 (USGS 11302000)

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	419	311	811	1607	1872	2065	1567	1755	968	679	693	654
Above Normal	1128	1051	1840	2270	2219	1575	1011	1152	802	390	353	349
Below Normal	339	286	270	298	553	471	831	785	1189	410	291	256
Dry	471	304	431	450	421	341	782	809	532	662	505	222
Critically Dry	319	282	283	213	282	785	640	566	543	467	381	312
2000-2006 WY Avg	316-526	253-390	252-1465	232-3917	223-1600	213-3084	364-4492	772-4021	441-1569	259-1202	226-1201	184-1168

2.2.3.2 Temperature

The NFMS Biological Opinion for the OCAP (NMFS 2004a) includes the following Term and Conditions relating to temperature on the Stanislaus River at Orange Blossom Bridge.

11. Reclamation shall manage the cold water supply within New Melones Reservoir and make cold water releases from New Melones Reservoir to optimize suitable rearing habitat for Central Valley steelhead in the Stanislaus River downstream of Goodwin Dam.

a. Reclamation shall manage cold water releases from New Melones Reservoir to maintain daily average water temperature in the Stanislaus River between Goodwin Dam and the Orange Blossom Road bridge at no more than 65°F during the period of June 1 through November 30 to protect rearing juvenile Central Valley steelhead.

b. Reclamation shall coordinate water temperature releases with CDFG and FWS to use fishery release water, to the extent possible, consistent with NMIPO, D-1641, and CVPIA.

c. If it becomes necessary to deviate from condition 7.a. above, Reclamation shall consult with CDFG, FWS, and NOAA Fisheries to develop a plan using all means possible to maximize suitable rearing habitat for Central Valley steelhead juveniles within the Stanislaus River below Goodwin Dam prior to June 1 each year.

Available temperature information for Orange Blossom Bridge from 2001 through 2006 was downloaded from the California Data Exchange Center (CDEC) to describe the temperature regime under existing conditions. This data indicates that temperatures are higher during drier years (Table 2-19). In wet water years, temperature averaged around 40°F between October and April, and reached 54°F during the summer. During drier years, temperatures range from the low to mid-50's during the winter and spring, to low 60's during the summer months.

Table 2-19
Average Temperature (°F) by Water Year Type on the Stanislaus River near Orange Blossom Bride between 2001 and 2006

Water Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Wet	41	41	42	41	41	41	42	52	54	44	46	54
Above Normal	-	-	-	-	-	-	-	-	-	-	-	-
Below Normal	57	54	52	51	51	54	54	56	57	61	62	61
Dry	58	54	51	49	51	54	55	56	59	61	62	56
Critically Dry	-	-	-	-	-	-	-	-	-	-	-	-

2.2.4 Merced and Tuolumne Rivers

The DMC Recirculation Project would have little affect on flows or water quality on the Merced and Tuolumne rivers. It may affect the anadromous fish resources of these rivers because these fish must pass through the San Joaquin River and Delta on their way to and from the ocean. Changes in water quality and composition in these waters may affect the ability of these fish to home effectively to their natal streams. Additionally, these changes in source water may result in increased straying of fish from other rivers into the Merced and Tuolumne rivers.

3.0 POTENTIAL EFFECTS / ASSESSMENT APPROACH AND CRITERIA

This section describes fishery related potential effects in all water bodies that may be affected by implementation of the DMC recirculation project along with the assessment approach to be used and significance criteria to be applied. In developing these approaches and criteria, it was necessary to formulate a number of assumptions in advance of actual modeling of the various alternatives. These assumptions were based on the best available information at the time and are intended only as a starting point for the development of approaches and criteria to assess impacts on aquatic resources. These assumptions are not intended to limit the range of potential project operations. If these assumptions are not met, it would be necessary to revisit the criteria and assess their validity in that situation. It may also be necessary to develop approaches and criteria beyond those described in this document. These starting assumptions are as follows:

- Flow and water quality will change in San Joaquin River
  - The flow increase is expected to be less than 300 - 500 cfs or 10 to 25 percent of total flow in the San Joaquin River.
  - Localized and short-term increases in turbidity are expected to occur near the inflow from the wasteway.
  - Localized and short-term increase in pesticides and other contaminants are expected to occur near the inflow from the wasteway.
- Pumping operations at the CVP and SWP will be modified.
- Water quality in the Delta will not change significantly from the perspective of fisheries requirements.
- Changes in flow direction and magnitude within the south Delta will occur.
- There will be no water quality and flow effects west of the Delta or on the Sacramento River side of the Delta.
- Flow in the Stanislaus River may change.
- Temperature in the Stanislaus River may change.

3.1 Potential Effects of Project on Fishery Resources

There are a number of variables related to the proposed project, which have the potential to either directly or indirectly effect fishery resources and the habitats upon which they rely within the project area. These are generally categorized into three major potential project areas of effects: 1) changes in hydrodynamics (i.e. flow, entrainment, etc.); 2) changes in water quality (i.e. water temperature, dissolved oxygen, heavy metals, trace elements); and 3) effects on biological characteristics of fisheries within the project area (i.e. straying issues, habitat suitability). The following sections provide a general discussion regarding the potential effects within these categories by affected ecoregion.

3.1.1 The Sacramento-San Joaquin Delta

3.1.1.1 Hydrodynamics

By increasing flow in the lower San Joaquin River and increasing Delta exports, the project could alter the hydrodynamics of the Delta in ways that are beneficial or detrimental to certain species of fish. Direct effects of export and flow changes could include changes to the frequency, magnitude, and duration of reverse flows (defined as a southward flow direction in Old and Middle Rivers), total Delta outflow, and export/inflow ratio. Flow and export changes could cause indirect effects including reverse flows and changes in the location of X2.

