Draft

Attachment 1
Assessment of Fisheries Impacts Within the Sacramento-San Joaquin Delta

Fisheries and Aquatic Ecosystems Technical Report

Shasta Lake Water Resources Investigation

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Contents

Chapter 1 Environmental Setting 1-1

1.1 Historical Factors Affecting the Bay-Delta 1-3
    1.1.1 Delta 1-3
    1.1.2 Suisun Bay 1-3
    1.1.3 San Pablo Bay 1-5
    1.1.4 San Francisco Bay 1-5
1.2 Delta Hydrology 1-5
    1.2.1 History 1-5
    1.2.2 Water Project Development 1-6
1.3 Loss of Wetlands 1-6
1.4 Pollutants 1-7
1.5 Commercial Fishing 1-7
1.6 Introduced Species 1-8
1.7 Salinity 1-10
1.8 Dredging 1-10
1.9 Flood Control Operations 1-11
1.10 Unscreened Diversions 1-11
1.11 Tides and Ocean Conditions 1-11
1.12 Facilities and Operations of the SWP and CVP Within the Delta 1-12
    1.12.1 SWP Delta Facilities 1-12
    1.12.2 CVP Facilities 1-17
1.13 Other Facilities 1-19
1.14 Fisheries and Aquatic Resources 1-19
    1.14.1 Phytoplankton 1-20
    1.14.2 Zooplankton 1-21
    1.14.3 Benthic and Epibenthic Macroinvertebrates 1-22
    1.14.4 Fish 1-24

Chapter 2 Potential Effects of Project Alternatives on Fish Habitat in the Delta 2-1

2.1 Delta Outflow 2-1
2.2 Delta Inflow 2-11
2.3 Sacramento River Inflow 2-20
2.4 San Joaquin River Flow at Vernalis 2-29
2.5 Entrapment Zone Location and X2 2-39
2.6 Old and Middle Rivers Reverse Flows 2-49
2.7 SWP and CVP Export Operations 2-62
2.8 Estimated Fish Entrainment/ Losses 2-83

Chapter 3 References 3-1

Tables

Table 1-1. Fish Species Inhabiting the Delta 1-9
Table 1-2. Status of Fishes of the Sacramento-San Joaquin Delta 1-25
Table 1-2. Status of Fishes of the Sacramento-San Joaquin Delta (contd.) 1-26
Table 2-1. Delta Outflow (cfs) in January, Modeled for Existing Project Alternatives 2-2
Table 2-2. Delta Outflow (cfs) in February, Modeled for Existing Project Alternatives 2-3
Table 2-3. Delta Outflow (cfs) in March, Modeled for Existing Project Alternatives 2-3
Table 2-4. Delta Outflow (cfs) in April, Modeled for Existing Project Alternatives 2-3
Table 2-5. Delta Outflow (cfs) in May, Modeled for Existing Project Alternatives 2-4
Table 2-6. Delta Outflow (cfs) in June, Modeled for Existing Project Alternatives 2-4
Table 2-7. Delta Outflow (cfs) in July, Modeled for Existing Project Alternatives 2-4
Table 2-8. Delta Outflow (cfs) in August, Modeled for Existing Project Alternatives 2-5
Table 2-9. Delta Outflow (cfs) in September, Modeled for Existing Project Alternatives 2-5
Table 2-10. Delta Outflow (cfs) in October, Modeled for Existing Project Alternatives 2-5
Table 2-11. Delta Outflow (cfs) in November, Modeled for Existing Project Alternatives 2-6
Table 2-12. Delta Outflow (cfs) in December, Modeled for Existing Project Alternatives 2-6
Table 2-13. Delta Outflow (cfs) in January, Modeled for Future Project Alternatives 2-6
Table 2-14. Delta Outflow (cfs) in February, Modeled for Future Project Alternatives 2-7
Table 2-15. Delta Outflow (cfs) in March, Modeled for Future Project Alternatives 2-7
Table 2-16. Delta Outflow (cfs) in April, Modeled for Future Project Alternatives 2-7
Table 2-17. Delta Outflow (cfs) in May, Modeled for Future Project Alternatives 2-8
Table 2-18. Delta Outflow (cfs) in June, Modeled for Future Project Alternatives 2-8
Table 2-19. Delta Outflow (cfs) in July, Modeled for Future Project Alternatives 2-8
Table 2-20. Delta Outflow (cfs) in August, Modeled for Future Project Alternatives 2-9
Table 2-21. Delta Outflow (cfs) in September, Modeled for Future Project Alternatives 2-9
Table 2-22. Delta Outflow (cfs) in October, Modeled for Future Project Alternatives 2-9
Table 2-23. Delta Outflow (cfs) in November, Modeled for Future Project Alternatives 2-10
Table 2-24. Delta Outflow (cfs) in December, Modeled for Future Project Alternatives 2-10
Table 2-25. Delta Inflow (cfs) in January, Modeled for Existing Project Alternatives 2-11
Table 2-26. Delta Inflow (cfs) in February, Modeled for Existing Project Alternatives 2-12
Table 2-27. Delta Inflow (cfs) in March, Modeled for Existing Project Alternatives 2-12
Table 2-28. Delta Inflow (cfs) in April, Modeled for Existing Project Alternatives 2-12
Table 2-29. Delta Inflow (cfs) in May, Modeled for Existing Project Alternatives 2-13
Table 2-30. Delta Inflow (cfs) in June, Modeled for Existing Project Alternatives 2-13
Table 2-31. Delta Inflow (cfs) in July, Modeled for Existing Project Alternatives 2-13
Table 2-32. Delta Inflow (cfs) in August, Modeled for Existing Project Alternatives 2-14
Table 2-33. Delta Inflow (cfs) in September, Modeled for Existing Project Alternatives 2-14
Table 2-34. Delta Inflow (cfs) in October, Modeled for Existing Project Alternatives 2-14
Table 2-35. Delta Inflow (cfs) in November, Modeled for Existing Project Alternatives 2-15
Table 2-36. Delta Inflow (cfs) in December, Modeled for Existing Project Alternatives 2-15
Table 2-37. Delta Inflow (cfs) in January, Modeled for Future Project Alternatives 2-15

Table 2-38. Delta Inflow (cfs) in February, Modeled for Future Project Alternatives............. 2-16
Table 2-39. Delta Inflow (cfs) in March, Modeled for Future Project Alternatives................. 2-16
Table 2-40. Delta Inflow (cfs) in April, Modeled for Future Project Alternatives.................... 2-16
Table 2-41. Delta Inflow (cfs) in May, Modeled for Future Project Alternatives..................... 2-17
Table 2-42. Delta Inflow (cfs) in June, Modeled for Future Project Alternatives..................... 2-17
Table 2-43. Delta Inflow (cfs) in July, Modeled for Future Project Alternatives 2-17
Table 2-44. Delta Inflow (cfs) in August, Modeled for Future Project Alternatives................ 2-18
Table 2-45. Delta Inflow (cfs) in September, Modeled for Future Project Alternatives........... 2-18
Table 2-46. Delta Inflow (cfs) in October, Modeled for Future Project Alternatives 2-18
Table 2-47. Delta Inflow (cfs) in November, Modeled for Future Project Alternatives 2-19
Table 2-48. Delta Inflow (cfs) in December, Modeled for Future Project Alternatives........... 2-19
Table 2-49. Sacramento River Inflow (cfs) in January, Modeled for Existing Project Alternatives2-20
Table 2-50. Sacramento River Inflow (cfs) in February, Modeled for Existing Alternatives... 2-21
Table 2-51. Sacramento River Inflow (cfs) in March, Modeled for Existing Project Alternatives2-21
Table 2-52. Sacramento River Inflow (cfs) in April, Modeled for Existing Project Alternatives.. 2-21
Table 2-53. Sacramento River Inflow (cfs) in May, Modeled for Existing Project Alternatives.. 2-22
Table 2-54. Sacramento River Inflow (cfs) in June, Modeled for Existing Project Alternatives.. 2-22
Table 2-55. Sacramento River Inflow (cfs) in July, Modeled for Existing Project Alternatives2-22
Table 2-56. Sacramento River Inflow (cfs) in August, Modeled for Existing Project Alternatives2-23
Table 2-57. Sacramento River Inflow (cfs) in September, Modeled for Existing Project Alternatives.. 2-23
Table 2-58. Sacramento River Inflow (cfs) in October, Modeled for Existing Project Alternatives2-23
Table 2-59. Sacramento River Inflow (cfs) in November, Modeled for Existing Project Alternatives.. 2-24
Table 2-60. Sacramento River Inflow (cfs) in December, Modeled for Existing Project Alternatives.. 2-24
Table 2-61. Sacramento River Inflow (cfs) in January, Modeled for Future Project Alternatives.. 2-24
Table 2-62. Sacramento River Inflow (cfs) in February, Modeled for Future Project Alternatives2-25
Table 2-63. Sacramento River Inflow (cfs) in March, Modeled for Future Project Alternatives.. 2-25
Table 2-64. Sacramento River Inflow (cfs) in April, Modeled for Future Project Alternatives.. 2-25
Table 2-65. Sacramento River Inflow (cfs) in May, Modeled for Future Project Alternatives.. 2-26
Table 2-66. Sacramento River Inflow (cfs) in June, Modeled for Future Project Alternatives.. 2-26
Table 2-67. Sacramento River Inflow (cfs) in July, Modeled for Future Project Alternatives.. 2-26
Table 2-68. Sacramento River Inflow (cfs) in August, Modeled for Future Project Alternatives.. 2-27

Table 2-69. Sacramento River Inflow (cfs) in September, Modeled for Future Project Alternatives 2-27
Table 2-70. Sacramento River Inflow (cfs) in October, Modeled for Future Project Alternatives 2-27
Table 2-71. Sacramento River Inflow (cfs) in November, Modeled for Future Project Alternatives 2-28
Table 2-72. Sacramento River Inflow (cfs) in December, Modeled for Future Project Alternatives2-28
Table 2-73. San Joaquin River Flow (cfs) at Vernalis in January, Modeled for Existing Project Alternatives 2-29
Table 2-74. San Joaquin River Flow (cfs) at Vernalis in February, Modeled for Existing Project Alternatives 2-30
Table 2-75. San Joaquin River Flow (cfs) at Vernalis in March, Modeled for Existing Project Alternatives 2-30
Table 2-76. San Joaquin River Flow (cfs) at Vernalis in April, Modeled for Existing Project Alternatives 2-31
Table 2-77. San Joaquin River Flow (cfs) at Vernalis in May, Modeled for Existing Project Alternatives 2-31
Table 2-78. San Joaquin River Flow (cfs) at Vernalis in June, Modeled for Existing Project Alternatives 2-31
Table 2-79. San Joaquin River Flow (cfs) at Vernalis in July, Modeled for Existing Project Alternatives 2-32
Table 2-80. San Joaquin River Flow (cfs) at Vernalis in August, Modeled for Existing Project Alternatives 2-32
Table 2-81. San Joaquin River Flow (cfs) at Vernalis in September, Modeled for Existing Project Alternatives 2-32
Table 2-82. San Joaquin River Flow (cfs) at Vernalis in October, Modeled for Existing Project Alternatives 2-33
Table 2-83. San Joaquin River Flow (cfs) at Vernalis in November, Modeled for Existing Project Alternatives 2-33
Table 2-84. San Joaquin River Flow (cfs) at Vernalis in December, Modeled for Existing Project Alternatives 2-33
Table 2-85. San Joaquin River Flow (cfs) at Vernalis in January, Modeled for Future Project Alternatives 2-34
Table 2-86. San Joaquin River Flow (cfs) at Vernalis in February, Modeled for Future Project Alternatives 2-34
Table 2-87. San Joaquin River Flow (cfs) at Vernalis in March, Modeled for Future Project Alternatives 2-35
Table 2-88. San Joaquin River Flow (cfs) at Vernalis in April, Modeled for Future Project Alternatives 2-35
Table 2-89. San Joaquin River Flow (cfs) at Vernalis in May, Modeled for Future Project Alternatives 2-35
Table 2-90. San Joaquin River Flow (cfs) at Vernalis in June, Modeled for Future Project Alternatives 2-36

Table 2-91. San Joaquin River Flow (cfs) at Vernalis in July, Modeled for Future Project Alternatives 2-36
Table 2-92. San Joaquin River Flow (cfs) at Vernalis in August, Modeled for Future Project Alternatives 2-36
Table 2-93. San Joaquin River Flow (cfs) at Vernalis in September, Modeled for Future Project Alternatives 2-37
Table 2-94. San Joaquin River Flow (cfs) at Vernalis in October, Modeled for Future Project Alternatives 2-37
Table 2-95. San Joaquin River Flow (cfs) at Vernalis in November, Modeled for Future Project Alternatives 2-37
Table 2-96. San Joaquin River Flow (cfs) at Vernalis in December, Modeled for Future Project Alternatives 2-38
Table 2-97. X2 Location (km) in January, Modeled for Existing Project Alternatives 2-41
Table 2-98. X2 Location (km) in February, Modeled for Existing Project Alternatives 2-41
Table 2-99. X2 Location (km) in March, Modeled for Existing Project Alternatives 2-41
Table 2-100. X2 Location (km) in April, Modeled for Existing Project Alternatives 2-42
Table 2-101. X2 Location (km) in May, Modeled for Existing Project Alternatives 2-42
Table 2-102. X2 Location (km) in June, Modeled for Existing Project Alternatives 2-42
Table 2-103. X2 Location (km) in July, Modeled for Existing Project Alternatives 2-43
Table 2-104. X2 Location (km) in August, Modeled for Existing Project Alternatives 2-43
Table 2-105. X2 Location (km) in September, Modeled for Existing Project Alternatives 2-43
Table 2-106. X2 Location (km) in October, Modeled for Existing Project Alternatives 2-44
Table 2-107. X2 Location (km) in November, Modeled for Existing Project Alternatives 2-44
Table 2-108. X2 Location (km) in December, Modeled for Existing Project Alternatives 2-44
Table 2-109. X2 Location (km) in January, Modeled for Future Project Alternatives 2-45
Table 2-110. X2 Location (km) in February, Modeled for Future Project Alternatives 2-45
Table 2-111. X2 Location (km) in March, Modeled for Future Project Alternatives 2-45
Table 2-112. X2 Location (km) in April, Modeled for Future Project Alternatives 2-46
Table 2-113. X2 Location (km) in May, Modeled for Future Project Alternatives 2-46
Table 2-114. X2 Location (km) in June, Modeled for Future Project Alternatives 2-46
Table 2-115. X2 Location (km) in July, Modeled for Future Project Alternatives 2-47
Table 2-116. X2 Location (km) in August, Modeled for Future Project Alternatives 2-47
Table 2-117. X2 Location (km) in September, Modeled for Future Project Alternatives 2-47
Table 2-118. X2 Location (km) in October, Modeled for Future Project Alternatives 2-48
Table 2-119. X2 Location (km) in November, Modeled for Future Project Alternatives 2-48
Table 2-120. X2 Location (km) in December, Modeled for Future Project Alternatives 2-48
Table 2-121. Old and Middle Rivers Reverse Flows (cfs) in January, Modeled for Existing Project Alternatives 2-50
Table 2-122. Old and Middle Rivers Reverse Flows (cfs) in February, Modeled for Existing Project Alternatives 2-50
Table 2-123. Old and Middle Rivers Reverse Flows (cfs) in March, Modeled for Existing Project Alternatives 2-51
Table 2-124. Old and Middle Rivers Reverse Flows (cfs) in April, Modeled for Existing Project Alternatives 2-51

Table 2-125. Old and Middle Rivers Reverse Flows (cfs) in May, Modeled for Existing Project Alternatives 2-52
Table 2-126. Old and Middle Rivers Reverse Flows (cfs) in June, Modeled for Existing Project Alternatives 2-52
Table 2-127. Old and Middle Rivers Reverse Flows (cfs) in July, Modeled for Existing Project Alternatives 2-53
Table 2-128. Old and Middle Rivers Reverse Flows (cfs) in August, Modeled for Existing Project Alternatives 2-53
Table 2-129. Old and Middle Rivers Reverse Flows (cfs) in September, Modeled for Existing Project Alternatives 2-54
Table 2-130. Old and Middle Rivers Reverse Flows (cfs) in October, Modeled for Existing Project Alternatives 2-54
Table 2-131. Old and Middle Rivers Reverse Flows (cfs) in November, Modeled for Existing Project Alternatives 2-55
Table 2-132. Old and Middle Rivers Reverse Flows (cfs) in December, Modeled for Existing Project Alternatives 2-55
Table 2-133. Old and Middle Rivers Reverse Flows (cfs) in January, Modeled for Future Project Alternatives 2-56
Table 2-134. Old and Middle Rivers Reverse Flows (cfs) in February, Modeled for Future Project Alternatives 2-56
Table 2-135. Old and Middle Rivers Reverse Flows (cfs) in March, Modeled for Future Project Alternatives 2-57
Table 2-136. Old and Middle Rivers Reverse Flows (cfs) in April, Modeled for Future Project Alternatives 2-57
Table 2-137. Old and Middle Rivers Reverse Flows (cfs) in May, Modeled for Future Project Alternatives 2-58
Table 2-138. Old and Middle Rivers Reverse Flows (cfs) in June, Modeled for Future Project Alternatives 2-58
Table 2-139. Old and Middle Rivers Reverse Flows (cfs) in July, Modeled for Future Project Alternatives 2-59
Table 2-140. Old and Middle Rivers Reverse Flows (cfs) in August, Modeled for Future Project Alternatives 2-59
Table 2-141. Old and Middle Rivers Reverse Flows (cfs) in September, Modeled for Future Project Alternatives 2-60
Table 2-142. Old and Middle Rivers Reverse Flows (cfs) in October, Modeled for Future Project Alternatives 2-60
Table 2-143. Old and Middle Rivers Reverse Flows (cfs) in November, Modeled for Future Project Alternatives 2-61
Table 2-144. Old and Middle Rivers Reverse Flows (cfs) in December, Modeled for Future Project Alternatives 2-61
Table 2-145. SWP and CVP Combined Export Flows (acre-feet) in January, Modeled for Existing Project Alternatives 2-71
Table 2-146. SWP and CVP Combined Export Flows (acre-feet) in February, Modeled for Existing Project Alternatives 2-71

Table 2-147. SWP and CVP Combined Export Flows (acre-feet) in March, Modeled for Existing Project Alternatives 2-72
Table 2-148. SWP and CVP Combined Export Flows (acre-feet) in April, Modeled for Existing Project Alternatives 2-72
Table 2-149. SWP and CVP Combined Export Flows (acre-feet) in May, Modeled for Existing Project Alternatives 2-73
Table 2-150. SWP and CVP Combined Export Flows (acre-feet) in June, Modeled for Existing Project Alternatives 2-73
Table 2-151. SWP and CVP Combined Export Flows (acre-feet) in July, Modeled for Existing Project Alternatives 2-74
Table 2-152. SWP and CVP Combined Export Flows (acre-feet) in August, Modeled for Existing Project Alternatives 2-74
Table 2-153. SWP and CVP Combined Export Flows (acre-feet) in September, Modeled for Existing Project Alternatives 2-75
Table 2-154. SWP and CVP Combined Export Flows (acre-feet) in October, Modeled for Existing Project Alternatives 2-75
Table 2-155. SWP and CVP Combined Export Flows (acre-feet) in November, Modeled for Existing Project Alternatives 2-76
Table 2-156. SWP and CVP Combined Export Flows (acre-feet) in December, Modeled for Existing Project Alternatives 2-76
Table 2-157. SWP and CVP Combined Export Flows (acre-feet) in January, Modeled for Future Project Alternatives 2-77
Table 2-158. SWP and CVP Combined Export Flows (acre-feet) in February, Modeled for Future Project Alternatives 2-77
Table 2-159. SWP and CVP Combined Export Flows (acre-feet) in March, Modeled for Future Project Alternatives........ 2-78
Table 2-160. SWP and CVP Combined Export Flows (acre-feet) in April, Modeled for Future Project Alternatives........ 2-78
Table 2-161. SWP and CVP Combined Export Flows (acre-feet) in May, Modeled for Future Project Alternatives........ 2-79
Table 2-162. SWP and CVP Combined Export Flows (acre-feet) in June, Modeled for Future Project Alternatives........ 2-79
Table 2-163. SWP and CVP Combined Export Flows (acre-feet) in July, Modeled for Future Project Alternatives........ 2-80
Table 2-164. SWP and CVP Combined Export Flows (acre-feet) in August, Modeled for Future Project Alternatives 2-80
Table 2-165. SWP and CVP Combined Export Flows (acre-feet) in September, Modeled for Future Project Alternatives 2-81
Table 2-166. SWP and CVP Combined Export Flows (acre-feet) in October, Modeled for Future Project Alternatives 2-81
Table 2-167. SWP and CVP Combined Export Flows (acre-feet) in November, Modeled for Future Project Alternatives 2-82
Table 2-168. SWP and CVP Combined Export Flows (acre-feet) in December, Modeled for Future Project Alternatives 2-82