3.1.1.2 Water Quality

It is anticipated that Recirculation would have minimal effects on water quality in the Delta from a fisheries perspective. The differences in water quality that are targeted to occur at Vernalis would not be sufficient to cause substantial effects downstream. As previously noted, the EC standards at Vernalis are for agricultural uses and correspond to a salinity of about 0.5 ppt. The location of X2, the 2 ppt isopleths is generally located west of Collinsville. The salinity within the Delta would generally fall between 1 and 2 ppt. This is well within the tolerance range of the principal management species. The changes in flow associated with creating the desired changes in water quality through additional exports, may however result in some changes. Among these are changes in the frequency of dissolved oxygen depletion in the Stockton Deep Water Ship Channel (DWSC) and changes in the location of X2. The assumption that water quality effects would be minimal from a fisheries perspective will be verified through the water quality assessment. If violations of water quality standards are observed to occur, the potential impacts of these changes on fisheries resources will be discussed qualitatively.

3.1.1.3 Biology

Changes in total exports caused by recirculation could lead to changes in flow patterns (potentially increases in the frequency and magnitude of reverse flows) and in the total entrainment and salvage of fish at the CVP and SWP pumping plants. Mortality rates of entrained and salvaged fish vary by species. Additional effects, not accounted for in salvage, also include increased predation along the approaches to the pumps, and losses when fish are drawn from more favorable to less favorable habitat by reverse flows in the south Delta. Increases in the entrainment and salvage of special status and ESA listed fish species would translate to direct take.

The mixing of Sacramento water into the San Joaquin River during recirculation, combined with potential hydrodynamic changes in the Delta, could interfere with the ability of salmon and steelhead to home to their natal streams and lead to an increase in straying in some runs. Recirculation could interfere with salmonid homing in three ways: 1) by interfering with the proper imprinting of out-migrating smolts in the San Joaquin River; 2) by masking the scent of the San Joaquin River; or 3) by causing false attraction of fish originating in the Sacramento River to the San Joaquin River.

Hydrodynamic and water quality changes in the lower San Joaquin River caused by recirculation could affect the abundance and distribution of exotic or undesirable ‘pest’ or predator species in the Delta by influencing the amount of physical habitat available to them. Of particular concern is the toxic cyanobacteria *Microcystis aruginosa,* which can form dense summer blooms in the central and southern Delta. The project may result in slight variations in some of the parameters that affect this species, but its range of tolerance to those slight changes is unknown. Therefore, the effects of the project on *Microcystis* cannot be predicted.

3.1.2 San Joaquin River

3.1.2.1 Hydrology

Recirculation would increase flow in the lower San Joaquin River with out-of-basin water, potentially affecting both chemical and physical habitat characteristics and could therefore affect habitat suitability for some fish species. However, modified operations of both project and non-project facilities (i.e. increased riparian diversions) along the lower San Joaquin River, as a result of increased flows, may reduce these potential affects. The project is generally expected to increase flows in the San Joaquin River when recirculation is occurring. This is expected to provide somewhat more habitat than is present under non-project conditions. This will be discussed qualitatively.

3.1.2.2 Water Quality

Water quality and fish toxicity impacts to the San Joaquin River near the wasteway is of particular concern. These potential impacts would be associated with the possible mobilization of sediment and contaminants from past, present, and future agricultural drainage from the wasteways into the San Joaquin River. The “first flush” of water through the wasteways may displace resident water in the wasteways and scour accumulated fine sediment. This would increase turbidity levels and potentially introduce high contaminant and organic carbon loads into the lower San Joaquin River. The biochemical oxygen demand of the first flush may also be high enough to affect dissolved oxygen levels in the San Joaquin River.

As previously discussed, the targeted changes in EC at Vernalis are for agricultural needs and not for fish and wildlife needs. These standards translate to approximately 0.5 ppt salinity. The project would reduce salinities that range up to about 1 ppt down to about 0.5 ppt. Salinity values this low would not affect the principal management species, as these species are all euryhaline and can easily tolerate changes in salinities in this range. These small changes in salinity, by themselves would not substantially affect conditions in the lower San Joaquin River or the Delta for fish, although the flows associated with achieving these reductions could affect conditions.

3.1.2.3 Biology

By influencing the flow patterns of the lower San Joaquin River, the DMC Recirculation Project could change the characteristics of physical habitat available to fishery resources utilizing the area and subsequently affect rearing, migration, and survival. The largest effect is expected to be changes in the water composition (source fraction) of the lower San Joaquin River, through introduction of Sacramento River water. This has the potential to affect imprinting and straying of Chinook salmon and steelhead into, or within, the San Joaquin basin.

3.1.3 Stanislaus River

3.1.3.1 Hydrology

The DMC recirculation project could decrease flow in the Stanislaus River by reducing or eliminating the need to use releases from New Melones Reservoir to meet Vernalis water quality or Delta flow requirements. Reduced New Melones releases may potentially affect physical habitat characteristics, and therefore habitat suitability for some fish species, within the Stanislaus River. Habitat quality for fish in the Stanislaus River depends not only on the water in the fish account. Releases of water from the other accounts, such as the Vernalis and Bay Delta accounts, can reduce the need for water from the fish account at some times of year. In drier periods, there is sometimes not enough water to maintain desired fish conditions under existing operations (NMFS 2004a). If there was a reduced need to release water from these other accounts, as a result of the project, the fish account water would potentially be spread more thinly over the course of the year, which may result in less favorable habitat conditions at some times of year and during drier years.

3.1.3.2 Water Quality

Changes in Stanislaus River flows as a result of the recirculation project may affect water temperatures in some reaches of the Stanislaus River. Reduced flows, and potentially increased water temperatures could affect the suitability of available salmon and steelhead habitat within the Stanislaus River. Reduced flows in the Stanislaus River, as a result of the recirculation project, may also affect water quality by eliminating potential dilution of agricultural or urban runoff into the river. These other water quality effects will be assessed qualitatively, if the water quality analysis indicates that any parameter would exceed standards.

3.1.3.3 Biology

By potentially influencing the flow patterns, water temperature, and water quality within the Stanislaus River, the recirculation project could change the characteristics of physical habitat available to fishery resources (i.e. salmon and steelhead) utilizing the area. This could subsequently affect successful spawning, rearing, migration, and survival of Stanislaus River fish resources. Fish straying would not be affected once fish entered the Stanislaus River from the San Joaquin, as the water would all be Stanislaus River water.

3.1.4 Tuolumne and Merced Rivers

3.1.4.1 Biology

The recirculation project is not anticipated to change flows or any other physical or chemical characteristics of available fish habitat within the Tuolumne or Merced rivers. However, anadromous fish from these rivers must pass through the lower San Joaquin River and Delta, therefore, they may be exposed to changes in these areas that may affect their survival or increase their potential for straying.

3.2 Assessment Approach

3.2.1 The Sacramento-San Joaquin Delta

3.2.1.1 Hydrology/Hydrodynamics

The results of hydrologic modeling (using both CALSIM II and DSM2) will provide information that will be used to evaluate the potential effects of DMC Recirculation project operations. The parameters and evaluation approaches described below were selected in consultation with the Fisheries Technical Working Group (FTWG). For the Delta area, the following modeling parameters were selected to be part of the fisheries analysis:

- Flow magnitude and direction in Old and Middle River;
- export through CVP and SWP Delta facilities;
- Delta outflow, and
- change in location of X2.

These parameters have been and are currently used to manage flows within the Delta and to evaluate potential effects on Delta fisheries. These parameters are described in the following sections.

Reverse Flows

Reverse flows (also known as upstream flows) occur in the south Delta when in-Delta, SWP, and CVP exports are greater than the inflow from the San Joaquin River. When this happens, water is drafted across the Delta from the Sacramento River and/or water can be drawn upstream from eastern Suisun Bay into the Delta creating a reverse flow in the channels in the south Delta, primarily Old and Middle Rivers and their interconnecting channels. Reverse flows can impact resident and anadromous fish species by drawing them into the southern Delta and increasing the potential for their entrainment into the CVP and/or SWP south Delta pumping facilities. Reverse flows also create habitat conditions less favorable to some species in the central and south Delta. In addition, reverse flows in the south delta may increase salmonid straying rates (Mesick 2001).

APPROACH

Changes in annual patterns of reverse flow will be analyzed using the DSM2 model. Analysis will look for any increase in reverse flows in the south delta, especially in the Old and Middle River channels. Significance criteria are described in Section 3.3.

Export through CVP and SWP Delta Facilities

The timing and volume of water exported affects entrainment at the Banks and Jones pumping plants and fish salvage facilities in the south Delta. This effect is discussed in Section 3.2.1.3.

Delta Outflow

Delta outflow is a general indication of habitat conditions in the Delta because of its effect upon salinity gradients and fish movement. It is not considered an indicator in and of itself for any of the listed species.

Delta outflow is believed to benefit the dispersal of fish species, such as delta smelt, longfin smelt, and striped bass to the estuary (closely related to X2). Delta outflow is also believed to be an important flow component for out-migrating juvenile salmon and steelhead to successfully exit the Delta on the way to the ocean; however, biological relationships are not well established.

Delta outflow data will be compiled from Net Delta Outflow (NDO) computed from CALSIM II modeling for the 72-year simulation period and totaled in cubic feet per second (cfs) for each month on record. Delta outflow data will be evaluated when recirculation occurs to determine whether outflow increases or decreases during implementation of the DMC recirculation project alternatives relative to conditions without the project. Significance criteria are described in Section 3.3.

X2 Location

The location of X2 has been used as a surrogate for evaluating changes in hydrologic conditions that are the result of inflows to the Delta, SWP and CVP export operations, and in-Delta use.

The location of X2 downstream of the Sacramento and San Joaquin confluence is closely associated with the natural logarithm of Delta outflow between 1959 and 1988 (USFWS 2005). Previous analyses have shown that delta smelt were usually distributed upstream of X2 (Sweetnam and Stevens 1993, Dege and Brown 2004). Prior to 1982, delta smelt abundance was highest when X2 was in or near the Delta. However, ever since a population decline in the early 1980s, upstream placement of X2 during spring has been associated with low delta smelt abundance in the CDFG townet survey[4] (Kimmerer 2002). The summer tow net index increased when outflow was between 34,000 and 48,000 cfs, which generally places X2 between Chipps and Roe islands, downstream of the Sacramento and San Joaquin confluence.

Empirical evidence shows that when X2 is upstream of the Sacramento-San Joaquin confluence, delta smelt are in the area of the San Joaquin River where flow conditions draw larval fish into the South Delta. This exposes them to other factors that potentially decrease survival (predation, warmer water temperatures, and greater risk of entrainment into the SWP and CVP delta pumping facilities). Critical habitat for delta smelt has been affected by diversions that have shifted the position of X2 upstream of the confluence of the Sacramento and San Joaquin rivers (USFWS 2005). When X2 is west of the confluence, delta smelt and other fishes are outside the area of influence of the pumps. Except for three years in the 1983-1994 period (1986, 1993, and 1994) the summer tow net survey has remained at consistently lower levels than experienced before 1983. These low levels correlate with the 1983 to 1994 mean location of X2 upstream of the confluence.

This relationship is not as solid in wet years when delta smelt typically are located well down stream into Suisun Bay and away from the influence of the south delta pumping facilities. For this reason, X2 does not necessarily regulate delta smelt distribution in all years. In wet years, their distribution is much more dispersed, and they can be found well west of the X2 location. This is believed to be related to the location of primary food resources (USFWS 2005a).