Table 2-169. Summary of Entrainment Indices for Selected Species under Existing Conditions 2-86
Table 2-169. Summary of Entrainment Indices for Selected Species under Existing Conditions (contd.) 2-87
Table 2-170. Summary of Entrainment Indices for Selected Species under Future Conditions 2-88
Table 2-170. Summary of Entrainment Indices for Selected Species under Future Conditions (contd.) 2-89

Figures

Figure 1-1. The San Francisco Bay and the Sacramento-San Joaquin River Delta..................... 1-4
Figure 1-2. Delta Facilities 1-13
Figure 1-3. Delta Smelt Salvage at the CVP, 2007.. 1-30
Figure 1-4. Delta Smelt Salvage at the SWP, 2007 1-31
Figure 1-5. The Seasonal Occurrence of Different Life Stages of the Four Chinook Salmon Runs1-33
Figure 1-6. Chinook Salmon Salvage at the CVP, 2007... 1-42
Figure 1-7. Chinook Salmon Salvage at the SWP, 2007 1-42
Figure 1-8. Longfin Smelt Salvage at the CVP, 2007 1-43
Figure 1-9. Longfin Smelt Salvage at the SVP, 2007*... 1-44
Figure 1-10. Sacramento Splittail Salvage at the CVP, 2007 1-48
Figure 1-11. Sacramento Splittail Salvage at the SWP, 2007... 1-48
Figure 2-1. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP1 and CP4 2-63
Figure 2-2. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP2 2-64
Figure 2-3. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP3 2-65
Figure 2-4. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP5 2-66
Figure 2-5. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP1 and CP4 2-67
Figure 2-6. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP2....................................... 2-68
Figure 2-7. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP3....................................... 2-69
Figure 2-8. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP5....................................... 2-70

Exhibits

EXHIBIT A SWP and CVP Entrainment/ Modeling Results by Month................................... A-1
EXHIBIT B SWP and CVP Fish Facility Densities Used in Entrainment/Modeling B-1

Abbreviations and Acronyms

°F	degrees Fahrenheit
Bay	San Francisco Bay
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta
CESA	California Endangered Species Act
cfs	cubic foot-per-second
CVP	Central Valley Project
Delta	Sacramento-San Joaquin Delta
CDFG	California Department of Fish and Game
CDFW	California Department of Fish and Wildlife
CE	California endangered
CESA	California Endangered Species Act
cfs	cubic feet per second
CSC	California species of concern
CT	California threatened
DCC	Delta Cross Channel
DSLS	Delta Smelt Larval Survey
DWR	California Department of Water Resources
EFH	Essential Fish Habitat
ESA	Endangered Species Act
FE	Federally endangered
fps	feet per second
FPT	Federal listing as threatened
FSC	Federal species of concern
FT	Federally threatened
km	kilometer
LSZ	Low Salinity Zone
mm	millimeter
NMFS	National Marine Fisheries Service
ppt	part per thousand
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
SWP	State Water Project
USFWS	U.S. Fish and Wildlife Service
YOY	young-of-the-year

Chapter 1
Environmental Setting

The Sacramento-San Joaquin Delta (Delta) and San Francisco Bay (Bay) make up the largest estuary (San Francisco Bay/Sacramento-San Joaquin Delta (Bay-Delta)) on the west coast (EPA 2007). The majority of land in the Delta, which covers approximately 678,200 acres, is irrigated cropland (CALFED 2000). Other terrestrial habitats include *"riparian vegetation, wetlands, and other forms of 'idle land'"* (CALFED 2000). Many factors have contributed to the decline of Delta species, including loss of habitat, contaminant input, entrainment in diversions, and introduction of nonnative species. The Delta is composed of a network of channels through which water, nutrients, and aquatic food resources are moved and mixed by tidal action. Pumps and siphons divert water for Delta irrigation and municipal and industrial use or into Central Valley Project (CVP) and State Water Project (SWP) canals. River inflow, Delta Cross Channel (DCC) operations, and diversions (including agricultural and municipal diversions and export pumping) affect Delta species through changes in habitat conditions (e.g., salinity intrusion), mortality attributable to entrainment in diversions, and mortality associated with mitigation.

Delta habitat is of key importance to fisheries, and includes anadromous, freshwater, brackish water, and saltwater fish and invertebrate species. The Delta provides spawning and nursery habitat for more than 40 resident and anadromous fish species, including delta smelt (*Hypomesus transpacificus*), Sacramento splittail (*Pogonichthys macrolepidotus*), American shad (*Alosa sapidissima*), and striped bass (*Morone saxatilis*). The Delta is also a migration corridor and seasonal rearing habitat for Chinook salmon, all four runs of Chinook salmon (*Oncorhynchus tshawytscha*) and steelhead. (*Oncorhynchus mykiss*). All anadromous fish of the Central Valley either migrate through the Delta to spawn and rear upstream or are dependent on the Delta to provide some critical part of their life cycle.

Delta inflow and outflow are important for species residing primarily in the Delta (e.g., delta smelt and longfin smelt (*Spirinchus thaleichthys*)) (USFWS 1994), as well as juveniles of anadromous species (e.g., Chinook salmon) that rear in the Delta before ocean entry. Seasonal Delta inflows affect several key ecological processes, including: (1) the migration and transport of various life stages of resident and anadromous fishes using the Delta, (2) salinity levels at various locations within the Delta as measured by the location of X2 (i.e., the position in kilometers eastward from the Golden Gate Bridge of the 2 parts-per-thousand (ppt) near-bottom isohaline), and (3) the Delta's primary (phytoplankton) and secondary (zooplankton) production.

The analysis of Delta fish species included as part of this assessment focuses primarily on the following Federal or State-listed species or species of concern:

- Delta smelt (Federally threatened (FT)/California endangered (CE))
- Longfin smelt (Proposed for Federal listing as threatened (FPT)/California threatened (CT))
- Central Valley fall-run Chinook salmon (Federal species of concern (FSC)/California species of concern (CSC))
- Sacramento River winter-run Chinook salmon (Federally endangered (FE)/CE)
- Central Valley spring-run Chinook salmon (FT/CT)
- Central Valley steelhead (FT)
- Sacramento splittail (CSC)
- Green sturgeon (*Acipenser medirostris*) (FT/CSC)

In addition, the assessment also includes consideration of striped bass, which is an important recreational fish species inhabiting the Delta.

The following sections describe the aquatic habitats and fish populations within the Delta. This section is organized into the following components: (1) a description of the Bay-Delta, including historical influences on aquatic resources and the effects of human development and Bay-Delta modification on the Bay-Delta's aquatic resources; (2) descriptions of the status, life history, and factors affecting abundances of selected fish and invertebrate species, focusing on those species having economic importance or those identified as species of concern by the Federal or State government; and (3) a description of principal hydraulic features of the Sacramento and San Joaquin rivers and the Delta that affect aquatic resources, including components of the CVP and SWP.

1.1 Historical Factors Affecting the Bay-Delta

The Bay-Delta is one of the largest estuaries in North America (Figure 1-1). The Bay-Delta serves as a transition between the fresh waters flowing down the Sacramento and San Joaquin rivers and the more saline water intruding from the Pacific Ocean. Therefore, a diverse range of flow regimes and salinities occurs within the Bay-Delta. The Delta, which occupies the upstream portion of the Bay-Delta, is a source of drinking water for about two-thirds of California's population and a source of irrigation water for approximately 2 million acres of agricultural lands. In addition, the Bay-Delta supports an assemblage of aquatic resources of great economic, aesthetic, and scientific value to California and to the nation.

1.1.1 Delta

The Delta's tidally influenced channels and sloughs cover a surface area of approximately 75 square miles. These waters support a number of resident freshwater fish and invertebrate species. The waters are also used as migration corridors and rearing areas for anadromous fish species and as spawning and rearing grounds for many estuarine species. Shallow-water habitats, defined as waters less than 3 meters deep (mean high water), are considered particularly important forage, reproduction, rearing, and refuge areas for numerous fish and invertebrate species.

1.1.2 Suisun Bay

Suisun Bay, which includes Grizzly and Honker bays, is a shallow embayment between the Delta and the eastern end of the Carquinez Strait covering an area of approximately 36 square miles at mean lower low tide. Suisun Marsh, the largest brackish marsh in the United States, is located north of Suisun Bay.

Suisun Bay is characterized by extensive shallow-water habitat, a deep ship channel, and broad seasonal fluctuations in salinity. The extensive shallows in Suisun Bay facilitate high rates of primary production, especially when the entrapment zone (the area where fresh and marine water mix) is located within its boundaries. The entrapment zone lies in Suisun Bay when outflow from the Delta is moderately high. Suisun Bay serves as a migration corridor for anadromous species and is a critical rearing area for both anadromous and estuarine species.

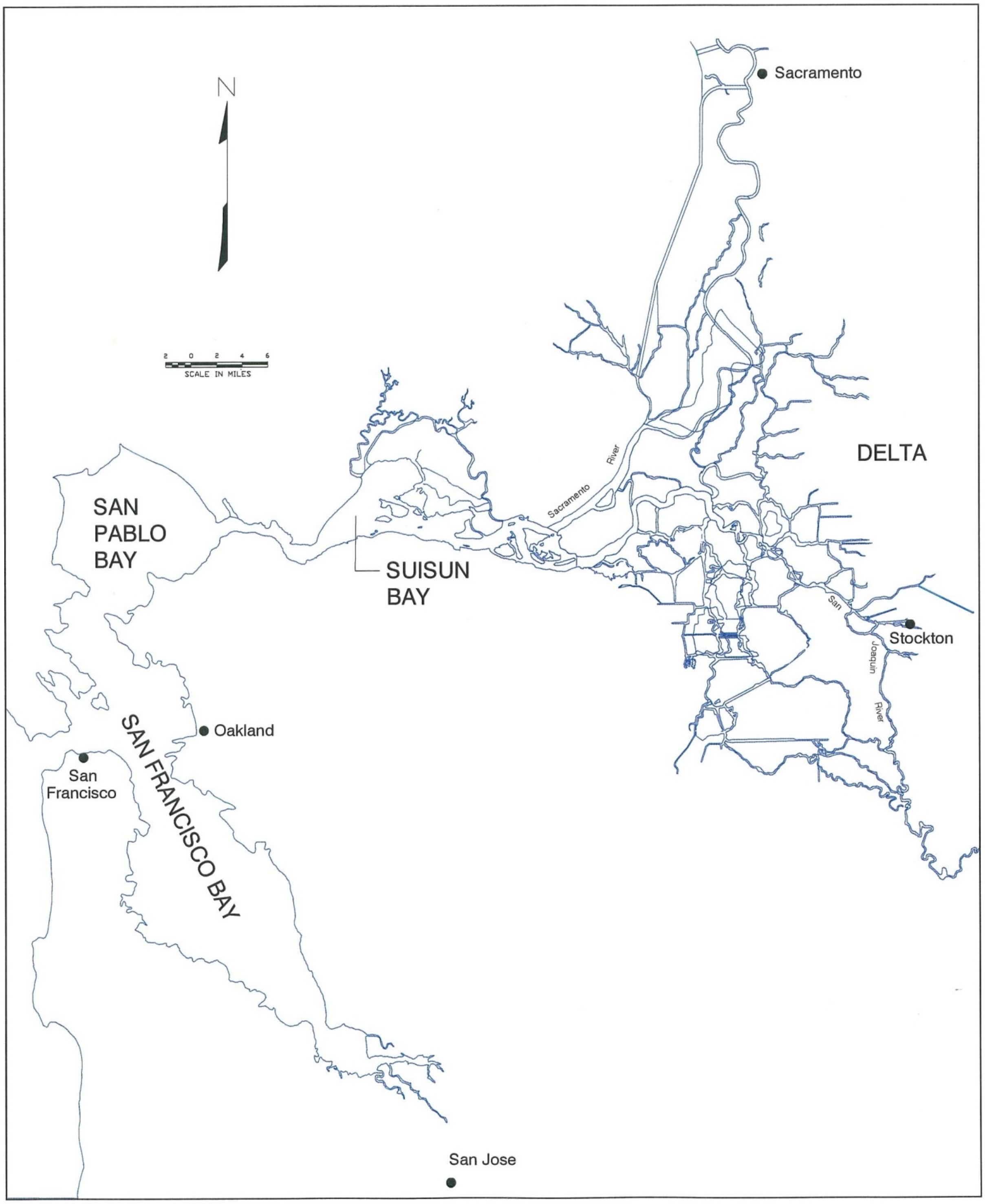


Figure 1-1. The San Francisco Bay and the Sacramento-San Joaquin River Delta

1.1.3 San Pablo Bay

San Pablo Bay is a large, open bay between the western end of the 12-mile-long Carquinez Strait and the northern part of San Francisco Bay. San Pablo Bay encompasses an area of approximately 105 square miles at mean lower low tide.

Except for channelized shipping routes, San Pablo Bay consists mainly of shallow mudflats. Salinities are highly variable, but typically are above 5 ppt. The composition of the aquatic community in San Pablo Bay varies from predominantly marine species to predominantly estuarine species, depending on the volume of freshwater inflows. San Pablo Bay also serves as a migration corridor and rearing area for resident and anadromous species.

1.1.4 San Francisco Bay

San Francisco Bay, which encompasses the Central and South bays, is located south of San Pablo Bay, and extends through the Golden Gate Bridge and to the Pacific Ocean on the west. San Francisco Bay covers an area of approximately 317 square miles at mean lower low tide.

The northern portion (Central Bay) of San Francisco Bay is characterized by relatively deep water with areas of shallow mudflats along its perimeter, while the southern portion (South Bay) is primarily composed of shallow-water habitats. Deep water areas experience high tidal water exchange and strong currents in addition to seasonally high freshwater inflows. San Francisco Bay supports many marine and estuarine species, and serves as a migration corridor for anadromous species.

1.2 Delta Hydrology

1.2.1 History

Human beneficial uses of the Bay-Delta's resources began with the Native Americans who thrived in the area for thousands of years before the arrival of the Europeans. Significant immigration of European-Americans began in 1848 with the discovery of gold on the American River. With the Gold Rush, hordes of newcomers began to harvest fish and wildlife in large numbers (SFEP 1992). During the 1860s, large-scale hydraulic gold mining operations washed mud, silt, sand, and gravel from the foothills down rivers and into the Delta, choking channels and raising the bottom of the Bay-Delta.

By 1860, many settlers had turned to agriculture. Rich Delta soils and Federal laws encouraging wetland reclamation prompted farmers to drain and dike Delta marshes. Eventually, most of the Bay-Delta's wetlands were converted to farming or urban uses. During the late 19th century, many Central Valley ranches and dry-farming lands were converted to irrigated agriculture.

Between 1940 and 1970, the Bay-Delta and its watershed were significantly altered as a result of dams, canals, pumping stations, and other freshwater development and flood control facilities, including the construction and operation of the CVP and SWP (SFEP 1992). These developments changed flow regimes of most Central Valley rivers and the Bay-Delta. Other changes resulted from the elimination or alteration of wetlands, waste discharge and runoff, commercial overfishing and poaching, introduction of nonnative species, increased salinity due to agricultural drainage, dredging of waterways and harbors, flood control operations, entrainment of fish in unscreened diversions, and upstream activities such as logging and livestock grazing.

1.2.2 Water Project Development

California's water resources have been developed through a lengthy and complex process involving private, local, State, and Federal agencies and individuals. This development has provided water supply, flood control, and hydropower as well as improvements to navigable waters. Adverse impacts of water resources development include blocked access of anadromous fish to habitats upstream from dams, alteration or destruction of fish and wildlife habitats, entrainment of young fish at diversions, and changes in water quality and sediment transport regimes.

The development of water storage and delivery systems affecting the Bay-Delta began in the early 1900s in response to flooding problems in the Delta and the Sacramento River Basin, summer salinity problems and associated damages to Delta farm crops, and the need for water in other parts of California. In 1995, approximately 59 major reservoirs with a total storage capacity of about 27 million acre-feet of water were in operation in the Central Valley watershed. Most of these reservoirs are operated for local water supply or for flood control.

Reservoir operations have altered the timing and magnitude of river flows in the Central Valley. Before water was diverted from the Delta, annual runoff into the Bay-Delta ranged from 19 million to 29 million acre-feet (SFEP 1992). Now, about half of the historical flow is diverted by upstream users, Bay Area cities, Delta farmers, and water projects. The water projects store water during the winter and spring months for release later in the year, which reduces the natural flow in April, May, and June and increases the flow in late summer and fall.

1.3 Loss of Wetlands

At one time, nearly two-thirds of the Bay-Delta was covered by tidal marshes. These marshes were a major source of dead plant material for the detrital food chain. The sloughs and channels of tidal marshes were important nursery and feeding areas for fish and shellfish, and the wetlands were important feeding and resting areas for migratory waterfowl (Cohen 1995).

Most of the tidal marshes have been reclaimed, altered, or cut off from the tides by human development. More than 90 percent of the Delta's freshwater wetlands have been diked, drained, and converted to farmland. Of the 300 square miles of brackish and salt marsh in the Bay-Delta, only about 50 square miles remain undiked. About 100 square miles of marsh have been diked, about 60 square miles have been converted to salt ponds, and the remainder has been drained. Sediment influx from hydraulic mining also impacted much of the original wetlands.

The remaining tidal marshes and the diked, managed wetlands of Suisun Marsh are now protected by State and Federal laws. Some piecemeal alteration or destruction of wetlands still occurs, especially in unmanaged wetland areas. Efforts are under way, however, to slow or reverse the loss of wetlands, including a California Department of Water Resources (DWR) program in the west Delta to return Sherman and Twitchell islands to wetland wildlife habitat.

1.4 Pollutants

Pollution in the Bay-Delta originates from the discharge of untreated sewage, industrial wastes, urban and agricultural runoff, and other sources. Since the 1950s, pollution from some municipal and industrial sources has been curtailed, but almost 50 municipal and 140 industrial producers still discharge significant quantities of waste each year, including 300 tons of trace metals (Cohen 1995). Urban runoff contains oil, grease, cadmium, lead, and zinc, while agricultural runoff includes pesticides. Other sources of contamination include dredging operations, atmospheric deposition, accidental spills, discharges from ships and boats, and pollutants leached from landfills.

The effects of toxic pollutants on aquatic organisms vary considerably and are not well understood. Lesions and liver abnormalities have been found in some fishes and invertebrates in the Bay-Delta. The livers of dead striped bass collected near Carquinez Strait have been found to have high levels of toxic chemicals (Brown et al. 1987).

1.5 Commercial Fishing

The first commercial fishery in the Sacramento-San Joaquin Basin appeared about 1850, and consisted of netting Chinook salmon in Central Valley rivers. Commercial fisheries were later founded throughout the Bay-Delta for smelt, starry flounder (*Platichthys stellatus*), Pacific sardine (*Sardinops sagax*), herring (*Clupea pallasi*), and northern anchovy (*Engraulis mordax*). There were few controls over these fisheries, and they soon depleted native species. Settlers responded by introducing new species such as American shad and striped bass. These species supported commercial and recreational fisheries within the Bay-Delta.

Commercial fishing bans within the Bay-Delta were imposed in the first half of this century on white sturgeon (*Acipenser transmontanus*), striped bass, steelhead, and American shad. Chinook salmon continues to support a viable commercial fishery, but only in ocean waters.

1.6 Introduced Species

There have been more than 100 documented introductions of exotic species to the Bay-Delta. These include intentionally introduced game fishes such as striped bass and American shad, as well as inadvertent introductions of undesirable organisms such as the Asian overbite clam and Asiatic clams. Table 1-1 gives common and scientific names for all known native and exotic fish species found in the Delta, including species no longer present (Baxter et al. 1999).

Introduced species generally affect native species adversely because they compete with them for food or living space, either directly or indirectly, or prey on them. For example, the Asian overbite clam, which filters algae and larval zooplankton from the overlying water, has greatly reduced the abundance of zooplankton. Many biologists are concerned that reductions in zooplankton are adversely affecting zooplankton-dependent fishes such as delta smelt, longfin smelt, young stages of salmon, and striped bass.

The inland silverside (*Menidia beryllina*), another species introduced to the Delta, may be a major predator on the larvae and eggs of the delta smelt (Bennett et al. 1995). Striped bass also prey on delta smelt and are probably major predators of juvenile Chinook salmon.

Table 1-1. Fish Species Inhabiting the Delta

Common Name	Scientific Name
Pacific lamprey *	*Lampetra tridentate*
River lamprey *	*Lampetra ayersi*
White sturgeon *	*Acipenser transmontanus*
Green sturgeon *	*Acipenser medirostris*
American shad	*Alosa sapidissima*
Threadfin shad	*Dorosoma petenense*
Central Valley steelhead *	*Oncorhynchus mykiss*
Chum salmon	*Oncorhynchus keta*
Chinook salmon (winter, spring, fall, and late-fall runs) *	*Oncorhynchus tshawytscha*
Longfin smelt *	*Spirinchus thaleichthys*
Delta smelt *	*Hypomesus transpacificus*
Wakasagi	*Hypomesus nipponensis*
Northern anchovy*	*Engraulis mordax*
Pacific sardine*	*Sardinops sagax*
Starry flounder*	*Platichthys stellatus*
Hitch *	*Lavinia exilicauda*
Sacramento blackfish *	*Orthodon microlepidotus*
Sacramento splittail *	*Pogonichthys macrolepidotus*
Hardhead *	*Mylopharodon conocephalus*
Sacramento pikeminnow *	*Ptychocheilus grandis*
Fathead minnow	*Pimephales promelas*
Golden shiner	*Notemigonus chrysoleucas*
Common carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Sacramento sucker *	*Catostomus occidentalis*
Black bullhead	*Ameiurus melas*
Brown bullhead	*Ameiurus nebulosus*
Yellow bullhead	*Ameiurus natalis*
White catfish	*Ameiurus catus*
Channel catfish	*Ictalurus punctatus*
Western mosquitofish	*Gambusia affinis*
Rainwater killfish	*Lucania parva*
Striped bass	*Morone saxatilis*
Inland silverside	*Menidia beryllina*
Bigscale logperch	*Percina macrolepida*
Bluegill	*Lepomis macrochirus*
Redear sunfish	*Lepomis microlophus*
Green sunfish	*Lepomis cyanellus*
Warmouth	*Lepomis gluosus*
White crappie	*Pomoxis annularis*
Black crappie	*Pomoxis nigromaculatus*
Largemouth bass	*Micorpterus salmoides*
Smallmouth bass	*Micropterus dolomieui*
Bigscale logperch	*Percina macrolepida*
Tule perch *	*Hysterocarpus traski*
Threespine stickleback *	*Gasterosteus aculeatus*
Yellowfin goby	*Acanthogobius flavimanus*
Chameleon goby	*Tridentiger trigonocephalus*
Prickly sculpin *	*Cottus asper*

Source: Baxter et al. 1999

Note:

* indicates a native species

1.7 Salinity

Historically during summer months, especially in dry years, salt water intruded far into the Delta (DWR 1987). After the State and Federal water projects were built, freshwater releases from upstream reservoirs helped reduce saltwater intrusion, however, salinity intrusion from the ocean remains a problem, and salts accumulated in agricultural drainage have increased salinities in the south Delta.

While freshwater inflows to the Delta during the summer months are generally higher than historical flows, winter and spring flows are typically lower because of reservoir storage and flood control. The lower inflows during the winter and spring lead to higher salinities in areas such as Suisun Bay and the western Delta, which are important nursery areas for many estuarine fish species during spring. Elevated salinities reduce growth and survival of young stages of these fish. Salinity intrusion is often particularly severe during spring, when agricultural demand is high, and during dry years.

Agricultural drainage discharged from Delta islands contains dissolved minerals that increase salinities in Delta channels. The salt content of drainage water flowing down the San Joaquin River is relatively high. Use of this water by Delta farmers increases the salinity of the irrigation return flows and further increases the concentration of salts flowing into the Bay-Delta.

Current and future efforts to control the level of salinity in the Bay-Delta focus on fresh water flow adjustments to maintain salinity standards, use of tidal flow barriers, and reductions in agricultural drainage.

1.8 Dredging

For decades, more than 7 million cubic yards of sediment has been dredged each year from the Bay-Delta's harbors and channels, mainly to ensure that waters remain navigable and that channels can carry maximum flood flows. Concerns over dredging revolve around the disturbance and disposal of such a huge quantity of material and the release of toxic chemicals contained in dredged sediments.

Both dredging and the disposal of dredged sediments tend to increase turbidity. Bottom-dwelling organisms can be harmed when they are removed by dredging or buried by disposal of the dredged material. Dredging and disposal are suspected of redistributing toxic pollutants, thereby increasing the contact of these chemicals with fish and other aquatic organisms (SFEP 1992).

1.9 Flood Control Operations

Operating storage facilities for flood control changes the timing and magnitude of flows in an effort to minimize property damage and loss of life. However, dams and other structures built for flood control can block fish migration pathways and access to spawning and rearing habitat. Such structures can also prevent replenishment of spawning gravels and reduce the frequency of flushing flows that remove silt from existing gravels. Flood control has diminished fish habitat by removing woody debris and riparian vegetation and by riprapping river banks.

1.10 Unscreened Diversions

Unscreened diversions may be responsible for entraining significant numbers of juvenile fish. There are more than 300 unscreened diversions on the Sacramento River and more than 1,800 in the Delta (CDFG 1998). These diversions primarily provide irrigation water for agriculture; in the summer growing season, they can divert roughly one-quarter of the freshwater inflow into the Delta. Some of these diversions are known to entrain larval and juvenile fish, and many studies have been conducted in an effort to quantify numbers entrained, although no conclusions have been made (Nobriga et al. 2004).

In recent years, efforts to screen many of these diversions have been undertaken, frequently as a result of actions taken under Federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA). California law requires fish screens on all new diversions and existing diversions that are relocated. Requirements are being proposed by various agencies to screen existing diversions, especially those diversions known to entrain the most fish. Other agencies propose to allow relocating diversion intakes and restricting diversion times as alternatives to expensive screening retrofits.

Fish losses also occur at the SWP and CVP diversions and louvered fish salvage facilities located in the south Delta. These losses are discussed below in Section 1.12.

1.11 Tides and Ocean Conditions

The Bay-Delta is influenced by two high tides and two low tides that pulse in and out of the Golden Gate within a 24.8-hour cycle. Tidal influences reach far inland to the rivers of the Delta. During each tidal cycle, an enormous volume of saltwater is moved in and out of the Bay-Delta due to tidal processes. The average water volume that moves during a tidal cycle is about 1,250,000 acre-feet, nearly one-fourth of the Bay-Delta's total volume, which compares to the

50,000 acre-feet average daily flow of fresh water into the Bay-Delta. The mixing of salt water and fresh water creates an estuarine transition zone (referred to as the entrapment zone), where suspended materials are concentrated. The entrapment zone apparently enhances food availability for a number of fish and invertebrate species. The zone moves up and down the Bay-Delta 2 to 6 miles, twice each day, with the tides.

Large fluctuations in oceanic conditions occur during El Niño events, when the influx of warmer tropical water overwhelms normal circulation patterns. These changes result in reduced upwelling and, therefore, decreased plankton productivity. Survival of the young of most fish species is strongly affected by plankton productivity (Lasker 1981). Thus, annual variations in oceanic conditions, particularly upwelling, are thought to influence recruitment success in a number of marine and anadromous fish species (Herbold et al. 1992). Pacific herring, a major salmon food source, declined significantly under past El Niño conditions.

1.12 Facilities and Operations of the SWP and CVP Within the Delta

1.12.1 SWP Delta Facilities

SWP facilities in the Delta include the North Bay Aqueduct, Clifton Court Forebay, John E. Skinner Delta Fish Protective Facility, Harvey O. Banks Delta Pumping Plant, and the intake channel to the pumping plant (Figure 1-2). The North Bay Aqueduct would be unaffected by the preferred program alternative and, therefore, is not discussed further. Banks Pumping Plant provides the initial lift of water from sea level to elevation 244 feet at the beginning of the California Aqueduct. An open intake channel conveys water to Banks Pumping Plant from Clifton Court Forebay. The forebay provides storage for off-peak pumping and permits regulation of flows into the pumping plant. All water arriving at Banks Pumping Plant flows first through the primary intake channel of the John E. Skinner Delta Fish Protective Facility. Louvers located within the intake channel direct fish into bypass openings leading into the salvage facilities. The main purpose of the fish facility is to reduce the number of fish lost from the Delta (fish collected in the fish salvage facilities are subsequently trucked and released into the Delta) and the amount of floating debris conveyed to the pumps.

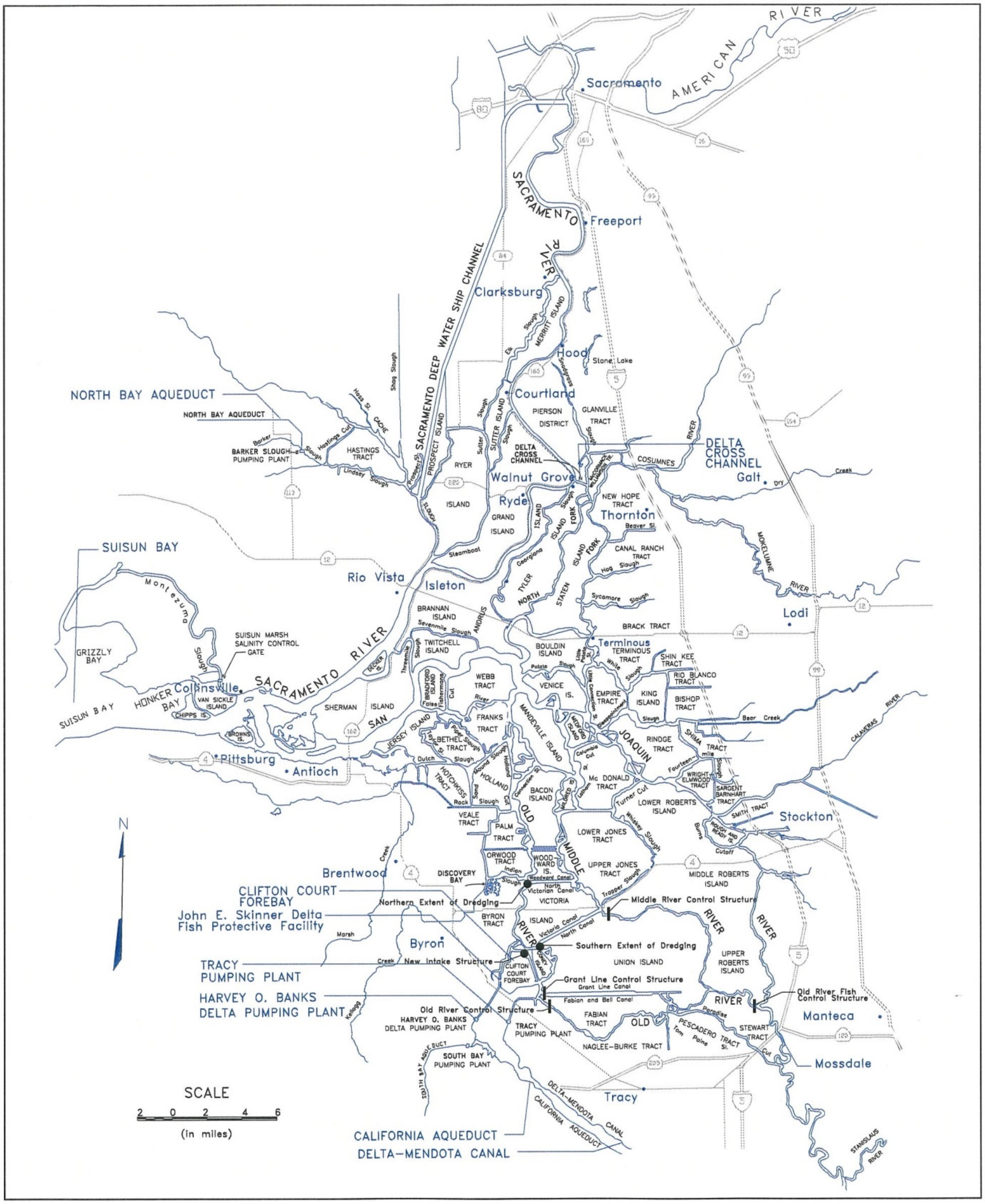


Figure 1-2. Delta Facilities

Clifton Court Forebay

Clifton Court Forebay serves as a regulating reservoir providing reliability and flexibility for the water pumping operations at the Banks Pumping Plant (DWR and Reclamation 1994). The forebay has a maximum total capacity of 31 thousand acre-feet. Five radial gates are opened during a high tide to allow the reservoir to fill, and are closed during a low tide to retain water that supplies the pumps.

When the gates are open at high tide, inflow can be as high as 15,000 cubic feet per second (cfs) for a short time, decreasing as water levels inside and outside the forebay reach equilibrium. This flow corresponds to a velocity of about 2 feet per second (fps) or more in the primary intake channel. Velocities decrease as water levels in the intake channel and forebay approach equilibrium. Starting in May 1994, gate operation patterns were adjusted to reduce entrainment of delta smelt into the forebay.

Fish that enter Clifton Court Forebay may take up residence in the forebay. Once in the forebay, fish may be eaten by other fish or taken by anglers (pre-screening losses); entrained by the pumps at the Banks Pumping Plant (direct losses); impinged on the fish screens at the Skinner Fish Protection Facility (direct loss); or bypassed and salvaged at the Skinner Fish Protection Facility (salvage). The California Department of Fish and Wildlife (CDFW formerly known as California Department of Fish and Game [CDFG]) views predation on fish entrained into the forebay as a concern insofar as it may exceed natural predation in Delta channels.

Juvenile salmon, juvenile striped bass, and other species entrained into the forebay are exposed to high levels of predation before they can be salvaged at the Skinner Fish Protection Facility (DWR and Reclamation 1994). CDFW and DWR have conducted studies to assess the loss rate of juvenile salmon, steelhead, and striped bass that cross the forebay (Schaffter 1978; Hall 1980; Brown and Greene 1992, DWR 2009). The operation of the existing radial gates entrains fish along with water into Clifton Court Forebay. The existing intake structure and gates are believed to provide cover and a feeding station for predators. Predation losses have been estimated to be very high. Based on studies of marked juvenile salmon released at the radial gates, estimates of the survival of fall-run juvenile Chinook salmon traversing the forebay range from 2 to 37 percent.

The losses for both striped bass and salmon are attributed to predation. Subadult striped bass are the major fish predator in Clifton Court Forebay. These fish were most abundant near the radial gates during winter and spring, when small fish may be particularly vulnerable. Predators have been periodically removed from the forebay and released in the Delta.

Loss rates of other fish species of concern, such as delta smelt, cannot be assessed accurately at this time. However, estimated salvage rates are discussed below.

John E. Skinner Fish Facility

The John E. Skinner Fish Facility includes primary and secondary fish screens designed to guide fish to bypass and salvage facilities before they are drawn into the Banks Pumping Plant (Brown and Greene 1992). The primary fish screens are composed of a series of V-shaped bays containing louver systems resembling venetian blinds that act as a behavioral barrier to fish. The secondary fish screen is a perforated plate, positive-pressure screen that excludes fish greater than about 20 millimeters (mm) in length. Salvaged fish are transported in trucks to one of several Delta release sites. Despite recent improvements in salvage operations, survival of species that are more sensitive to handling, such as delta smelt, is believed to be low (DWR and Reclamation 1994).

The fish screening and salvage facilities began operating in 1968 (Brown and Greene 1992). In the early 1970s, CDFW and DWR initiated extensive evaluations of the facility that have led to improved performance and reduced fish losses. Most of this effort focused on fall-run Chinook salmon, striped bass, and American shad. Screening efficiency studies have been proposed for delta smelt, but difficulties have arisen because the fish are susceptible to losses during handling. Alternative approaches are being investigated. A direct loss model has been developed by DWR and CDFW to estimate losses based on operations at the SWP south Delta facilities. This model can be used to estimate the effect of changes in operations on salmon, striped bass, and steelhead.

Fish that are not bypassed by the salvage facility may survive passage through the pumps and enter the aqueduct. Fish, including striped bass and resident species, may rear in the canals and downstream reservoirs. These fish support recreational fisheries both in the aqueduct and in downstream reservoirs.

Harvey O. Banks Pumping Plant

The initial Banks Pumping Plant facilities, including seven pumps, were constructed in 1962. The pumping plant was completed in 1992 with the addition of four pumps. The total capacity of these eleven pumps is 10,668 cfs, with two pumps rated at 375 cfs, five at 1,130 cfs, and four at 1,067 cfs. Water is pumped into the California Aqueduct, which extends 444 miles into Southern California.

Total annual exports at the Banks Pumping Plant have increased since construction of the initial facilities. The exports have contributed to changes in flows within and downstream from the Delta. These changes are believed to have directly and indirectly adversely affected many fish and invertebrate species.

Limitations on export pumping are imposed by the State Water Resources Control Board under its authority to issue water rights permits for the SWP. Biological Opinions issued by U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) to protect listed fish species have also constrained export operations. In 2007, litigation in Federal court regarding the protection of delta smelt has resulted in additional restrictions on export operations.

South Delta Temporary Barriers

The Temporary Barriers Project, operated by DWR since 1991, has involved seasonally installing, operating, and removing temporary barriers in channels of the south Delta. The purpose of these barriers is to benefit local agricultural diversions by increasing water levels and circulation and to improve fisheries conditions for up-migrating adult salmon and outmigrating smolts (DWR 1995). The locations and periods of operation of the temporary barriers are as follows: Middle River near Victoria Canal, installed and operated May through September; Old River near Tracy, installed and operated April through September; Grant Line Canal 1/4 mile east of Old River, never installed but planned for June through September; and Old River at head, installed and operated April through mid-June and mid-September through November. Some barriers have not been installed in some years because of varying hydrologic and hydrodynamic conditions, and concerns about endangered species (DWR 1994).