Similar physical processes affect other euryhaline species, such as longfin smelt, outmigrating juvenile Chinook salmon and steelhead, and life stages of other species that move into or through the Delta during the spring and summer. The change in location of X2 relative to the Sacramento-San Joaquin river

[4] The summer townet survey was originally used to provide an index of the abundance of young striped bass when their average size is 38 mm by sampling 31 stations from San Pablo Bay through the Delta. The original purpose was to predict recruitment to the adult stock but the index has proven valuable in gauging the environmental health of the estuary

confluence during key life history stages can be used to evaluate the effects of the DMC recirculation project on conditions for Delta species.

APPROACH

To assess the effects of action alternatives on the location of X2, CALSIM II simulations will be run for the 72-year simulation period (1922-1994) to model X2 locations without the project and for the various DMC alternatives. Output from CALSIM II provides the X2 location for the end of each month. The locations of X2 with and without the project will then be compared and evaluated with regard to net movement and movement towards the west would be considered beneficial, whereas a movement toward the east would be considered adverse.

3.2.1.2 Water Quality

As described previously, basic water quality parameters such as salinity, water temperature, dissolved oxygen, turbidity, and pollutants can affect fish and fish habitat. It is not anticipated that the DMC recirculation project will result in substantial changes in these parameters, but this potential effect cannot be totally discounted. Salinity will be addressed through the evaluation of X2 location, as previously described.

Dissolved oxygen problems have been documented in the Stockton Deepwater Ship Channel (DWSC). The effects of recirculation on these problems will be assessed through comparison of flow levels with flow-dissolved oxygen relationships for the DWSC. The RWQCB evaluated daily flow and dissolved oxygen concentrations from November 1995 to September 2000 (CVRWQCB 2005), and found that no violations of the dissolved oxygen objectives occurred when the net daily flow was above 3,000 cfs. At flows below 1,000 cfs, about half of the daily minimum dissolved oxygen concentrations were below 5.0 mg/L. It is recognized that many other factors can affect dissolved oxygen levels, such as nutrient loading and algal blooms. However, the dissolved oxygen vs. flow curves are sufficient for a comparative analysis of the alternatives.

The project is not anticipated to result in increased impairment of dissolved oxygen in other areas of the Delta. In these areas, low dissolved oxygen is associated with high biological and chemical oxygen demand resulting from operation of barriers and discharges into Delta waterways. The project will not affect these factors. Turbidity and water temperature are not expected to be affected and will not be modeled. Pollutants will be evaluated in the water quality evaluation. The biological implications of any problems noted will be discussed qualitatively in the fisheries evaluation.

3.2.1.3 Biology

Entrainment at the CVP/SWP Facilities

Implementation of the DMC recirculation project alternatives would affect the amount of water pumped at the SWP and CVP south delta pumping facilities. The amount of water pumped at these facilities, both directly and indirectly, affects fish survival within the Delta (USFWS 2005). The number of fish lost due to pumping operations is believed to be proportional to the numbers entrained and collected by salvage. Survival of fish species entrained in the CVP and SWP south delta pumping facilities is generally considered to be low, especially for certain species and/or life stages, such as young delta smelt, which are believed to be underrepresented in the salvage data and are sensitive to handling impacts during and after salvage. Mortalities of juvenile salmon and steelhead also are proportional to entrainment and salvage. In addition to salvage and entrainment at the pumping facilities, exports may also increase losses due to predation along the approaches to the pumps. These predation losses are influenced by operation of the pumps, in that exports can draw vulnerable fish into areas where predator densities are higher. Therefore, increased salvage numbers are considered to represent an overall adverse effect of an action or project upon fish resources.

The magnitude of losses resulting from export operations is a function of the magnitude of monthly water exports from each facility (CVP or SWP), the relative abundance of fish that are exposed to entrainment near the export facilities, and the vulnerability of species and life stages. When fish abundance near the export facilities, as indicated by salvage, is high and export flows also are high, fish losses are more likely to be high, as well. When export pumping is low or fish densities are low, losses would be expected to be low.

APPROACH

An approach has been developed to evaluate the relative amount of entrainment that might be experienced at the CVP and SWP export facilities. This approach combines data developed by Reclamation on the number of fish salvaged by month and hydrologic condition (wetter or drier conditions) and the amount of water exported via the pumps as predicted by the CALSIM II model, for both the Federal and State facilities. This information was used to develop an index of the relative impact to different species and life stages.

Reclamation used historical salvage data at the SWP and CVP pumping facilities for the period 1993-2004 to calculate salvage density by species and month for wetter and drier hydrologic conditions. Salvage densities were calculated by totaling species salvage by month for each export facility and dividing by the appropriate volume pumped. This provided salvage densities by species for each export facility for each month and year of the evaluation. These were then averaged by water year condition to derive average salvage densities by species, month, and hydrological condition; wetter years consisting of wet and above normal water years, and drier conditions consisting of below normal, dry, and critically dry water years.

The entrainment index for operational alternatives is calculated by multiplying the volume of water pumped in a month (as determined from the CALSIM II model) at a facility by the salvage density (or loss) for the appropriate month and water year condition for each species. The results for the two export facilities are totaled by month and year. Average calculated salvage by month (long-term average) is produced and tabulated for the overall evaluation period by water year type. This information can then be used to evaluate the potential effects of the DMC recirculation project on fish species found in the Delta.

The values calculated are considered an index, as this approach will not precisely calculate the number of fish entrained by the CVP and SWP facilities or account for associated effects of pumping and salvage (i.e. predation, handling mortality). Nor will this approach calculate the loss of entrained organisms generally under-represented in the salvage data or lost due to negative flows in Old and Middle River that may draw fish from more favorable to less favorable habitats. However, it seems reasonable to assume that the relationship between export rates and these factors would be the same for all alternatives with and without the DMC recirculation project and would be a useful tool to assess potential effects of the project.

Underlying assumptions of this analysis include:

1. Historical (1993-2004) species salvage densities that include the effect of the POD are sufficiently representative for this analysis and represent likely future densities for similar hydrological conditions;
2. Simulation of alternatives over the historic period of record is sufficiently representative of future conditions under those alternatives.
3. Factors not included in this analysis would not unduly affect the validity of the evaluation of the comparisons of alternatives.