The temporary barriers are constructed of rock and sand stockpiled for reuse when the barriers are removed. During the fall, the barrier on Old River at head is designed to impede outflow from the San Joaquin River to Old River. The additional flow in the San Joaquin River helps maintain adequate dissolved oxygen concentrations for adult salmon migrating upstream (Hayes and Lee 1999). The barrier is notched at the top in the fall to allow passage of salmon migrating up Old River to the San Joaquin River. During spring, the barrier remains partially closed with operable culverts to prevent downstream migrating salmon smolts in the San Joaquin River from entering Old River, with subsequent exposure to SWP, CVP, and agricultural diversions. Several buried 48-inch pipes traverse the other three temporary barriers with flap gates on one end that allows unidirectional flow. These barriers operate by allowing water to flow through the pipes and flap gates during flood tides to fill the upstream channels. During ebb tides, the flap gates close to retain water in the channels. This operation maintains water levels and facilitates agricultural diversion of higher quality water.

The presence of the temporary barriers alters the patterns and volume of flow in south Delta channels. In particular, installation of the Old River barrier prevents San Joaquin River inflow to Old River, causing the SWP and CVP pumps to draw more water from the central Delta via Columbia Cut and Turner Cut. Changes in the south Delta flow patterns affect the distribution and abundance of fishes in the south Delta as well as direct losses to the export facilities. The barriers may also alter survival of fall-run Chinook salmon smolts emigrating from the San Joaquin River and spawning migrations of adult salmon. Since the barriers provide additional cover for fish predators, predation loss of juvenile fish at the barriers is probably increased.

1.12.2 CVP Facilities

The U.S. Department of the Interior, Bureau of Reclamation (Reclamation), operates CVP facilities in the Delta, including the DCC, Jones Pumping Plant, and Tracy Fish Collection Facility.

Jones Pumping Plant

The Jones Pumping Plant is located next to Clifton Court Forebay (Figure 1-2). The Jones Pumping Plant pumps water directly from Old and Middle rivers. Its pumping capacity is 4,600 cfs, which is supplied to the Delta-Mendota Canal.

Tracy Fish Collection Facility

Fish salvage facilities at the Tracy Pumping Plant are composed of a system of primary and secondary louvers (Brown and Greene 1992). Four bypasses placed equidistantly along the screen face direct fish from the primary louvers to a secondary set of louvers, where they are concentrated and bypassed to holding tanks. Salvaged fish are periodically transferred by truck to release points in the Delta.

The Tracy pumps are usually operated continuously, and because water is drawn directly from the Delta, pumping is subject to tidal influence, causing variation in channel velocity and approach velocities to fish screens (Brown and Greene 1992). There has never been a complete field evaluation of the efficiency of the fish protection facility, although fish loss and salvage are monitored closely. CDFW conducted efficiency tests on the primary louver system, which revealed that striped bass longer than 24 mm were effectively screened and bypassed. However, planktonic eggs, larvae, and juveniles less than 24 mm in length received no protection from entrainment (Hallock et al. 1968). The tests also indicated that juvenile Chinook salmon would be effectively screened because they would be greater than 24 mm in length by the time they were exposed to the screens and pumps. Screening efficiency for delta smelt has yet to be determined.

Delta Cross Channel and Georgiana Slough

The DCC near Walnut Grove (Figure 1-2) was constructed in 1951. It conveys Sacramento River water into eastern Delta channels (including the north and south forks of the Mokelumne River) to supply the southern Delta with water for export via CVP and SWP pumps. Flow through the DCC is regulated by two radial gates near the Sacramento River entrance to the channel. The gates can be closed to provide for flood control of interior Delta channels.

Georgiana Slough, a natural, unregulated channel about 1 mile downstream from the DCC, can convey Sacramento River water to the Delta and San Joaquin River. Georgiana Slough is not a component of the CVP, but because of the similarities between Georgiana Slough and the DCC in their effects on flows and on fish, it is logical to discuss these two features together.

Approximately 25 percent to 40 percent of Sacramento River flow enters the central Delta through the DCC when both gates are open. The percentage of flow diverted through the channel increases in response to higher Sacramento flows. During moderate Sacramento River flows, about 16.5 percent of its flow is diverted through Georgiana Slough. The rate of diversion in Georgiana Slough increases when the DCC gates are closed. Thus, roughly 15 percent to 50 percent of the Sacramento River flow is diverted into the central Delta, based on mean monthly DWR estimates. The hydraulic capacities of the DCC and Georgiana Slough physically limit the amount of flow of Sacramento River water that can be conveyed toward the pumping plants in the south Delta. This limitation can result in insufficient flows to meet pumping demand, which results in additional water being drawn from the San Joaquin River. When this "reverse flow" condition occurs, water is drawn from downstream areas upstream toward the pumps from the lower rivers.

The principal fisheries concern with respect to the DCC and Georgiana Slough is that many emigrating juvenile anadromous fish produced in the Sacramento River drainage are shunted into the central and southern Delta. Juvenile Chinook salmon, and probably other species, shunted into the central Delta have lower survival rates than if they continued down the Sacramento River (Kjelson and Brandes 1989). The migration routes through the central Delta to the ocean are longer and less direct than the Sacramento River route, exposing emigrating juvenile fish to greater predation and diversion risks. There are a large number of small, unscreened diversions in the central Delta and in other areas that entrain small fish. Fish that avoid entrainment in the small agricultural diversions may pass into the southern Delta, where they are vulnerable to mortality at the SWP or CVP export facilities. Nearly all the species of special concern are affected by DCC operations, including all races of Chinook salmon, steelhead, American shad, striped bass, and green and white sturgeon. Delta smelt are potentially affected by DCC operations both during upstream migrations by spawning adults and during downstream transport of larvae.

The DCC is not screened. However, the gates of the DCC can be operated to reduce flow from the Sacramento River into the central Delta. The 1995 Water Quality Control Plan calls for closing the gates from February through late May to reduce straying of winter-run Chinook salmon smolts and other fish from the Sacramento River (SWRCB 1995).

Studies have been conducted to coordinate operation of the DCC gates with the abundance of vulnerable life stages of various fish species upstream. Other studies are evaluating measures to reduce diversions of fish through Georgiana Slough.

1.13 Other Facilities

Other major facilities in the Delta that may affect fish include the Contra Costa Diversion Canal, the North Bay Aqueduct, the Pittsburg and Antioch once-through cooling system power plants, the Montezuma Slough Salinity Control Structure, and municipal water diversions. These projects would neither affect nor be affected by the project alternatives and therefore are not included in this discussion.

1.14 Fisheries and Aquatic Resources

The Bay-Delta is a complex estuarine ecosystem, a transition zone between inland sources of freshwater and saltwater from the ocean. Along the salinity gradient extending from the Golden Gate upstream into the central Delta and tributaries, the species composition of the aquatic community changes dramatically, although the basic functional relationships among organisms (e.g., predator-prey) remain similar throughout the system.

The primary energy input to the system is solar radiation, which is used, along with nutrients, by the primary producers (phytoplankton, vascular plants, and macroalgae) to convert inorganic carbon and nutrients to organic matter through photosynthesis. Zooplankton (e.g., copepods, cladocerans, mysid shrimp) feed on the phytoplankton. The vascular plants and macroalgae are grazed on and also produce detritus, which is decomposed by microbes and consumed by detritivores (e.g., polychaete worms, amphipods, cladocerans, and a diverse group of other fish and macroinvertebrates). The primary consumers are in turn preyed upon by secondary consumers, consisting mainly of a variety of invertebrates (polychaete worms, snails, copepods, mysid shrimp, bay shrimp, and crabs) and fishes (delta smelt, threadfin shad (*Dorosoma petenense*) and American shad, gobies (yellowfin goby (*Acanthogobius flavimanus*) and chameleon goby (*Tridentiger trigonocephalus*)), prickly sculpin (*Cottus asper*), juvenile Chinook salmon, and other resident and migratory fish species). These species in turn are preyed on by top consumers, such as fish (striped bass, catfish, sturgeon, largemouth bass (*Micorpterus salmoides*), Sacramento pikeminnow (*Ptychocheilus grandis*)), marine mammals, birds, and man. The role of a species in the food web may be different at different life stages, or it may use various levels of the food web simultaneously.

In the following sections, the major components of the Bay-Delta aquatic community are briefly discussed, including phytoplankton, zooplankton, benthic macroinvertebrates, fish, shrimp, and crabs.

1.14.1 Phytoplankton

Phytoplankton are small photosynthetic plants that form the base of the estuarine food web. They are usually microscopic in size and consist of single cells or chains of cells. Major groups of phytoplankton in the Bay-Delta include diatoms, dinoflagellates, and cryptomonads (Herbold et al. 1992). Phytoplankton are of prime importance to the ecology of the Bay-Delta because of their position at the base of the food web. The seasonal abundance (standing crop) of copepods, cladocerans, and other pelagic herbivores closely follows the seasonal cycle of phytoplankton abundance in the Bay-Delta. Juvenile survival and growth of many fish species, such as striped bass and threadfin shad, depend on the quality and quantity of phytoplankton and/or associated zooplankton available as a direct or indirect food resource within the central Delta and elsewhere.

In the low-salinity and freshwater areas of the Bay-Delta, diatoms are the dominant phytoplankton. Green algae are abundant during winter and spring and may constitute as much as 60 percent to 70 percent of the phytoplankton populations of the Delta and Suisun Bay. Green algae are generally less abundant in the more saline regions of the Bay-Delta, but may be common in the fresh, slowly flowing waters of the interior Delta. The highest abundance of phytoplankton within the Bay-Delta typically occurs within the Suisun Bay freshwater and saltwater mixing zone. Abundance of phytoplankton is typically low during the winter, increasing substantially during the spring and summer months, followed by a reduction in abundance during the fall. Factors affecting the geographic and seasonal distribution of phytoplankton within the Bay-Delta include seasonal patterns of solar radiation, seasonal water temperatures, availability of nutrients, current patterns and residence time, and salinity gradients. Turbidity, suspended sediments, and water depth also affect availability of sunlight and the abundance of phytoplankton within different areas of the Bay-Delta including the shallow open waters of the Delta where sediment resuspension rates and turbidity are typically high.

In the Delta, interannual variability of phytoplankton is largely reflected in the corresponding variability in Delta inflow and outflow. Phytoplankton productivity is dominated by shallow-water shoal productivity, and interannual variability therefore reflects fluctuations in shoal, rather than channel productivity (Herbold et al. 1992). Net water column productivity in the deeper open water areas and channels is almost always negative because of the small portion of the water column in the photic zone, so biomass must be imported from the shallow-water shoal and channel areas. Advective transport, particularly on ebb tide, is an important mechanism for transporting chlorophyll downstream in estuaries, and Delta outflow therefore is a major factor in controlling variability of phytoplankton productivity. Another major process appears to be consumption by benthic herbivores (Lucas et al. 2002) including the recently introduced Asian overbite clam (C*orbula amurensis*) and the freshwater clam (*Corbicula fluminea*), especially during low-flow periods where benthic invertebrates can become established in high enough densities to filter large quantities of water, affecting phytoplankton biomass.

Lehman (1998) discusses the importance of high concentrations of large diatoms (e.g., *Skeletonema costatum, Coscinodiscus spp. and Cyclotella spp.*) that, during the spring in the 1970s, accumulated in the Low Salinity Zone (LSZ) where salinity ranges between 0.6 and 4 ppt in Suisun Bay. This accumulation was considered to be a primary factor in controlling interannual variation in fish populations within the Bay-Delta because it supported zooplankton production. However, since the early 1980s, chlorophyll concentrations and shifts in species composition have occurred throughout the Bay-Delta. A tenfold decrease in chlorophyll concentrations in Suisun Bay has occurred since 1986. This decrease is associated with, and may be the result of, the introduction of the Asian clam. These recent trends have raised questions about the ability of phytoplankton production in the Bay-Delta to support zooplankton production.

1.14.2 Zooplankton

Zooplankton are microscopic and macroscopic animals that are planktonic (free-floating) or weak swimming fish and invertebrates. Some are permanent members of the plankton and are known as holoplankton. Others, such as eggs, larvae, and juveniles of benthic invertebrates and fish, are members of the plankton only during early life stages and are known as meroplankton. A number of zooplankton species have been introduced into the Bay-Delta (Kimmerer 1998) through ballast water discharges from commercial shipping and have impacted native species inhabiting the Bay-Delta.

Zooplankton, the primary consumers within the Bay-Delta, are at the center of the Bay-Delta food web and therefore are not only important to lower trophic levels upon which they feed (phytoplankton, detritus), but also to the higher trophic levels for which they serve as prey (fish and macroinvertebrates). Zooplankton include herbivores, which forage mainly on phytoplankton, and detritivores that feed on detritus and microbes. Zooplankton are primarily suspension feeders. Zooplankton include small macroinvertebrates such as calanoid copepods and cladocerans but also include fish and macroinvertebrate eggs and larvae, including delta smelt larvae, threadfin shad, and striped bass larvae, crabs, and bay shrimp. The abundance and distribution of zooplankton varies substantially within the Bay-Delta in response to seasonal cycles and environmental factors such as salinity gradients and river flow and tidal currents. In the low-salinity regions of Delta, the primary zooplankton are calanoid copepods (*Eurytemora affinis* and *A. clausi*) and the opossum shrimp (*Neomysis mercedis*), which has declined in abundance significantly in recent years. The cladocerans (*Daphnia pulex* and *D. parvula*), and calanoid copepods (*Diaptomus* spp. and *Limnocalanus macrurus*) are the primary zooplankton species occurring within the freshwater portions of the Delta.

Salinity is one of the major factors affecting the distribution and abundance of zooplankton within the Bay-Delta as evidenced by the changes in species composition that occur within various regions of the Bay-Delta. The distribution and abundance of zooplankton is also related to the availability of food. Physical and chemical conditions that promote phytoplankton productivity (warm temperatures, high solar radiation, high nutrients, slow-moving water, low turbidity and suspended sediment concentrations, shallow waters, etc.) indirectly promote the productivity of zooplankton. Water body configuration and bathymetry also affect phytoplankton productivity and, therefore, zooplankton productivity. The shallow areas of Suisun Bay are highly productive, as are many of the shallow slow-moving open and backwater areas further upstream within the Delta. The location of the salt water and freshwater mixing zone during the spring also influences the abundance of both phytoplankton and zooplankton within the Bay-Delta. When the mixing zone is located in the shallow portions of Suisun Bay, the abundance of both phytoplankton and zooplankton increases. When the mixing zone is upstream in the deeper channels of the lower Sacramento and lower San Joaquin rivers and Delta in response to reduced freshwater inflow that occurs during drought conditions, productivity and abundance of both phytoplankton and zooplankton is reduced.

Seasonal variations in zooplankton abundance are determined by temperature or photoperiod, seasonal cycles of phytoplankton, and Delta inflow and outflow (Kimmerer 2002a, 2002b). Zooplankton biomass tends to be highest in the Bay-Delta during spring and early summer. The abundance of several important zooplankton species inhabiting the Delta has decreased substantially over the past several decades. The most dramatic change occurred with the introduction of the Asian overbite clam in 1986 (Kimmerer and Orsi 1996). The overbite clam plays a significant role in grazing zooplankton, consuming not only diatoms but also nauplii of the copepod, which is a dominant species in the Bay-Delta, and other holoplanktonic and meroplanktonic invertebrates (Carlton et al. 1990). At the time of the invasion, the copepod (*Pseudodiaptomus forbesi*), the mysid (*Acanthomysis spp*), and amphipods became abundant in the regions formerly occupied by calanoid copepods (Kimmerer and Orsi 1996; Kimmerer et al. 1999). The introduction of nonnative fish and invertebrates has been identified as a major factor affecting the abundance and species composition of zooplankton, and the fish and macroinvertebrate community in general, within the Bay-Delta.

1.14.3 Benthic and Epibenthic Macroinvertebrates

Within the Bay-Delta, benthic macroinvertebrates typically live within the top 12 inches of sediment on the Bay-Delta floor. Epibenthic macroinvertebrates typically live on the sediment surface. Within the Delta, benthic and epibenthic species include bay shrimp, opossum shrimp, amphipods, polychaetes, oligochaetes, and clams. A recently introduced clam species (*C. amurensis*) has rapidly expanded its geographic distribution and abundance within Suisun Bay and the Delta (Thompson and Peterson 1998) and has achieved sufficiently high population abundance that feeding (clams are filter feeders) has significantly altered the abundance of phytoplankton and zooplankton within the Bay-Delta.

Characteristics of the benthic and epibenthic macroinvertebrate community are influenced by a variety of physical and water quality conditions that occur within the Bay-Delta, the most important being flow velocities, substrate characteristics, and salinity gradients (Thompson et al. 2000). As stated in Herbold et al. (1992), the factors most affecting the abundance, composition, and health of the benthic community from year to year are outflow from the Delta, local runoff, and pollution (Nichols and Pamatmat 1988). Lower outflows are associated with lower phytoplankton biomass and hence lower productivity during periods of low flow. High outflows lead to lower salinities, which particularly control the species abundance and composition in shallow areas where animals are exposed to less saline surface water.

Benthic communities in the Bay-Delta have also been influenced by disturbances such as dredging and filling activities. Sediment grain-size distributions show that sandy sediments persist in areas of high current velocities such as the channel areas (Rubin and McCulloch 1979), while finer sediments settle in areas of lower current velocity such as in the shoals and small channels (Krone 1979) and within the shallow open water habitat within the Delta. Benthic and epibenthic invertebrate populations are generally most abundant in areas having reduced water velocities, fine-grained sediments, and relatively stable benthic environments (little sediment resuspension, movement or disturbance, slow rates of accretion or depletion of sediments). In deeper water channels, and high-velocity areas characterized by sand and coarse substrate with substantial daily, seasonal or interannual substrate movement and accretions and depletions, benthic and epibenthic macroinvertebrate communities characteristically have reduced species diversity and abundance.

Many of the more common benthic species that inhabit the Bay-Delta are not native to the region but have been transported and introduced into the Bay-Delta through the discharge of ballast water from commercial ships, or on the shells of oysters brought from the East Coast for commercial farming in the late 19th century (Carlton 1979). Today, more than 40 percent of the individuals comprising the benthic community in a given area of the Bay-Delta can be nonindigenous species (Carlton 1979; Cohen 2000). Many of these introduced species may serve ecological functions similar to native species that they may have displaced; however, some species may be detrimental to the aquatic ecosystem of the Bay-Delta.

All but two of the benthic mollusks (i.e., oysters, clams) inhabiting the Delta are introduced. Within the Delta, one of the dominant mollusks, the Asiatic clam (*Corbicula fluminea*), is intolerant of saline waters.

Unlike the mollusks, the epibenthic crustaceans (e.g., crabs and shrimp) inhabiting the Delta are still made up of many native species, particularly bay shrimp (*Crangon spp.*). The smaller epibenthic fauna in the Bay-Delta are dominated by four species of shrimp commonly called bay shrimp (*Crangon franciscorum* – California bay shrimp, *C. nigricauda* – blacktail bay shrimp, *C. nigromaculata* – blackspotted bay shrimp, and *Palaemon macrodactylus*). The California bay shrimp are most abundant in lower salinities, blacktail bay shrimp prefer salinities of 25 ppt or more, and blackspotted bay shrimp are seldom found at salinities below 30 ppt (Baxter et al. 1999). The blackspotted bay shrimp, introduced from Korea, is found only in the upper Bay-Delta, particularly Suisun Bay. All three *Crangon* shrimps show responses to flow patterns, where the mechanism appears to be greater transport of post-larval shrimp into the Bay-Delta by bottom currents in years of high freshwater outflow. Crabs inhabiting the Delta are dominated by the introduced Chinese mitten crab (Veldhuizen and Messer 2001).

Processes that regulate the abundance and distribution of benthic communities also affect the colonization of the bottom after disturbances, such as modifying or removing habitat by dredging, or sediment disposal. Patterns of reproduction and the availability of colonists can also have a profound effect on benthic community recovery. Polychaete worms, bivalve mollusks, crabs and shrimp recruit by small larval stages that can be planktonic and capable of dispersal over large geographic areas, or by larger crawl-away larvae that remain near the bottom and the adult habitat. Amphipods and other similar crustaceans brood their young until they are small juveniles that disperse much like crawl-away larvae. In some species, the adults are the dispersal stage and the first colonists after disturbance. Benthic macroinvertebrates typically have high fecundity and dispersal mechanisms that facilitate colonization of habitat within the estuarine environment.

1.14.4 Fish

Fish species use the Bay-Delta for any or all of their life history stages. They may have planktonic, epibenthic (demersal), and pelagic (open water) life histories. The majority of fish species (e.g., delta smelt, threadfin shad, striped bass, gobies) inhabiting the Bay-Delta have planktonic larval stages; as plankton they feed on zooplankton and in some cases phytoplankton (Wang 1986). Many of these species forage on plankton during the larval and early juvenile life stages, and then as juveniles and adults become more selective predators and feed on large invertebrates and fish. Demersal fish such as sturgeon, gobies, sculpin, and striped bass, are planktivorous as larvae but begin to feed on epibenthic invertebrates and fish as juveniles. Many smaller fish including delta smelt and threadfin shad are planktivorous throughout their lives (Wang 1986, Moyle 2002).

Some estuarine fish do not rely on plankton as a major food source at any life stage. The live-bearing tule perch (*Hysterocarpus traski*), for example, predominantly feed on epibenthic invertebrates, such as mollusks, crustaceans, and polychaetes throughout their life. Sturgeon feed on benthic and epibenthic invertebrates by shoveling through the substrate, and also feed on fish and large invertebrates in the water column. Many freshwater fish such as juvenile Chinook salmon prey primarily on benthic and drifting insect larvae and crustaceans, because zooplankton abundance is low in the swifter flowing freshwater sloughs and rivers.

The abundance and species composition of fish inhabiting the Bay-Delta vary in response to salinity gradients (Baxter et al. 1999). In the low-salinity areas of the central Delta the most abundant taxa include striped bass, American shad, threadfin shad, white catfish, delta smelt, Chinook salmon, and largemouth bass (Table 1-2). Anadromous fish species such as Chinook salmon, steelhead, American shad, striped bass, and sturgeon use the entire estuarine system as a seasonal migration corridor and foraging habitat.

Table 1-2. Status of Fishes of the Sacramento-San Joaquin Delta

Common Name	Scientific Name	Life History	Status
Pacific lamprey*	*Lampetra tridentata*	A	declining
River lamprey*	*Lampetra ayersi*	A	SC
White sturgeon*	*Acipenser transmontanus*	A	declining fishery
Green sturgeon*	*Acipenser medirostris*	A	SC
American shad	*Alosa sapidissima*	A	declining; fishery
Threadfin shad	*Dorosoma petenense*	A	declining; common
Steelhead*	*Oncorhynchus mykiss*	A	FT, SC
Pink salmon*	*Oncorhynchus gorbuscha*	A	SC
Chum salmon*	*Oncorhynchus keta*	A	SC
Coho salmon*	*Oncorhynchus kisutch*	A	ST, FT
Chinook salmon*	*Oncorhynchus tshawytscha*	A	declining fishery
Sacramento			
Fall-run			SC
Late fall-run			SC
Winter-run			FE, SE
Spring-run			FT, ST
San Joaquin			
Fall-Run			rare
Spring run			extinct
Longfin smelt*	*Spirinchus thaleichthys*	A-R	FP, SP
Delta smelt*	*Hypomesus transpacificus*	R	FT, ST
Wakasagi	*Hypomesus nipponensis*	R?	invading
Thicktail chub*	*Gila crassicauda*	R	extinct
Hitch*	*Lavinia exilicauda*	R	unknown
Sacramento blackfish*	*Orthodon microlepidotus*	R	unknown
Sacramento splittail*	*Pogonichthys macrolepidotus*	R	SC,
Hardhead*	*Mylopharodon conocephalus*	N	SC
Sacramento pikeminnow*	*Ptychocheilus grandis*	R	common
Fathead minnow	*Pimephales promelas*	R	rare
Golden shiner	*Notemigonus chrysoleucas*	R?	uncommon
Common carp	*Cyprinus carpio*	R	common
Goldfish	*Carassius auratus*	R	Uncommon
Sacramento sucker*	*Catostomus occidentalis*	R	common
Black bullhead	*Ameiurus melas*	R	common

Table 1-2. Status of Fishes of the Sacramento-San Joaquin Delta (contd.)

Common Name	Scientific Name	Life History	Status
Brown bullhead	*Ameiurus nebulosus*	R	uncommon
Yellow bullhead	*Ameiurus natalis*	R	rare?
White catfish	*Ameiurus catus*	R	decling; abundant
Channel catfish	*Ictalurus punctatus*	R	common
Blue catfish	*Ictalurus furcatus*	R?	rare
Western mosquitofish	*Gambusia affinis*	R	abundant
Rainwater killifish	*Lucania parva*	R?	rare
Striped bass	*Morone saxatilis*	R-A	decling; abundant
Inland silverside	*Menidia beryllina*	R	abundant
Sacramento perch*	*Archoplites interruptus*	R	SC
Bluegill	*Lepomis macrochirus*	R	common
Redear sunfish	*Lepomis microlophus*	R	uncommon
Green sunfish	*Lepomis cyanellus*	R	uncommon
Warmouth	*Lepomis gulosus*	R	uncommon
White crappie	*Pomoxis annularis*	R	common
Black crappie	*Pomoxis nigromaculatus*	R	uncommon
Largemouth bass	*Micropterus salmoides*	R	common
Smallmouth bass	*Micropterus dolomieui*	R	Uncommon
Bigscale logperch	*Percina macrolepida*	R	common
Yellow perch	*Perca flavescens*	N	rare
Tule perch*	*Hysterocarpus traski*	R	declining; common
Threespine stickleback*	*Gasterosteus aculeatus*	R	common
Yellowfin goby	*Acanthogobius flavimanus*	R	declining; common
Chameleon goby	*Tridentiger trigonocephalus*	R	invading
Staghorn sculpin*	*Leptocottus armatus*	M	common
Prickly sculpin*	*Cottus asper*	R	abundant
Starry flounder*	*Platichthys stellatus*	M	declining; common

Notes:
Modified from USFWS 1994
* indicates a native species
Key:
A = anadromous
M = marine
R = resident

Factors affecting the abundance and geographic distribution of fish within the Bay-Delta include water velocities, substrate, salinity gradients, water temperature, and food availability. Many of the fish that inhabit the Bay-Delta reside in coastal marine waters, entering the Bay-Delta on a seasonal basis for foraging or reproduction. The seasonal cycles of fish abundance vary in response to migration patterns, reproductive cycles, foraging patterns, and environmental conditions occurring both within the Bay-Delta and coastal marine waters.

The fish community inhabiting the Bay-Delta is diverse and dynamic (Table 1-1). Abundance of the species may fluctuate substantially within and among years (Baxter et al. 1999) in response to both population dynamics and environmental conditions. Life-history strategies and habitat requirements also vary substantially among species within the fish community. The following sections briefly describe the species composition of the fish community inhabiting the Delta. The primary source of information used to described species composition and seasonal patterns in abundance and geographic distribution for various fish species was the extensive fish monitoring program conducted by CDFW (Baxter et al. 1999), the CDFW 20 mm delta smelt surveys, and results of fish salvage monitoring at the SWP and CVP fish salvage facilities.

Eggs and Larvae

Ichthyoplankton are the egg and larval forms of estuarine fishes. Many species of fish release their eggs into the water column, or larvae are resuspended into the water column after hatching. Larvae initially depend on yolk sac reserves for nutrition, then feed as planktonic forms as they gradually transform from their larval morphology to their juvenile, free-swimming form (nekton). Seasonal abundance and geographic distribution of ichthyoplankton species within the Bay-Delta are dependent on the reproductive cycles of the adults and circulation patterns within the Bay-Delta. Generally, fish larvae are present in the plankton community during peaks of phytoplankton and zooplankton in the winter and spring (Ambler et al. 1985). Common ichthyoplankton present in the Delta include the eggs and larval forms of fish species such as striped bass, longfin smelt, delta smelt, threadfin shad, and gobies (Table 1-2). Delta smelt larvae are most abundant during the spring (March through May) when spawning occurs. The abundance of longfin smelt larvae tends to be highest during late winter (Wang 1986; Baxter et al. 1999). Striped bass eggs and larvae are most abundant from April through June.

Since ichthyoplankton are planktonic and/or weak swimmers (depending on life history stage), they are transported by water currents within various regions of the Bay-Delta. Information is available from extensive fish monitoring studies conducted throughout the Bay-Delta by the CDFW (Baxter et al. 1999; CDFG unpublished 20 mm survey results) and others (Wang 1986) that provide data on the species composition, seasonal and geographic distributions, and densities of ichthyoplankton within the Delta.

Resident and Migratory Fish

A diverse and dynamic assemblage of fish species inhabits the Delta (Tables 1-1 and 1-2). As part of the scientific and technical foundation used to characterize the fish community of the Delta information is needed regarding the species composition, occurrence of species of special concern, geographic distribution, and abundance (density) of species inhabiting the area. The species composition and abundance vary within and among years in response to a variety of environmental and biological factors including variation in delta inflow, tidal currents and hydraulics, salinity, water temperature, and other factors affected in large part by seasonal and interannual variation in freshwater inflow from the Sacramento and San Joaquin river systems, water depth and habitat use. Habitat use includes: seasonal migrations for spawning and emigration, and seasonal usage by various species including threatened and endangered species for reproduction and/or foraging and nursery habitat. The Delta is within the area of the Bay-Delta that has been designated as critical habitat for delta smelt and Central Valley steelhead. The mainstem Sacramento River and lower regions of the Bay-Delta have been identified as critical habitat for winter-run and spring-run Chinook salmon. The San Francisco Bay and Sacramento-San Joaquin River Delta have also been designated as Essential Fish Habitat (EFH) by the NMFS reflecting the importance of the estuarine habitats within the bay for managed fish species. Therefore, a detailed knowledge of the characteristics and the variation in these biological communities is an important component in the environmental analysis of potential impacts resulting from water project operations.

The fisheries survey programs designed and implemented by CDFW (Baxter et al. 1999) are long-term studies, with data collected monthly or more frequently using multiple gear types to sample both juvenile and adult fish and macroinvertebrates. In the past, the fish monitoring program also sampled fish eggs and larvae. The CDFW delta smelt 20 mm surveys, conducted throughout the spring months within the Delta since the early 1990s, provide additional information on the seasonal and geographic distribution of delta smelt larvae within various regions of the Delta. CDFW has also implemented an additional Delta Smelt Larval Survey (DSLS) since the beginning of 2005, in light of historically low delta smelt populations in the Bay-Delta, starting in mid-winter (January/February) with sampling conducted every other week and continuing through early summer (June/July), or until catch efficiency decreases and/or delta smelt are not in danger of being entrained at the CVP and SWP pumps. Detailed data collected as part of SWP and CVP salvage (CDFG and DWR unpublished data) on the density, species composition, and seasonal distribution of fish are also available dating back to the 1950s up to the present.

Delta Smelt

Status Delta smelt are listed as a threatened species under both the ESA and CESA. Delta smelt are endemic to the Bay-Delta. Delta smelt inhabit the freshwater portions of the Delta and Sacramento and San Joaquin rivers and the low-salinity portions of Suisun Bay. Delta smelt typically have a 1-year life cycle, although a small percentage of the adults may live two years. Adult delta smelt migrate upstream into channels and sloughs of the eastern delta during the fall and winter in preparation for spawning. Delta smelt live their entire life cycle within the Delta.

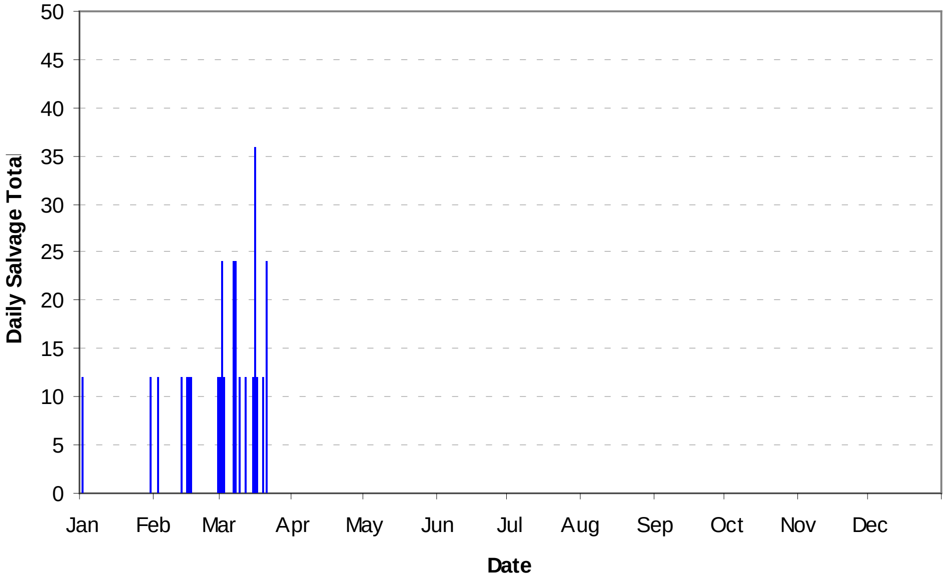
Additional measures have been taken since the beginning of 2005 to aide in determining the magnitude of entrainment at the CVP and SWP intakes, such as the DSLS conducted by CDFW to monitor and provide additional information on delta smelt abundance and distribution in the upper Bay-Delta, and on entrainment at the SWP and CVP pumps.

Life History Delta smelt is a short-lived estuarine species endemic to the Bay-Delta. Adult delta smelt typically range in length from approximately 60 to 70 mm (standard length), although some individuals within the population have been reported to be as large as 100 to 120 mm (Moyle 2002). Juvenile and adult delta smelt typically inhabit open waters of the Delta and Suisun Bay. Delta smelt inhabit shallow-water areas (typically less than 3 meters [9 feet] deep at the lower low water), however juvenile and adult delta smelt are also known to occur within the deeper channel areas (Hanson, unpublished data). Juvenile and adult delta smelt are generally found in the lower reaches of the Sacramento River downstream from Rio Vista, the San Joaquin River downstream from Mossdale, and within Suisun Bay where salinity typically ranges from approximately 2 to 7 ppt.

During the fall and winter, adult delta smelt migrate upstream into the freshwater channels and sloughs of the Delta and lower reaches of the Sacramento and San Joaquin rivers in preparation for spawning. Spawning occurs between January and July; peak spawning occurs during April through mid-May (Moyle 2002). Spawning occurs in shallow edge waters within the Delta channels and sloughs, such as Cash, Lindsay, and Barker sloughs, and the lower reaches of the Sacramento River. Delta smelt have adhesive eggs, which are broadcast over the bottom and other hard substrate, including rocks, woody material, and aquatic vegetation (Wang 1986; Wang, personal communication). Eggs remain attached to the substrate during incubation. After hatching the larval delta smelt drift downstream (planktonic) with river and tidal currents. Larval delta smelt feed on zooplankton during the spring and early summer months. As the larval and early juvenile delta smelt grow they are distributed further downstream within low-salinity habitats of the Delta and Suisun Bay where they continue to rear through the summer and fall months.

Factors Affecting Abundance The delta smelt historically was one of the most common fish in the Sacramento-San Joaquin Estuary. Delta smelt abundance fluctuates greatly from year to year, however, information from seven independent data sets demonstrated a dramatic decline of the delta smelt population and low population levels in recent years (CDFG 2007). Fall abundance of delta smelt is usually higher when low salinities of 2 ppt or less occur in Suisun Bay in the preceding spring. Delta smelt are considered environmentally sensitive because they have a 1-year life cycle, unusually low fecundity for a fish with planktonic larvae, a limited diet, and reside primarily within the interface between salt and freshwater reductions in outflow from the Bay-Delta. CDFW (2007) has identified a number of factors that have contributed to the decline of delta smelt in recent years, including: entrainment to water diversions, extremely high outflow, changes in food organisms, toxic substances, disease, competition, predation, and loss of genetic integrity by hybridization with the introduced Wagasaki (*Hypomesus nipponensis*).

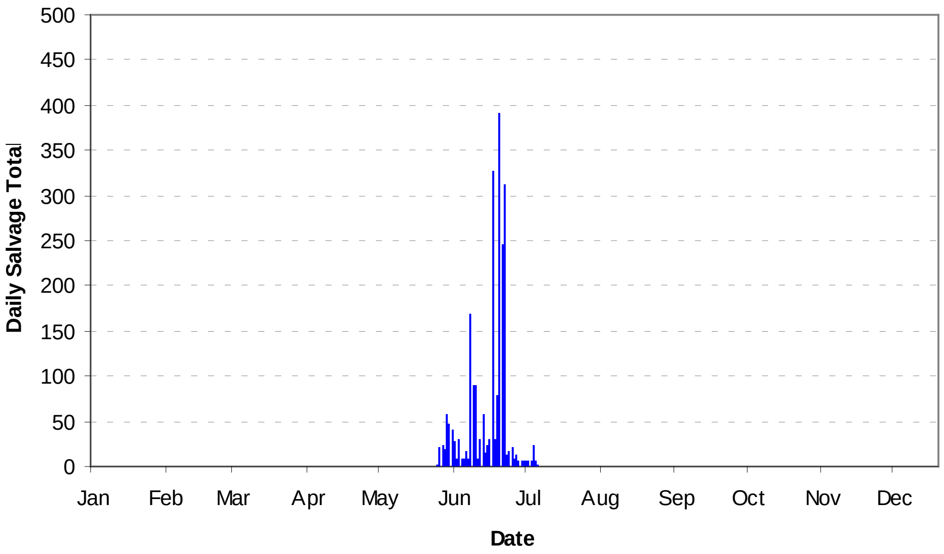
A variety of environmental and biological factors have been identified as affecting the abundance of delta smelt within the Bay-Delta (USFWS 1996, Moyle 2002). These factors include, but are not limited to, changes in the seasonal timing and magnitude of freshwater inflow to the Delta, entrainment of larval, juvenile, and adult delta smelt into a large number of unscreened water diversions located throughout the Delta in addition to entrainment and salvage mortality occurring at the CVP and SWP water export facilities (Figures 1-3 and 1-4) (DWR and Reclamation 1994). In addition, changes in the species composition and abundance of zooplankton, thought to be in response to competition with introduced zooplankton species and increased grazing by introduced fish and macroinvertebrates, affect food availability for delta smelt. Predation by striped bass, largemouth bass, and a number of other fish species inhabiting the Bay-Delta has also been identified as a source of mortality for delta smelt.