The entrainment index by species with and without the DMC recirculation project, by water year category and for all years combined, will be considered when assessing impacts. The net change in the entrainment indices would indicate whether the DMC recirculation project alternatives would result in a change in the entrainment index relative to what would be expected without the project. Entrainment indices for late fall run Chinook and green and white sturgeon will not be developed as the data available are not sufficient to support this type of analysis.

Salmonid Straying

Straying rates of Central Valley fall-/late-fall run Chinook salmon, Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead could be affected by the DMC recirculation project. The DMC recirculation project is expected to affect the hydrology of the lower San Joaquin River and southern Delta when recirculation is occurring, and cause additional amounts of exported Sacramento River water to be sent down the San Joaquin River. The mixing of Sacramento River water with San Joaquin River water, combined with potential changes in Delta hydrodynamics (i.e. reverse flows), could hinder the abilities of San Joaquin River Chinook salmon and steelhead juveniles and smolts to imprint effectively during emigration. It could also affect the ability of adult Chinook salmon and steelhead from all areas to home from the ocean to their natal streams. The result could be increased straying of salmon and steelhead.

Sacramento River water is a component of the water exported at the SWP and CVP facilities, so a component of Sacramento River water already flows down the San Joaquin River, as it is used to irrigate crops within the San Joaquin River watershed and flows into the San Joaquin River as agricultural drainage. It is not known how the chemical signature of this water (or that of native San Joaquin River water) is changed during this process.

Juvenile salmonids imprint on the sequence of these olfactory chemical cues as they migrate downstream. The presence of a large component of Sacramento River water in the San Joaquin River during the emigration season could impair the imprinting of San Joaquin River salmonids. Juvenile salmon remember the sequence of cues during their downstream migration. Adult salmonids home to their natal stream to spawn primarily using olfactory environmental cues. The unique chemical composition of streams provides the olfactory stimulus that adult salmonids search for as they migrate upstream. When these individuals return to freshwater as adults, they search for the sequence of stream confluences and chemical cues in reverse order. Once the natal stream is found the fish proceed upstream to locate substrate, depth, and velocity conditions suitable for spawning using visual and tactile cues (Quinn 2005, Quinn 1993). When they return as adults, if recirculation is not occurring, these fish may be induced to enter the Sacramento River, rather than the San Joaquin, because of this missing source fraction. Even if the fish do eventually enter the right river, they may be confused and delayed in the Delta, which may reduce their fitness and spawning success. If the natal stream cannot be found, adult fish will at some point select a stream and proceed to find suitable spawning habitat. Some natural straying occurs within all populations of salmonids and this allows for the colonization of new habitats (Quinn 2005). However, in many watersheds, such as the Central Valley, anthropogenic causes have resulted in increased straying rates.

Hatchery origin salmon and steelhead runs in the Central Valley already exhibit high straying rates due primarily to the downstream transport and release of hatchery-reared juveniles, often many miles from the hatchery. These fish are more susceptible to false flow cues due to the lack of imprinting. Therefore, it is anticipated that any change in straying rates due to the DMC recirculation project would have to be large to be detectable over existing rates.

Fretwell (1989) showed experimentally that sockeye salmon could detect a source water change greater than 10 percent and a source water change greater than 20 percent could cause a significant number of fish to change migration course. Fretwell's experiment took place in the Fraser River system of British Columbia and involved tracking adult sockeye as they chose between pure home stream water and home stream water diluted with various percentages of water from another tributary. In the experiment sockeye were observed to choose pure home stream water over home stream water diluted with as little as 20 percent tributary water in significant numbers. Although the experiment did not indicate what conditions would cause the salmon to stray completely from home stream water, it did show the sensitivity of sockeye to a source fraction change. Based on life history type, Chinook salmon and steelhead presumably have a similar or lesser degree of stream fidelity, and home stream sensitivity, than sockeye (Quinn 2005). Therefore, the analysis of straying effects will focus on project affected areas that have a change in source water fraction greater than 20 percent. Once these areas are identified it must be determined whether the project has significantly altered the sequence of water sources experienced by migrating salmon and steelhead sufficiently to cause straying. Each population (run) of salmon potentially affected by the project must be analyzed individually. Fall run Chinook are likely to be affected differently than spring and winter run Chinook. Hatchery fish that have been trucked downstream will be affected differently than fish that have experienced a natural downstream migration. Both juvenile and adult fish from the San Joaquin drainage could be potentially affected. Only adult fish originating from the Sacramento River would be affected.

APPROACH

Personal communication with Dr. Thomas Quinn of the University of Washington, an expert on salmonid straying, indicates that little is known about how much of a change in the chemical composition of the source water or the sequence of olfactory clues can occur without inducing additional straying (Quinn, personal communication, July 6, 2007). Consequently, only a qualitative assessment of project effects on straying will be possible. The fraction of different source waters will be determined through the DSM2 model. The change in these fractions under the various recirculation alternatives relative to without project conditions will be compared. Larger changes in the composition of source water will indicate a higher likelihood of induced straying. Source water fractions will be evaluated along the path that salmonids would follow to enter the San Joaquin River. The points include the following locations from near Antioch to near Mossdale and cover the area of the south Delta where recirculation would likely result in a commingling of water from the Sacramento and San Joaquin Rivers:

- San Joaquin River near Antioch
- Old River near Rock Slough
- Middle River south of Mildred Island
- San Joaquin River near Fourteen Mile slough
- San Joaquin River upstream of Old River near Lathrop
- Old River near Stewart Tract

Source water mixing may affect adult straying, juvenile imprinting, or both. Several different kinds of impacts may be possible based on which life history stages are affected.

3.2.2 San Joaquin River

3.2.2.1 Hydrology/Hydrodynamics

Flow Effects

Recirculation is expected to increase San Joaquin River flows, which may affect habitat suitability for fish. Habitat parameters such as water depth and velocity could change as a result of the recirculation project. Generally speaking, it is assumed that these flow changes would be approximately 200 to 500 cfs, or 10 to 25 percent of the total San Joaquin River flow. The project would only increase flows and would not result in decreased flows. No habitat vs. flow relationships are available for the lower San Joaquin River. This change in flow is not anticipated to appreciably change physical habitat quality, due to the size and configuration of the channel, nor would these changes be expected to inundate any floodplain areas. Consequently, flow related physical habitat will not be evaluated quantitatively, but will be described qualitatively. Increases in San Joaquin River flow would be considered beneficial.

3.2.2.2 Water Quality

The DMC Recirculation project is expected to result in minimal effects on fisheries resources through water quality in the San Joaquin River, except immediately downstream of the wasteway selected for discharge.

It is not expected to result in substantial changes in water temperature (although this will be verified through modeling), because the water released from the DMC via the wasteways is expected to be at equilibrium temperatures before it enters the San Joaquin River. Because of the distance between New Melones Dam and the San Joaquin River, cool water released from the reservoir would attain an equilibrium temperature before it reaches the mouth of the river.

During the 2004 Recirculation Pilot study (Reclamation 2005), dissolved oxygen concentrations in the San Joaquin River dipped during the first flush of water from the wasteway, but the dissolved oxygen concentration did not drop below 6 mg/L. The dissolved oxygen concentration increased after the first flush but continued to show a depression relative to that in the San Joaquin River above the wasteway (7.7 vs. 8.3, respectively, on average over the remainder of the study).

Turbidity is a commonly used measure of light transmittance in water, but is influenced by numerous factors that have different effects on fish (algal community composition, water color, suspended solids, etc.). The fisheries analysis will concentrate on suspended sediment concentrations (SSC) as a parameter that has direct impacts on fish. During recirculation, the flow of water down the wasteway will result in disturbance and suspension of fine sediment particles from the bed of the wasteway. These suspended sediments may adversely affect fish by reducing visibility, and thus their feeding efficiency, and at very high concentrations, by clogging or abrading their gills. SSC will be modeled and the concentration and distribution of project-induced SSC will be estimated. These values will then be evaluated relative to literature-based information (Newcombe and Jensen 1996) on the effects of SSC on salmonids (Figure 3-1).

Duration of exposure to SS ($\log_e$ hours)

(B) Average severity-of-ill-effect scores (calculated)

Concentration (mg SS/L)	0	1	2	3	4	5	6	7	8	9	10	($\log_e$ mg SS/L)
162755	10	11	11	12	12	13	14	14	-	-	-	12
59874	9	10	10	11	12	12	13	13	14	-	-	11
22026	8	9	10	10	11	11	12	13	13	14	-	10
8103	8	8	9	10	10	11	11	12	13	13	14	9
2981	7	8	8	9	9	10	11	11	12	12	13	8
1097	6	7	7	8	9	9	10	10	11	12	12	7
403	5	6	7	7	8	9	9	10	10	11	12	6
148	5	5	6	7	7	8	8	9	10	10	11	5
55	4	5	5	6	6	7	8	8	9	9	10	4
20	3	4	4	5	6	6	7	8	8	9	9	3
7	3	3	4	4	5	6	6	7	7	8	9	2
3	2	2	3	4	4	5	5	6	7	7	8	1
1	1	2	2	3	3	4	5	5	6	7	7	0
	1	3	7	1	2	6	2	7	4	11	30	
	Hours			Days			Weeks		Months			

Figure 3-1 Severity of Ill Effects Scores from SSC from Newcombe and Jensen 1996

The project may also introduce a variety of pesticides, herbicides, fertilizers and other compounds that have accumulated in the wasteways into the San Joaquin River. Over 100 of these compounds were evaluated in the 2004 Pilot Study (Reclamation 2005). Only four toxic compounds were observed at detectible levels, none of these was observed consistently, and none exceeded standards. The potential for effects from compounds of this nature will be evaluated in the water quality section. If the water quality evaluation finds significant changes in the concentrations of these substances, the fisheries evaluation will include a qualitative discussion of the likely effects of these compounds on fish.

3.2.2.3 Biology

Salmonid Straying

As previously discussed, straying rates of Chinook salmon and steelhead into the lower San Joaquin River could be affected by the DMC recirculation project

Most straying for upstream migrants is expected to occur in the Delta, as this is where immigrants would be faced with commingling water sources in a tidally influenced environment and would need to select whether to move up the Sacramento, Mokelumne, or San Joaquin rivers. Migrating adults can move substantial distances up and downstream in search of their natal stream odor, sometimes resulting in delays to their upstream migration. Adults will continue to seek out their natal stream influenced by their pending maturation that may accelerate a decision to select one river over another. At that time, once these fish have selected a course, they are likely to stay with that choice.

Once in the San Joaquin River, salmonids would need to find either the Stanislaus, Tuolumne, or Merced rivers. It is possible that the addition of Sacramento River water in the San Joaquin River could affect the fish’s ability to find their natal stream. A greater proportion of Sacramento River water in the San Joaquin

River may also result in fish that were natal to the Sacramento River being attracted to go up the San Joaquin River. Once these fish have committed to this source, they may choose to spawn in the San Joaquin River system, possibly with San Joaquin River origin fish, rather than returning to the Delta to seek the Sacramento River.

APPROACH

A qualitative assessment of project effects on straying will be conducted based on the change in proportion of various source waters at different locations as described for the Delta. The periodicity of these changes will be compared to that of the salmon life history stages present in the delta to determine potential impacts.

3.2.3 Stanislaus River

3.2.3.1 Hydrodynamics

Flow Effects

The DMC recirculation project may cause flows in the Stanislaus River to decrease relative to existing conditions due to decreased releases from New Melones reservoir that are currently made to meet D-1641 requirements on the San Joaquin River. Decreases in flow may alter the amount of suitable habitat available to certain fish species and life stages.