Source: DWR 2008

Note: Data through end of November 2007

Figure 1-3. Delta Smelt Salvage at the CVP, 2007



Source: DWR 2008DWR 2008
Note: Data through end of November 2007

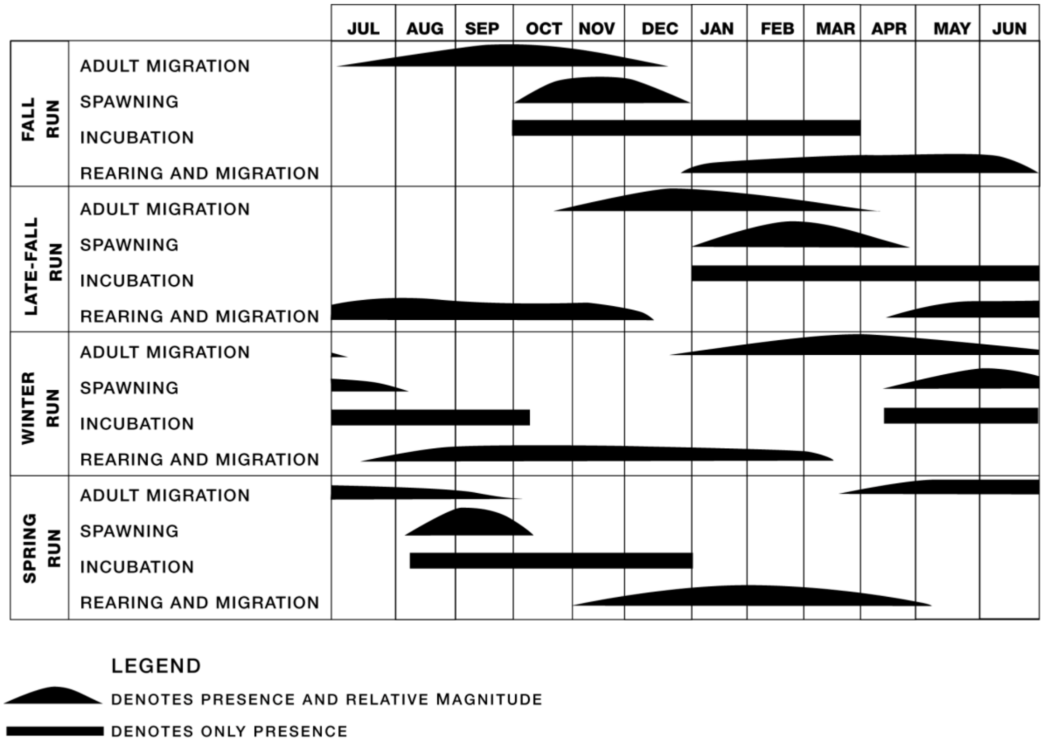
Figure 1-4. Delta Smelt Salvage at the SWP, 2007

Sacramento River Winter-Run Chinook Salmon

Status Sacramento River winter-run Chinook salmon are listed as an endangered species under both the ESA and CESA. NMFS designated critical habitat for Sacramento River winter-run Chinook salmon.

Winter-run Chinook salmon historically migrated into the upper tributaries of the Sacramento River for spawning and juvenile rearing (Hallock 1985). With the construction of Shasta and Keswick dams, winter-run salmon no longer had access to historic spawning habitat within the upper watersheds. As a result of migration blockage, spawning and juvenile rearing habitat for winter-run Chinook is limited to the mainstem Sacramento River downstream from Keswick Dam. During the mid-1960s, adult winter-run Chinook salmon returns to the Sacramento River were relatively high (approximately 80,000 returning adults). However, the population declined substantially during the 1970s and 1980s. The population decline continued until 1991 when the adult winter-run Chinook salmon population returning to Sacramento River was estimated to be less than 200 fish. As a result of the substantial decline in abundance the species was listed as endangered under both the ESA and CESA. During the mid- and late 1990s the numbers of adult winter-run salmon returning to the Sacramento River gradually increased and the trend of increasing abundance continues to present. Approximately 8,200 adult winter-run salmon returned to the river to spawn in 2001, 7,400 adults in 2002, and 8,200 adults in 2003, 7,784 in 2004, 15,730 in 2005, and 17,153 in 2006 (CDFG 2006) As with other Chinook salmon stocks, NMFS is continuing to evaluate the status of the winter-run Chinook salmon population and the effectiveness of various management actions implemented within the Sacramento River, Delta, and ocean to provide improved protection and reduced mortality for winter-run salmon, in addition to providing enhanced habitat quality and availability for spawning in and juvenile rearing. NMFS published a draft recovery plan for winter-run Chinook salmon in 2009 (NMFS 2009).

Life History Winter-run Chinook salmon, are an anadromous species spending 1 to 3 years within the ocean before migrating upstream into the Sacramento River to spawn. The majority of adult winter-run Chinook salmon returning to spawn are 3-year-olds; however, the adult population also includes 2- and 4-year-olds (Hallock 1985). Adult winter-run salmon migrate upstream through San Francisco Bay, Suisun Bay, and the Delta during the winter and early spring months (Figure 1-5) with peak migration occurring during March (Moyle 2002). Adult winter-run Chinook salmon migrate upstream within the Sacramento River with the majority of adults spawning in the reach upstream from Red Bluff. Winter-run Chinook salmon spawn within the mainstem of the Sacramento River in areas where gravel substrate, water temperatures, and water velocities are suitable. Spawning occurs during the spring and summer (mid-April through August) (Moyle 2002). Egg incubation continues through the fall months. Juvenile winter-run Chinook salmon rear within the Sacramento River throughout the year, and feed primarily on aquatic insects. Juvenile winter-run salmon (smolts) migrate downstream through the lower reaches of the Sacramento River, Delta, Suisun Bay, and San Francisco Bay during the winter and early spring (December through May) as they migrate from the freshwater spawning and juvenile rearing areas into the coastal marine waters of the Pacific Ocean (Figure 1-5). The Sacramento River mainstem is the primary upstream and downstream migration corridor for winter-run Chinook salmon. Juvenile winter-run Chinook salmon may migrate from the Sacramento River into the Delta, passing into the Delta through the DCC, Georgiana Slough, or Three Mile Slough, during their downstream migration. The migration timing of juvenile winter-run Chinook salmon varies within and among years in response to a variety of factors including increases in river flow and turbidity resulting from winter storms.



Source: Vogel and Marine 1991

Figure 1-5. The Seasonal Occurrence of Different Life Stages of the Four Chinook Salmon Runs

Factors Affecting Abundance A variety of environmental and biological factors have been identified that affect the abundance, mortality, and population dynamics of winter-run Chinook salmon. One of the primary factors that have affected population abundance of winter-run Chinook salmon has been the loss of access to historic spawning and juvenile rearing habitat within the upper reaches of the Sacramento River and its tributaries as a result of the migration barrier caused by Shasta and Keswick dams (Brandes and McLain 2001). Water temperatures within the mainstem Sacramento River have also been identified as a factor affecting incubating eggs, holding adults, and growth and survival of juvenile winter-run Chinook salmon rearing in the upper Sacramento River (Baker and Morhardt 2002). Modifications to Shasta Reservoir storage and operations and water temperature management have been implemented in recent years to improve water temperature conditions within the upper reaches of the Sacramento River. Juvenile winter-run Chinook salmon are also vulnerable to entrainment at a large number of unscreened water diversions located along the Sacramento River and within the Delta in addition to entrainment and salvage mortality at the SWP and CVP export facilities (DWR and Reclamation 2000). Changes in habitat quality and availability for spawning and juvenile rearing, exposure to contaminants and acid mine drainage, predation mortality by Sacramento pikeminnow, striped bass, largemouth bass, and other predators, and competition and interactions with hatchery-produced Chinook salmon have been identified as factors affecting winter-run Chinook salmon abundance. In addition, subadult and adult winter-run Chinook salmon are vulnerable to recreational and commercial fishing, ocean survival is affected by climatic and oceanographic conditions, and adults are vulnerable to predation mortality by marine mammals (Brandes and McLain 2001).

In recent years a number of changes have been made to improve the survival and habitat conditions for winter-run Chinook salmon. Modifications have been made to reservoir operations for instream flow and temperature management, and several large previously unscreened water diversions have been equipped with positive barrier fish screens. Changes to ocean salmon fishing regulations have also been made to improve the survival of adult winter-run Chinook salmon. Modifications to SWP and CVP export operations have also been made in recent years to improve survival of juvenile salmon during migration through the Delta. These changes in management actions, in combination with favorable hydrologic and oceanographic conditions in recent years, are thought to have contributed to the trend of increasing abundance of adult winter-run Chinook salmon returning to the upper Sacramento River to spawn since the mid-1990s.

Status in the Delta Adult and juvenile winter-run Chinook salmon primarily migrate upstream and downstream within the mainstem Sacramento River. Juvenile winter-run Chinook salmon may migrate from the Sacramento River into the Delta during their downstream migration; the Delta serves as a temporary foraging area and migration pathway during the winter and early spring migration period. The occurrence of juvenile winter-run Chinook salmon within the Delta would be expected to occur during the late fall through early spring when water temperatures within the Delta would be suitable for juvenile winter-run Chinook salmon migration.

Although the majority of adult winter-run Chinook salmon migrate upstream within the mainstem Sacramento River, there is a probability, although low, that adults may migrate into the central Delta. The occurrence of adult winter-run Chinook salmon within the Delta, although expected to be very low, would be limited to the winter and early spring period of adult upstream migration.

Central Valley Spring-Run Chinook Salmon

Status Central Valley spring-run Chinook salmon are listed as a threatened species under both ESA and CESA. NMFS designated critical habitat for spring-run Chinook salmon

Spring-run Chinook salmon were historically widely distributed and abundant within the Sacramento and San Joaquin river systems (Yoshiyama et al. 1998). Spring-run Chinook salmon historically migrated upstream into the upper reaches of the mainstem rivers and tributaries for spawning and juvenile rearing. Construction of major dams and reservoirs on these river systems eliminated access to the upper reaches for spawning and juvenile rearing and completely eliminated the spring-run salmon population from the San Joaquin River system. Spring-run Chinook salmon abundance has declined substantially and the geographic distribution of the species within the Central Valley has also declined substantially. Spring-run spawning and juvenile rearing currently occurs on a consistent basis within only a small fraction of their previous geographic distribution, including populations inhabiting Deer, Mill, and Butte creeks, the mainstem Sacramento River, several other local tributaries on an intermittent basis, and the lower Feather River. Recent genetics studies have shown that spring-run-like Chinook salmon returning to lower Feather River are genetically similar to fall-run Chinook salmon. Hybridization between spring-run and fall-run Chinook salmon, particularly on the Feather River where both stocks are produced within the Feather River hatchery, is a factor affecting the status of the spring-run salmon population. NMFS published a draft recovery plan for Central Valley spring-run Chinook salmon in 2009 (NMFS 2009).

Life History Spring-run Chinook salmon are an anadromous species, spawning in freshwater and spending a portion of their life cycle within the Pacific Ocean. Adult spring-run Chinook salmon migrate upstream into the Sacramento River system during the spring months, but are sexually immature (Fisher 1994). Adult spring-run Chinook salmon hold in deep cold pools within the rivers and tributaries over the summer months before spawning. Spawning occurs during the late summer and early fall (late August through October) in areas characterized by suitable spawning gravels, water temperatures, and water velocities. Eggs incubate within the gravel nests (redds) emerging as fry during the late fall and winter. A portion of fry appear to migrate downstream soon after emerging where they rear within the lower river channels, and potentially within the Delta, during winter and spring months. After emergence a portion of the spring-run Chinook salmon fry remain resident in the creeks and rear for a period of approximately 1 year. The juvenile spring-run Chinook salmon that remain in the creeks migrate downstream as yearlings primarily during the late fall, winter and early spring with peak yearling migration occurring in November (Hill and Webber 1999). The downstream migration of both spring-run Chinook salmon fry and yearlings during the late fall and winter typically coincides with increased flow and turbidity associated with winter stormwater runoff.

Factors Affecting Abundance A variety of environmental and biological factors have been identified that affect the abundance, mortality, and population dynamics of spring-run Chinook salmon. One of the primary factors that have affected population abundance of spring-run Chinook salmon has been the loss of access to historic spawning and juvenile rearing habitat within the upper reaches of the Sacramento River and its tributaries and San Joaquin River as a result of the migration barriers caused by construction of major dams and reservoirs. Water temperatures within the rivers and creeks have also been identified as a factor affecting incubating eggs, holding adults, and growth and survival of juvenile spring-run Chinook salmon. Juvenile spring-run Chinook salmon are also vulnerable to entrainment at a large number of unscreened water diversions located along the Sacramento River and within the Delta in addition to entrainment and salvage mortality at the SWP and CVP export facilities. Changes in habitat quality and availability for spawning and juvenile rearing, exposure to contaminants, predation mortality by Sacramento pikeminnow, striped bass, largemouth bass, and other predators, and competition and interactions with hatchery-produced Chinook salmon have all been identified as factors affecting spring-run Chinook salmon abundance. In addition, sub-adult and adult spring-run Chinook salmon are vulnerable to recreational and commercial fishing, ocean survival is affected by climatic and oceanographic conditions, and adults are vulnerable to predation mortality by marine mammals.

In recent years a number of changes have been made to improve the survival and habitat conditions for spring-run Chinook salmon. Several large, previously unscreened water diversions have been equipped with positive barrier fish screens. Changes to ocean salmon fishing regulations have been made to improve the survival of adult spring-run Chinook salmon. Modifications to SWP and CVP export operations have been made in recent years to improve survival of juvenile Chinook salmon migrating through the Delta. Improvements in fish passage facilities have also been made to improve migration and access to Butte Creek. These changes and management actions, in combination with favorable hydrologic and oceanographic conditions in recent years, are thought to have contributed to the trend of increasing abundance of adult spring-run Chinook salmon returning to spawn in Butte Creek and other habitats within the upper Sacramento River system in recent years.

Status in the Delta Adult and juvenile spring-run Chinook salmon primarily migrate upstream and downstream within the mainstem Sacramento River. Juvenile spring-run Chinook salmon may migrate from the Sacramento River into the Delta during their downstream migration and may also use the Delta as a temporary foraging area and migration pathway during the winter and early spring migration period. The occurrence of juvenile spring-run Chinook salmon within the Delta would be expected to occur during the late fall through early spring when water temperatures within the Delta would be suitable for juvenile spring-run Chinook salmon migration.

Although the majority of adult spring-run Chinook salmon migrate upstream within the mainstem Sacramento River, there is a probability, although low, that adults may migrate into the central Delta. The occurrence of adult spring-run Chinook salmon within the Delta, although expected to be very low, would be limited to the late winter and spring period of adult upstream migration.

Central Valley Steelhead

Status Central Valley steelhead have been listed as a threatened species and critical habitat has been designated under the ESA. Steelhead are not listed for protection under the CESA, but are identified as a species of concern.

Central Valley steelhead historically migrated upstream into the high gradient upper reaches of Central Valley streams and rivers for spawning and juvenile rearing. Construction of dams and impoundments on the majority of Central Valley rivers has created impassable barriers to upstream migration and substantially reduced the geographic distribution of steelhead. Although quantitative estimates of the number of adult steelhead returning to Central Valley streams to spawn are not available, anecdotal information and observations indicate that population abundance is low (NMFS 1996). Steelhead distribution is currently restricted to the mainstem Sacramento River downstream from Keswick Dam, the Feather River downstream from Oroville Dam, the American River downstream from Nimbus Dam, the Mokelumne River downstream from Comanche Dam, Cosumnes River, and a number of smaller tributaries to the Sacramento River system, Delta, and San Francisco Bay. Steelhead have also been reported from tributaries to the San Joaquin River, however the status of these populations is under investigation. Currently, under the San Joaquin River Restoration Program, research is being conducted to test the feasibility of reintroducing spring-run Chinook salmon to the San Joaquin River downstream from Friant Dam.

The Central Valley steelhead population is composed of both naturally spawning steelhead and steelhead produced in hatcheries. NMFS published a draft recovery plan for Central Valley steelhead (NMFS 2009).

Life History Central Valley steelhead, like Chinook salmon, are anadromous. Adult steelhead spawn in freshwater and the juveniles migrate to the Pacific Ocean where they reside for a period of years before returning to the river system to spawn. Steelhead that do not migrate to the ocean, but spend their entire life in freshwater, are known as resident rainbow trout.

Adult steelhead migrate upstream during the fall and winter (September through approximately February) with steelhead migration into the upper Sacramento River typically occurring during the fall and adults migrating into lower tributaries typically during the late fall and winter. Steelhead spawn in areas characterized by clean spawning gravels, cold-water temperatures, and moderately high velocity. Spawning typically occurs during the winter and spring (December through April) with the majority of spawning activity occurring during January and March. Unlike Chinook salmon that die after spawning, adult steelhead may migrate downstream after spawning and return to spawn in subsequent years.

Steelhead spawn by creating a depression in the spawning gravels where eggs are deposited and fertilized (redd). The eggs incubate within the redd for a variable period of time which is dependent upon the water temperature. After hatching, the young steelhead emerge from the gravel redd as fry. Young steelhead rear within the stream system, foraging on insects for 1 to 2 years or longer before migrating to the ocean. After rearing within the stream, the juvenile steelhead undergo a physiological transformation (smolting) that allows the juvenile steelhead to migrate from the freshwater rearing areas downstream to coastal marine waters. Downstream migration of steelhead smolts typically occurs during the late winter and early spring, (January through May), as reflected in the seasonal occurrence in SWP and CVP fish salvage. The seasonal timing of downstream migration of steelhead smolts may vary in response to a variety of environmental and physiological factors including changes in water temperature, changes in stream flow, and increased turbidity resulting from stormwater runoff. The juvenile steelhead rear within the coastal marine waters for approximately 2 to 3 years before returning to their natal stream as spawning adults.

The steelhead life cycle is characterized by a high degree of flexibility (plasticity) in the duration of both their freshwater and marine rearing phases. The steelhead life cycle is adapted to respond to environmental variability in stream hydrology and other environmental conditions.

Factors Affecting Abundance Factors affecting steelhead abundance are similar to those described for winter-run and spring-run Chinook salmon. One of the primary factors affecting population abundance of steelhead has been the loss of access to historic spawning and juvenile rearing habitat within the upper reaches of the Sacramento River and its tributaries and within the San Joaquin River as a result of the migration barriers caused by construction of major dams and reservoirs. Water temperatures within the rivers and creeks, particularly during summer and early fall months, have also been identified as a factor affecting growth and survival of juvenile steelhead. Juvenile steelhead are vulnerable to entrainment at a large number of unscreened water diversions located along the Sacramento River and within the Delta in addition to entrainment and salvage mortality at the SWP and CVP export facilities. Changes in habitat quality and availability for spawning and juvenile rearing, exposure to contaminants, predation mortality, passage barriers and impediments to migration, changes in land use practices, and competition and interactions with hatchery-produced steelhead have all been identified as factors affecting steelhead abundance. Unlike Chinook salmon, steelhead are not vulnerable to recreational and commercial fishing within the ocean, although steelhead support a small inland recreational fishery for hatchery produced fish. Ocean survival is affected by climatic and oceanographic conditions, and adults are vulnerable to predation mortality by marine mammals.

In recent years a number of changes have been made to improve the survival and habitat conditions for steelhead. Several large previously unscreened water diversions have been equipped with positive barrier fish screens. Improvements to fish passage facilities have also been made to improve migration and access to spawning and juvenile rearing habitat.

Status in the Delta Adult and juvenile steelhead primarily migrate upstream and downstream within the mainstem Sacramento River and its tributaries, Mokelumne River, and Cosumnes River. Juvenile steelhead migrate from the upstream spawning and rearing areas through the Delta, Suisun Bay, and San Francisco Bay during the winter and early spring migration period. Steelhead do not spawn within the Delta, however juvenile steelhead may temporarily forage within the Delta during emigration. The occurrence of juvenile steelhead in the Delta would be expected to occur during the winter and early spring migration period when water temperatures within the Delta would be suitable for juvenile steelhead migration.

Pacific Salmon

Status Fall-run Chinook salmon are the most abundant species of Pacific Salmon inhabiting the Sacramento and San Joaquin river systems. Fall-run Chinook salmon are not listed for protection under either the ESA or CESA. In addition to fall-run Chinook salmon the group of Pacific Salmon is composed of late fall-run Chinook salmon (which are not listed under either the ESA or CESA), spring-run Chinook salmon and winter-run Chinook salmon, which are discussed above. Although fall-run and late fall-run Chinook salmon are not listed for protection under the ESA they are included in this analysis since they occur seasonally within the Delta within the area identified as EFH for Pacific salmon.