APPROACH

The modeled changes in flow resulting from the Recirculation project will be evaluated through a two-step process. Preliminary results indicate that flow changes on the Stanislaus River may be small, because compliance with other criteria often drive releases from New Melones Dam. The magnitude of flow changes will be evaluated relative to conditions without the project. If these changes are not substantial, their effects will be described qualitatively. If these flow changes are substantial, then the changes in the amount of physical habitat present will be evaluated using existing flow habitat relationships.

3.2.3.2 Water Quality

Water Temperature

The effects of the DMC recirculation project on flows in the Stanislaus River may also affect water temperatures. Water temperature increases may negatively affect salmonids.

APPROACH

The impacts of the project on water temperature will be assessed using a water temperature model. The model will be used to assess the length of the river that has mean daily and maximum daily temperatures below optimal and sub-optimal levels. The criteria for defining optimal and sub-optimal temperatures will vary by season, based on the salmonid lifestages expected to be present at that time. These optimal and sub-optimal thresholds will be developed by the FTWG.

3.2.3.3 Biology

Salmonid Straying

Straying rates of Chinook salmon and steelhead using the Stanislaus River would be affected primarily in the Delta and would be evaluated through that evaluation. As the Stanislaus enters the San Joaquin River just upstream of Vernalis, there would be minimal likelihood of affecting upstream migrant fish once they have entered the San Joaquin River. This effect would occur if the contribution of Stanislaus River water to the San Joaquin River total flow was substantially reduced. Once these fish enter the Stanislaus River, there would be no difference in source water or olfactory clues as a result of project operations. For downstream migrants, the issues would be the same as those discussed for the San Joaquin River.

3.3 Significance Criteria

3.3.1 Sacramento-San Joaquin Delta

3.3.1.1 Hydrology/Hydrodynamics

Reverse Flows

The project could potentially result in an increase in reverse flows in Old and Middle rivers as a consequence of export increases. Reverse flows may adversely affect fish in the Delta. The frequency and magnitude of reverse flows under the project alternatives will be evaluated in relation to without project conditions based on the following criteria. These criteria are based on the recommendations in the Pelagic Fish Action Plan (DWR and CDFG 2007) and on discussions with the FTWG.

- During January 1 through February 15, an increase in the frequency of upstream (reverse) flows greater than 4,000 cfs would be considered significant.
- During January through April 15, positive downstream flow through Old and Middle River should be maintained and any increase in upstream (reverse) flows would be considered significant.

Delta Outflow

Delta outflow is linked to ecosystem health and has historically been related to the abundance of several species. Generally speaking, increases in Delta outflow would be considered beneficial, while decreases would be considered adverse. To evaluate project effects on Delta outflow, Delta outflow will be tabulated by month and water year type and compared to without project conditions. A 10 percent change in outflow was established as a threshold level, based on the error inherent in standard hydrologic measurements (Hirsh and Costa 2004, Gordon et al. 1992) and in the modeling process, which only approximates actual operations. Significance will be considered as follows:

- A reduction in Delta Outflow of more than 10 percent, occurring with a frequency of more than 10 percent during any month would be considered a significant adverse impact.
- An increase in Delta Outflow of more than 10 percent, occurring with a frequency of more than 10 percent during any month would be considered a significant benefit.
- A change in Delta outflow of less than 10 percent, or occurring less than 10 percent of the time during any month, would be considered less than significant.

X2 Location

The location of X2 is an indication of habitat quality for Delta fishes. The CVP and SWP will be operated to meet these criteria under any alternative. For this evaluation, the DMC recirculation project will be compared to without project, conditions during each month by water year type. In each of these comparisons, a 0.5 km significance threshold was applied following that used in the USFWS OCAP BO (USFWS 2005). In each of these comparisons, the following criteria will be used to determine significance:

- If an Alternative causes X2 to shift more than 0.5 km to the east in any month, the impact will be considered a significant adverse effect.
- If an Alternative causes X2 to shift more than 0.5 km to the west in any month, the impact will be considered a significant beneficial effect.
- A shift in X2 location of less than 0.5 km in any month will be considered a less than significant effect.

3.3.1.2 Water Quality

Salinity will be addressed through the evaluation of X2 location, as previously described. Water temperature is not expected to be affected and will not be evaluated within the Delta. Dissolved oxygen in the DWSC will be qualitatively assessed through comparison of flow levels with flow-dissolved oxygen relationships, providing a comparison of the relative effect of the different alternatives on this parameter. It is recognized that other factors, such as nutrient concentrations and algal blooms, also affect dissolved oxygen concentrations in the DWSC, however the project would not directly affect these parameters and adequate models are not available to address these factors. Pollutants will be evaluated in the water quality evaluation. The biological implications of any problems noted will be discussed qualitatively in the fisheries evaluation.

3.3.1.3 Biological

Entrainment Index at the CVP and SWP Facilities

Export amounts will be evaluated to calculate an entrainment index for each species of concern for which reliable data are available, as described in Section 3.2.1.3. Increases in the entrainment index indicate an increase in the total number of that species potentially lost to entrainment or related causes and are considered adverse. Given the sensitivities of the species involved, a change of 5 percent was selected as a conservative threshold for evaluating impacts, for all species except delta smelt. This level is considered conservative given the uncertainties of the modeling and range of variability in salvage densities recorded at the CVP and SWP facilities (BDAT accessed October 2007). Given the extreme sensitivity of delta smelt, any increase in delta smelt entrainment is considered significant. Entrainment will be evaluated monthly, but the significance criteria will be applied on an annual basis for all species except delta smelt, the significance criteria for entrainment are:

- If the entrainment index increases by 5 percent or more annually in comparison to without project conditions, the impacts would be considered significant.
- If the entrainment index decreases by 5 percent or more in comparison to without project conditions, the impact would be considered beneficial.
- If the entrainment index changes by less than 5 percent in comparison to without project conditions, the impact would be considered less than significant.