In 1998, NMFS proposed that Central Valley fall-run and late fall-run Chinook salmon be listed under the ESA as a threatened species. Based upon further analysis and public comment, NMFS decided that fall-run and late fall-run Chinook salmon did not warrant listing but should remain a species of concern.

Although fall-run and late fall-run Chinook salmon inhabit a number of watersheds within the Central Valley for spawning and juvenile rearing, the largest populations occur within the mainstem Sacramento River, Feather River, Yuba River, American River, Mokelumne River, Merced River, Tuolumne River, and Stanislaus River. Fall-run Chinook salmon, in addition to spawning in these river systems, are also produced in fish hatcheries located on the Sacramento River, Feather River, American River, Mokelumne River, and Merced River. Hatchery operations are intended to mitigate for the loss of access to upstream spawning and juvenile rearing habitat resulting from construction of dams and reservoirs within the Central Valley in addition to producing fall-run Chinook salmon as part of the ocean salmon enhancement program to support commercial and recreational ocean salmon fisheries. Fall-run Chinook salmon also support an inland recreational fishery.

Life History Fall-run Chinook salmon are anadromous with spawning and juvenile rearing occurring within freshwater rivers and streams and juvenile and adult rearing occurring within coastal marine waters. Adult fall-run Chinook salmon migrate from the coastal marine waters upstream through San Francisco Bay, Suisun Bay, and the Delta during late summer and early fall (approximately late July through early December). Adult fall-run Chinook salmon migrate upstream to areas characterized by suitable spawning conditions, which include the availability of clean spawning gravels, cold water (considered be less than 56 degrees Fahrenheit (°F)) and relatively high water velocities. Fall-run Chinook salmon spawning is similar to that described for other Chinook salmon with the creation of redds where eggs are deposited and incubate. Fall-run Chinook salmon spawning occurs between October and December, with the greatest spawning activity occurring typically in November and early December.

The success of fall-run Chinook salmon spawning is dependent, in part, upon seasonal water temperatures. After incubating and hatching, the young salmon emerge from the gravel redd as fry. A portion of the fry population migrate downstream soon after emergence, where they rear within the lower river channels, Delta, and Suisun Bay during the spring months (Baker and Morhardt 2002). The remaining portion of juvenile salmon continue to rear in the upstream stream systems through the spring months, until they are physiologically adapted to migration into saltwater (smolting), which typically takes place between April and early June. A small proportion of the fall-run Chinook salmon juveniles may, in some systems, rear through the summer and fall months migrating downstream during the fall, winter, or early spring as yearlings.

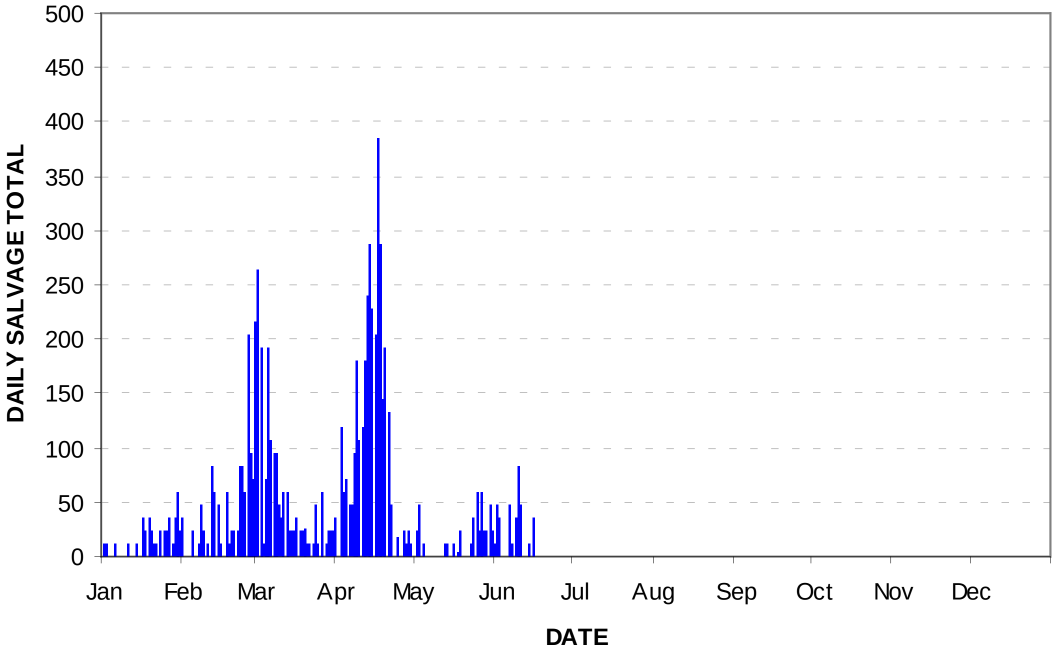
The juvenile and adult Chinook salmon rear within coastal marine waters, foraging on the fish and macroinvertebrates (e.g., northern anchovy, Pacific herring, squid, krill), until they reach maturation. Adult Chinook salmon spawn at ages ranging from approximately 2 to 5 years of age, with the majority of adult fall-run Chinook salmon returning at age three. Chinook salmon, unlike steelhead, die after spawning.

Late fall-run Chinook salmon have a similar life history as described for other Pacific salmon.

Factors Affecting Abundance   A variety of environmental and biological factors have been identified that affect reproductive success, mortality, and population dynamics of fall-run and late fall-run Chinook salmon. The loss of access to historic spawning and juvenile rearing areas as a result of the construction of dams and reservoirs on many of the Central Valley river systems is a factor affecting population abundance. In addition, exposure to seasonal water temperatures during both the upstream migration of adults and downstream migration of juveniles, changes in instream flows resulting from reservoir operations, degradation of the quality and availability of suitable spawning habitat and juvenile rearing areas, and the effects of hatchery operations on Chinook salmon have been identified as important factors affecting abundance. Juvenile Chinook salmon are also susceptible to entrainment at unscreened water diversions, losses resulting from salvage and handling at the SWP and CVP export facilities, and predation mortality by native and nonnative fish species. Interannual variability in hydrologic conditions within the streams and river systems, and variability in ocean rearing conditions, have also been identified as factors affecting reproduction, growth, and survival of Chinook salmon. Concerns also been expressed regarding the effects of contaminant exposure, and impediments and barriers to upstream and downstream migration. Ocean commercial and recreational angler harvest, and inland recreational harvest, has also been identified as factors affecting population abundance.

Management changes have occurred to regulate commercial and recreational angler harvest, improve instream flow conditions, improve water temperature management downstream from reservoirs, improve quality and availability of spawning and juvenile rearing habitat, and improve fish passage facilities at a number of existing migration impediments and barriers. Management changes have also occurred to address concerns regarding contaminant exposure, the success of fish handling and salvage at the SWP and CVP export facilities, and a number of water diversions located on both the Sacramento and San Joaquin river systems have been equipped with positive barrier fish screens designed to reduce or eliminate juvenile Chinook salmon entrainment mortality. These management changes, in combination with favorable hydrology and ocean rearing conditions in recent years, have contributed to an increasing trend in adult fall-run Chinook salmon abundance within the ocean and Central Valley river systems.

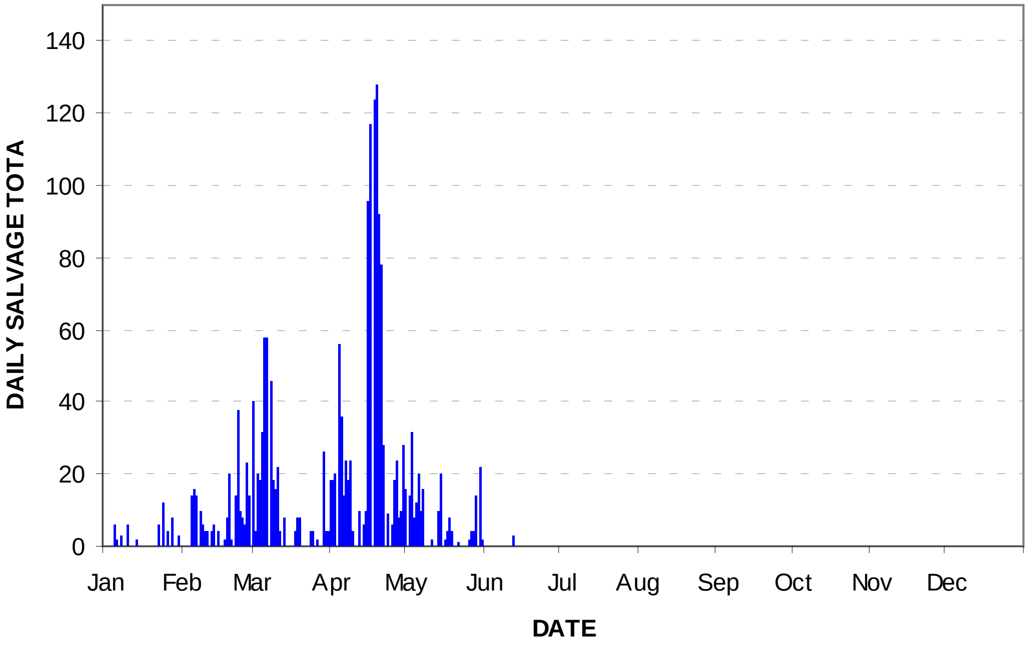
Status in the Delta Adult and juvenile Chinook salmon primarily migrate upstream and downstream within the mainstem Sacramento, San Joaquin, and Mokelumne rivers, and therefore both adult and juvenile Chinook salmon migrate through Delta channels (Baker and Morhardt 2002). Juvenile Chinook salmon, particularly in the fry stage (fish generally 1.5 to 3 inches in length) may rear within the Delta and Suisun Bay, foraging along channel and shoreline margins and lower velocity backwater habitats. The occurrence of juvenile fall-run Chinook salmon within the Delta would be expected to occur during the late winter (fry) through early spring (smolts) when water temperatures within the Delta would be suitable for juvenile Chinook salmon migration (Moyle 2002). The seasonal occurrence of juvenile Chinook salmon (all runs) observed within SWP and CVP fish salvage (Figures 1-6 and 1-7) reflects the seasonal distribution of Pacific salmon. The occurrence of adult fall-run Chinook salmon within the Delta would be in limited to the fall period (primarily September through December) of adult upstream migration.



Source: DWR 2008

Note: Data through end of November 2007

Figure 1-6. Chinook Salmon Salvage at the CVP, 2007



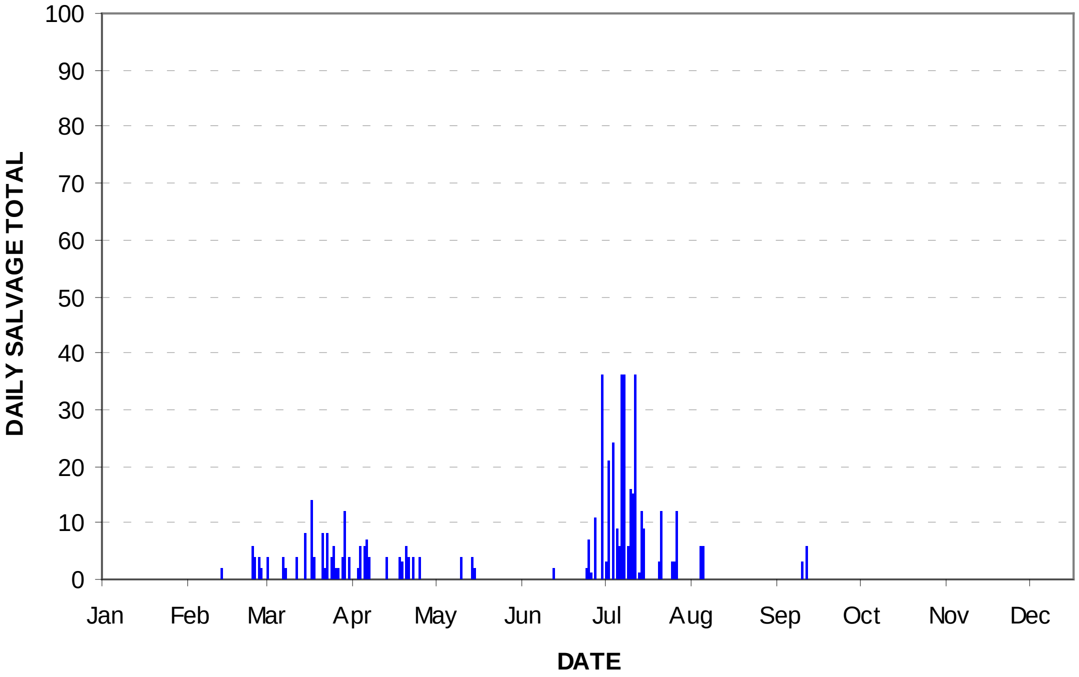
Source: DWR 2008

Note: Data through end of November 2007

Figure 1-7. Chinook Salmon Salvage at the SWP, 2007

Longfin Smelt

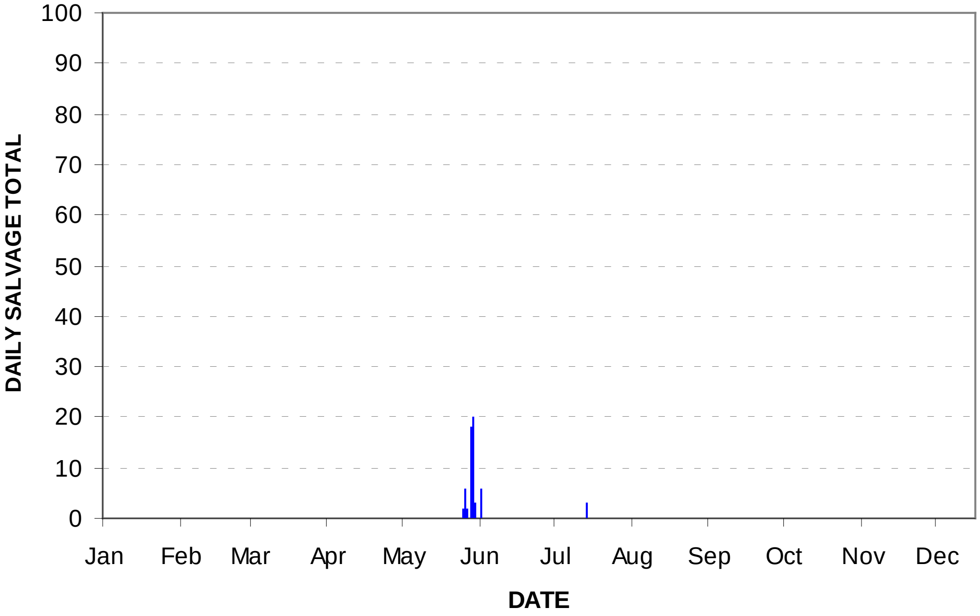
The longfin smelt is a Federal Species of Concern and a State threatened species. The longfin smelt is a small, planktivorous fish found in several Pacific coast estuaries from San Francisco Bay to Prince William Sound, Alaska. Longfin smelt can tolerate a broad range of salinity concentrations, ranging from freshwater to seawater. Spawning occurs in fresh-to-brackish water over sandy-gravel substrates, rocks, or aquatic vegetation. In the Bay-Delta, the longfin smelt life cycle begins with spawning in the lower Sacramento and San Joaquin rivers, the Delta, and freshwater portions of Suisun Bay (Baxter 1996). Spawning may take place as early as November and may extend into June, with the peak spawning period occurring from February to April. The eggs are adhesive and after hatching, the larvae are carried downstream by freshwater river flow to nursery areas in the lower Delta and Suisun and San Pablo bays. Adult longfin smelt are found mainly in Suisun, San Pablo, and San Francisco bays, although their distribution is shifted upstream in years of low outflow (SWRCB 1999). The seasonal occurrence of longfin smelt in SWP and CVP salvage (Figures 1-8 and 1-9) is considered to be representative of the seasonal periods when juvenile and adult longfin smelt would be in the Delta.



Source: DWR 2008

Note: Data through end of November 2007

Figure 1-8. Longfin Smelt Salvage at the CVP, 2007



Source: DWR 2008
Note: *Data through end of November 2007

Figure 1-9. Longfin Smelt Salvage at the SVP, 2007*

Like the delta smelt, the longfin smelt spawn adhesive eggs in river channels of the eastern Bay-Delta and have larvae that are carried to nursery areas by freshwater outflow; otherwise the two species differ substantially. Consistently, a measurable portion of the longfin smelt population survives into a second year. During the second year of life, they inhabit the San Francisco Bay and, occasionally, the Gulf of the Farallones (Wang 1986). Therefore, longfin smelt are often considered anadromous (SWRCB 1999).

Longfin smelt are also more broadly distributed throughout the Delta and are found at higher salinities than delta smelt (Baxter 1996). Because longfin smelt seldom occur in freshwater except to spawn, but are widely dispersed in brackish waters of the Bay, it is likely that their range formerly extended as far up into the Delta as saltwater intruded. The easternmost catch of longfin smelt in fall mid-water trawl samples has been at Medford Island in the central Delta. The depth of habitat is a pronounced difference between the two species in their region of overlap in Suisun Bay; longfin smelt are caught in greater quantities at deep stations (more than 32 feet), whereas delta smelt are more abundant at shallow stations (less than 10 feet) (SWRCB 1999).

The main food of longfin smelt is the opossum shrimp, although copepods and other crustaceans are important at times, especially to small fish. Longfin smelt, in turn, are eaten by a variety of predatory fishes, birds, and marine mammals (SWRCB 1999). Recent declines in the abundance of opossum shrimp and other zooplankton have been identified as a factor affecting the abundance of longfin smelt.

Longfin smelt were once one of the most common fish in the Delta. Their abundance has fluctuated widely in the past, but, since 1982, abundance has declined significantly (Baxter 1996, The Bay Institute 2007). The abundance of longfin smelt also has declined relative to other fishes, dropping from first or second in abundance in most trawl surveys during the 1960s and 1970s, to seventh or eighth in abundance. Abundance improved substantially in 1995 but was again relatively low in 1996 and 1997. Longfin abundance indices, although variable, were at very low levels in recent years (e.g., 2004 through 2006). The causes of decline are thought to be multiple and synergistic, including reduction in outflows, entrainment losses to water diversions, climatic variation, toxic substances, predation, and introduced species (SWRCB 1999).

Green Sturgeon

Green sturgeon inhabiting San Francisco Bay, the Delta, and tributaries have recently been listed as a threatened species by NMFS under the ESA and are identified as a California Species of Special Concern.

San Francisco Bay, San Pablo Bay, Suisun Bay, and the Delta support the southernmost reproducing population of green sturgeon. White sturgeon are the most abundant sturgeon in the system, and green sturgeon have always been comparatively uncommon. Habitat requirements of green sturgeon are poorly known, but spawning and larval ecologies probably are similar to those of white sturgeon. Adult green sturgeon are more marine than white sturgeon, spending limited time in estuaries or freshwater (SWRCB 1999).

Indirect evidence indicates that green sturgeon spawn mainly in the Sacramento River; spawning has been reported in the mainstem as far north as Red Bluff. Spawning times in the Sacramento River are presumed to be from March through July, peaking from mid-April to mid-June. Adult sturgeon are in the river, presumably spawning, when temperatures typically range from 46°F to 57°F. Their preferred spawning substrate is large cobble, but substrates range from clean sand to bedrock. Eggs are broadcast spawned and externally fertilized in relatively high water velocities and at depths of less than 10 feet.