For delta smelt:

- An increase in delta smelt entrainment in any month would be considered significant.
- A decrease in delta smelt entrainment in any month would be considered beneficial

Salmonid Straying

The potential of the project to increase straying within the Delta will be discussed qualitatively based on changes in the composition of source water at various points along the migration pathway. The analysis will be based on the assumptions that salmon and steelhead are sensitive to a source fraction change as small as 20 percent and will prefer a home stream water composition similar to that which they experienced during juvenile emigration.

3.3.2 San Joaquin River

3.3.2.1 Hydrology

Flow Effects

Recirculation would increase San Joaquin River flows relative to existing conditions. Any increase in San Joaquin River flow would be considered a beneficial impact. These changes will be described qualitatively.

3.3.2.2 Water Quality

Temperature Effects

The project is not expected to result in a significant change in water temperatures in the San Joaquin River. This will be verified using a temperature model. If the DMC recirculation project alternative causes water temperatures at Vernalis to be elevated relative to without project conditions during either the upstream or downstream migration seasons, this could adversely affect fish. This effect would be considered significant if it caused temperatures to cross thresholds between the optimal, suboptimal, and intolerable ranges. These ranges will be determined by the FTWG.

Suspended Sediment Concentrations

Suspended sediment concentrations (SSC) can adversely affect salmonid homing and can cause physiological stress in fish. SSC will be evaluated based on the change in SSC and duration of exposure relative to the baseline conditions. These changes will be evaluated based on the Severity of Ill Effects values (SEV) developed by Newcombe and Jensen (1996). They established four major classes of effects, as indicated by the diagonal lines on Figure 3-1. These major categories are (1) no effect, (2) behavioral effects, (3) sublethal effects, and (4) lethal effects. A change from one of these categories to another would be considered significant.

- If the project causes SEV to increase across the threshold between SEV categories, this would be considered a significant impact.

Pollutants

Pollutants would be evaluated using the standards outlined in the water quality section. If pollutants exceeded the standards described there, then a qualitative discussion of the potential biological impacts of these pollutants will be included in the fisheries section of the EIR/EIS.

3.3.2.3 Biological

Salmonid Straying

Salmonid straying would be evaluated as described in the Delta section. Once fish have entered the San Joaquin River, potential for straying will be qualitatively evaluated based on the source fractions of the water below the confluence of each major tributary. Once fish enter one of the tributary streams, they would no longer be influenced by Sacramento River water, and additional straying would not be expected.

3.3.3 Stanislaus River

3.3.3.1 Hydrology

Flow Effects

If the DMC recirculation project causes flows to decrease within the Stanislaus River enough to reduce the extent of suitable habitat for any life stage of salmon or steelhead then the impact would be considered significant. Preliminary analyses indicate that Stanislaus flows may not change substantially because of other requirements. Therefore, this will be evaluated in a two-step process. The first step would be to look at the change in flow between the project alternatives and the without project conditions. If this change is more than 10 percent, which is the accuracy with which flows can be measured (Hirsh and Costa 2004, Gordon et al. 1992). The second step would be to evaluate the change in physical habitat quantity and quality based on existing flow-habitat relationships for different lifestages of anadromous salmonids. A 20 percent threshold was selected based on the amount of error inherent in stream flow measurements and in the habitat suitability criteria used to generate the physical habitat index.

- A reduction in quantity of available physical habitat of more than 20 percent would be considered a significant adverse impact.
- An increase in quantity of available physical habitat of more than 20 percent would be considered a benefit.

3.3.3.2 Water Quality

Water Temperature

If the DMC recirculation project causes water temperatures to increase or decrease enough to reduce the length of the Stanislaus River with optimal or sub-optimal habitat relative to without project conditions, this would be an adverse impact.

- A decrease in the length of river with optimal temperatures (to be defined by the FTWG) of more than 0.5 km would be significant.
- A decrease in the length of river with sub-optimal temperatures (to be defined by the FTWG) of more than 1.0 km would be significant.

3.3.3.3 Biology

Salmonid Straying

Straying is not expected to be an issue, once fish enter the Stanislaus River. Any straying of Stanislaus River fish would occur in the Delta and these impacts are evaluated there.

4.0 FISHERIES ISSUES FOR CONSIDERATION

It is widely recognized that the most sensitive period for fish in the Delta is the winter and spring months, January through June. Most management actions within the past two decades have been targeted to reduce impacts during this period, recognizing that this is when fish are most vulnerable to entrainment at the CVP and SWP pumps. The majority of the fish species considered in this report have either larval, fry, juvenile or migratory stages in or passing through the Delta within this time frame. The Environmental Water Account, which is intended to minimize entrainment of fish at the CVP and SWP pumps, and in other ways benefit fish in the Delta, generally uses its assets during this season to reduce the volume of water pumped when fish and particularly delta smelt are most vulnerable to entrainment. In 2007 a new strategy was implemented that limited reverse flows in Old and Middle Rivers to be less than 4,000 cfs. This management measure appeared to be successful, in that few delta smelt were entrained at the pumps prior to the shutdown of the pumps in June. However, this apparent success could also be due to extremely low number of delta smelt present in the Delta in 2007. It is also unclear whether this strategy will be successful in all water year types.

The fisheries evaluation criteria developed in consultation with the FTWG reflect the importance of delta smelt in the management of Delta operations and fisheries. These criteria consider any increase in the entrainment index for delta smelt to be a significant adverse impact. This concern is also borne out in recent court decisions (NRDC et al. vs. Kempthorne et al. and others) where courts have ordered reduction and even cessation of exports at the CVP and SWP to protect delta smelt.

Given the sensitivity of delta smelt at this time and for the foreseeable future and the sensitivity of this species during January through June, the DMC recirculation project should avoid any additional pumping during these months.

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