Female green sturgeon produce 60,000 to 140,000 eggs, each approximately 0.15 inch in diameter. Eggs hatch approximately 196 hours after spawning, and larvae are 8 to 19 millimeters long. Juveniles range in size from less than 1 inch to almost 5 feet. Juveniles migrate to sea before 2 years of age, primarily during the summer and fall. The occurrence of green sturgeon in fish sampling and SWP/CVP fish salvage is extremely low and therefore has not been used to represent the seasonal period of juvenile movement through the Delta. During 2007, for example, green sturgeon were collected in the SWP and CVP fish facilities during 1 day at each out of the year. Green sturgeon tend to remain near estuaries at first but may migrate considerable distances as they grow larger (SWRCB 1999).

Green sturgeon grow approximately 3 inches per year until they reach maturity at 4 to 5 feet in length, around age 15 to 20; thereafter, growth slows down (Wang 1986). The largest fish are thought to be 40 years old, but this estimate may be low. Adults can reach sizes of 7.5 feet and 350 pounds, but in the San Francisco Bay, most are less than 100 pounds (SWRCB 1999).

Both the juvenile and adult green sturgeon are benthic feeders and may also eat small fish. Juveniles in the Delta feed on opossum shrimp, amphipods (*Corophium* sp.), and other macroinvertebrates. The green sturgeon is apparently reduced in numbers throughout its range, although evidence is limited. Rough estimates of the numbers of green sturgeon longer than 3 feet in the Bay-Delta between 1954 and 1991 range from 200 to 1,800 fish, based on intermittent studies by the CDFW (Kolhorst, unpublished data). There is no direct evidence of a decline in the numbers of green sturgeon in the Sacramento River. However, the population is so small that a collapse could occur, and it would hardly be noticed because of limited occurrence in conventional fish sampling programs (SWRCB 1999).

In the Delta, the major factors that may negatively affect green sturgeon abundance are sport fisheries, modification of spawning habitat, entrainment, and toxic substances.

Sacramento Splittail

The Sacramento splittail is a Federal Species of Concern and a California Species of Special Concern.

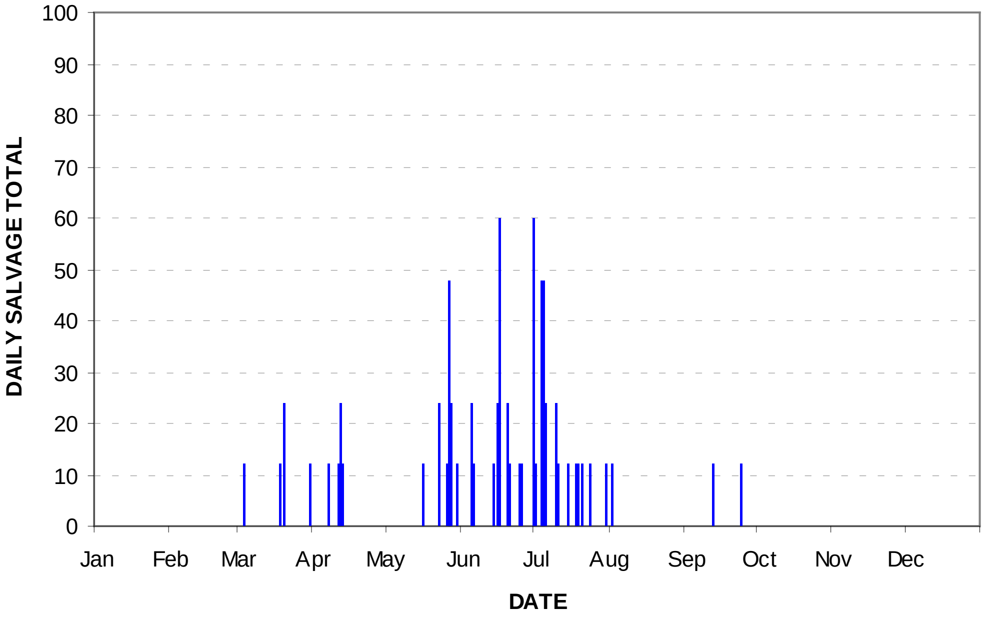
The Sacramento splittail is a large minnow endemic to the Bay-Delta. Once found throughout low-elevation lakes and rivers of the Central Valley from Redding to Fresno, this native species now occurs in the lower reaches of the Sacramento and San Joaquin rivers and tributaries, the Delta, Suisun and Napa marshes, and the Sutter and Yolo bypasses, and the tributaries of north San Pablo Bay. Although the Sacramento splittail is generally considered a freshwater species, the adults and sub-adults have an unusually high tolerance for saline waters (up to 10 to 18 ppt) for a member of the minnow family (Young and Cech 1996). The salt tolerance of splittail larvae is unknown, but they have been observed in water with salinities of 10 to 18 ppt (SWRCB 1999).

The Sacramento splittail, which has a high reproductive capacity, can live 5 to 7 years, and generally begins spawning at 2 years of age. Spawning, which seems to be triggered by increasing water temperatures and day length, occurs over beds of submerged vegetation in slow-moving stretches of water (such as flooded terrestrial areas and dead-end sloughs). Adults spawn from February through May in the Delta, upstream tributaries, Napa Marsh, Napa and Petaluma rivers, Suisun Bay and Marsh, and the Sutter and Yolo bypasses (Baxter et al. 1996). Hatched larvae remain in shallow, weedy areas until they move to deeper offshore habitat later in the summer. Young splittail may occur in shallow and open waters of the Delta and San Pablo Bay, but they are particularly abundant in the northern and western Delta (Sommer et al. 1997; SWRCB 1999). The seasonal occurrence of juvenile splittail in SWP and CVP fish salvage (Figures 1-10 and 1-11) is representative of the periods when juvenile splittail inhabit the Delta.

Splittail are bottom foragers that feed extensively on opossum shrimp and opportunistically on earthworms, clams, insect larvae, and other invertebrates. They are preyed on by striped bass and other predatory fish in the Bay-Delta. In the past, anglers commonly used splittail as bait when fishing for striped bass (SWRCB 1999).

Young-of-the-year (YOY) splittail abundance appears to fluctuate widely from year to year. Young splittail abundance dropped dramatically during the 1987-to-1992 drought. However, wet conditions in 1995 resulted in high indices for most measures of YOY abundance. Abundance was relatively low in 1996 and 1997, but higher than during the drought years (Meng and Moyle 1995). In 1998, YOY abundance, indexed by the summer townet survey, was again relatively high (SWRCB 1999). In recent years, indices of juvenile splittail abundance have continued to fluctuate substantially among years.

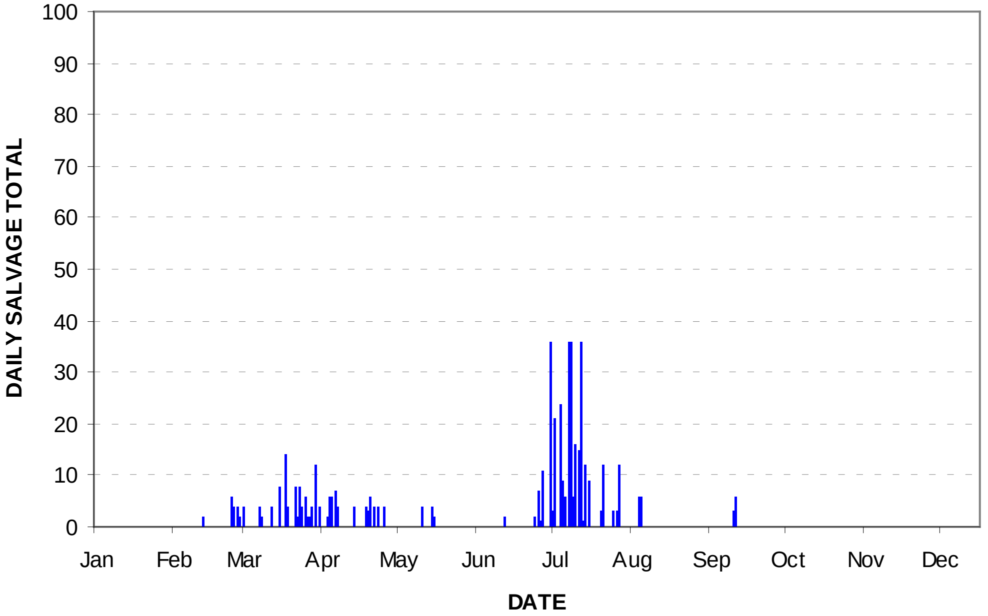
In contrast to young splittail, adult abundance shows no obvious decline during the 1987 to 1992 drought. The species’ long lifespan and multiple year classes moderate adult population variation. Factors affecting abundance of young splittail include variations in flooding of terrestrial areas that provide spawning and rearing habitat; changed estuarine hydraulics, especially reduced outflow; modifications of spawning habitat; climatic variation; toxic substances; introduced species; predation; and exploitation (Sommer et al. 1997; SWRCB 1999).



Source: DWR 2008DWR 2008

Note: Data through end of November 2007

Figure 1-10. Sacramento Splittail Salvage at the CVP, 2007



Source: DWR 2008

Note: Data through end of November 2007

Figure 1-11. Sacramento Splittail Salvage at the SWP, 2007

Chapter 2

Potential Effects of Project Alternatives on Fish Habitat in the Delta

The proposed Shasta project has the potential to affect the quality and availability of fish habitat within the Bay-Delta. These potential changes may result from changes in the seasonal timing of water storage and releases from the upstream reservoir as well as changes in water project operations within the Delta. To investigate these potential effects results of hydrologic modeling were compared between projected operations under the proposed project conditions and baseline conditions. For purposes of these analyses, consideration was limited to potential effects within the Delta. Potential effects of proposed project operations on fish habitat within upstream tributaries and the mainstem Sacramento River are not addressed in this analysis. Results of these analyses are described in Chapter 11 of the Programmatic Environmental Impact Statement, and additional tables of results are presented below. This attachment does not discuss the level of impacts.

The potential effects of the proposed project operations in various hydrologic water year types on Delta fish habitat include potential changes in parameters such as Delta outflow, Delta inflow, Sacramento River inflow to the Delta, San Joaquin River flows, the location of the X2 (the low salinity region of the Bay-Delta) within the western Delta and Suisun Bay, reverse flows in Old and Middle rivers, and SWP and CVP export operations resulting in changes fish entrainment and salvage. Results of these comparisons are summarized below.

2.1 Delta Outflow

Water development has changed the volume and timing of freshwater flows through the Bay-Delta. Over the past several decades the volume of the Bay-Delta's fresh water supply that has been reduced by upstream diversions, in-Delta use, and Delta exports. As a result, the proportion of Delta outflow depleted by upstream and Delta diversions has grown substantially. In wet years, diversions reduce outflow by 10 percent to 30 percent. In dry years, diversions may reduce outflow by more than 50 percent.

Water development has also altered the seasonal timing of flows passing into and through the Bay-Delta. Flows have decreased in April, May, and June and have increased slightly during the summer and fall (SFEP 1992). Seasonal flows influence the transport of eggs and young organisms (e.g., zooplankton, fish eggs and larvae) through the Delta and into San Francisco Bay. Flows during April, May, and June play an especially important role in determining the reproductive success and survival of many estuarine species including salmon, striped bass, American shad, delta smelt, longfin smelt, splittail, and others (Stevens and Miller 1983, Stevens et al. 1985, Herbold 1994, Meng and Moyle 1995).

Results of the comparison of Delta outflows under existing conditions with and without the proposed project are summarized by month and water year type in Tables 2-1 through 2-12, while those under future conditions are presented in Tables 2-13 through 2-24. The comparison includes the estimated average monthly outflow under the baseline conditions, the average monthly flow under each of the three project alternatives evaluated, and the percentage change between base flows and proposed project operations. For purposes of evaluating the potential effect of changes in outflow on fish habitat within the Delta and Bay, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows modeled under baseline and with the proposed project that were less than 5 percent (+ or –) would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by Delta outflow, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

Table 2-1. Delta Outflow (cfs) in January, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	42,078	42,002	0%	41,860	-1%	41,783	-1%	41,817	-1%
Wet	84,136	83,964	0%	83,807	0%	83,571	-1%	83,584	-1%
Above Normal	47,221	47,120	0%	47,015	0%	46,936	-1%	46,892	-1%
Below Normal	21,610	21,622	0%	21,643	0%	21,584	0%	21,578	0%
Dry	14,166	14,038	-1%	13,955	-1%	13,973	-1%	13,956	-1%
Critical	11,560	11,687	1%	11,263	-3%	11,366	-2%	11,649	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-2. Delta Outflow (cfs) in February, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	51,618	51,526	0%	51,459	0%	51,432	0%	51,340	-1%
Wet	95,261	95,104	0%	94,989	0%	94,991	0%	94,826	0%
Above Normal	60,080	59,779	-1%	59,683	-1%	59,591	-1%	59,474	-1%
Below Normal	35,892	35,976	0%	35,856	0%	35,791	0%	35,776	0%
Dry	20,978	20,924	0%	20,902	0%	20,909	0%	20,804	-1%
Critical	12,902	12,898	0%	12,954	0%	12,924	0%	12,945	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-3. Delta Outflow (cfs) in March, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	42,722	42,651	0%	42,580	0%	42,577	0%	42,532	0%
Wet	78,448	78,500	0%	78,493	0%	78,457	0%	78,481	0%
Above Normal	53,486	53,121	-1%	52,768	-1%	52,493	-2%	52,431	-2%
Below Normal	23,102	22,906	-1%	22,799	-1%	22,943	-1%	22,800	-1%
Dry	19,763	19,848	0%	19,860	0%	19,864	1%	19,873	1%
Critical	11,881	11,747	-1%	11,740	-1%	11,892	0%	11,750	-1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-4. Delta Outflow (cfs) in April, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	30,227	30,236	0%	30,239	0%	30,300	0%	30,282	0%
Wet	54,640	54,650	0%	54,645	0%	54,671	0%	54,674	0%
Above Normal	32,141	32,127	0%	32,130	0%	32,225	0%	32,147	0%
Below Normal	21,773	21,820	0%	21,868	0%	21,952	1%	21,903	1%
Dry	14,347	14,343	0%	14,317	0%	14,430	1%	14,429	1%
Critical	9,100	9,108	0%	9,119	0%	9,115	0%	9,121	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-5. Delta Outflow (cfs) in May, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	22,619	22,567	0%	22,539	0%	22,552	0%	22,547	0%
Wet	41,184	41,165	0%	41,155	0%	41,155	0%	41,151	0%
Above Normal	24,296	24,201	0%	24,237	0%	24,171	-1%	24,183	0%
Below Normal	16,346	16,144	-1%	15,984	-2%	15,983	-2%	15,948	-2%
Dry	10,554	10,580	0%	10,553	0%	10,655	1%	10,660	1%
Critical	6,132	6,110	0%	6,134	0%	6,134	0%	6,132	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-6. Delta Outflow (cfs) in June, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	12,829	12,776	0%	12,759	-1%	12,779	0%	12,756	-1%
Wet	23,473	23,473	0%	23,471	0%	23,473	0%	23,471	0%
Above Normal	12,080	11,746	-3%	11,650	-4%	11,666	-3%	11,625	-4%
Below Normal	7,995	8,019	0%	7,992	0%	8,004	0%	7,977	0%
Dry	6,691	6,656	-1%	6,666	0%	6,734	1%	6,681	0%
Critical	5,361	5,361	0%	5,361	0%	5,363	0%	5,360	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-7. Delta Outflow (cfs) in July, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	7,864	7,864	0%	7,869	0%	7,877	0%	7,864	0%
Wet	11,230	11,237	0%	11,243	0%	11,270	0%	11,223	0%
Above Normal	9,562	9,530	0%	9,538	0%	9,525	0%	9,519	0%
Below Normal	7,117	7,118	0%	7,124	0%	7,130	0%	7,131	0%
Dry	5,005	5,006	0%	5,006	0%	5,005	0%	5,006	0%
Critical	4,034	4,050	0%	4,053	0%	4,054	1%	4,074	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-8. Delta Outflow (cfs) in August, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	4,322	4,337	0%	4,343	0%	4,316	0%	4,335	0%
Wet	5,302	5,319	0%	5,313	0%	5,307	0%	5,274	-1%
Above Normal	4,000	4,000	0%	4,000	0%	4,000	0%	4,000	0%
Below Normal	4,000	4,000	0%	4,000	0%	4,000	0%	4,000	0%
Dry	3,906	3,896	0%	3,895	0%	3,878	-1%	3,903	0%
Critical	3,520	3,604	2%	3,655	4%	3,509	0%	3,676	4%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-9. Delta Outflow (cfs) in September, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	9,841	9,840	0%	9,845	0%	9,836	0%	9,866	0%
Wet	19,695	19,670	0%	19,670	0%	19,687	0%	19,717	0%
Above Normal	11,784	11,771	0%	11,771	0%	11,771	0%	11,771	0%
Below Normal	3,876	3,886	0%	3,878	0%	3,885	0%	3,862	0%
Dry	3,508	3,516	0%	3,554	1%	3,484	-1%	3,576	2%
Critical	3,008	3,040	1%	3,033	1%	3,027	1%	3,061	2%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-10. Delta Outflow (cfs) in October, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,067	6,063	0%	6,081	0%	6,056	0%	6,072	0%
Wet	7,926	7,894	0%	7,872	-1%	7,866	-1%	7,870	-1%
Above Normal	5,309	5,360	1%	5,334	0%	5,368	1%	5,293	0%
Below Normal	5,479	5,514	1%	5,551	1%	5,502	0%	5,559	1%
Dry	5,228	5,234	0%	5,250	0%	5,247	0%	5,264	1%
Critical	4,741	4,684	-1%	4,815	2%	4,682	-1%	4,765	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-11. Delta Outflow (cfs) in November, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	11,706	11,549	-1%	11,549	-1%	11,541	-1%	11,531	-1%
Wet	17,717	17,621	-1%	17,588	-1%	17,637	0%	17,590	-1%
Above Normal	12,667	11,852	-6%	11,996	-5%	11,728	-7%	11,767	-7%
Below Normal	8,543	8,513	0%	8,501	0%	8,527	0%	8,509	0%
Dry	8,482	8,468	0%	8,483	0%	8,479	0%	8,481	0%
Critical	6,250	6,256	0%	6,173	-1%	6,256	0%	6,266	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-12. Delta Outflow (cfs) in December, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	21,755	21,601	-1%	21,621	-1%	21,427	-2%	21,437	-1%
Wet	44,974	44,556	-1%	44,605	-1%	44,189	-2%	44,310	-1%
Above Normal	18,581	18,667	0%	18,426	-1%	18,521	0%	18,300	-2%
Below Normal	12,219	12,135	-1%	12,041	-1%	11,752	-4%	11,850	-3%
Dry	8,531	8,453	-1%	8,494	0%	8,477	-1%	8,517	0%
Critical	5,580	5,567	0%	5,882	5%	5,730	3%	5,578	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-13. Delta Outflow (cfs) in January, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	47,457	47,275	0%	47,194	-1%	47,099	-1%	47,115	-1%
Wet	89,328	88,930	0%	88,690	-1%	88,512	-1%	88,469	-1%
Above Normal	51,267	51,100	0%	51,113	0%	51,061	0%	51,053	0%
Below Normal	27,576	27,609	0%	27,603	0%	27,612	0%	27,598	0%
Dry	20,371	20,221	-1%	20,094	-1%	20,093	-1%	20,094	-1%
Critical	16,749	16,724	0%	16,872	1%	16,701	0%	16,882	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-14. Delta Outflow (cfs) in February, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	57,623	57,478	0%	57,385	0%	57,342	0%	57,250	-1%
Wet	102,606	102,393	0%	102,252	0%	102,190	0%	102,066	-1%
Above Normal	65,574	65,008	-1%	64,768	-1%	64,664	-1%	64,598	-1%
Below Normal	41,374	41,419	0%	41,385	0%	41,367	0%	41,253	0%
Dry	26,431	26,356	0%	26,332	0%	26,290	-1%	26,214	-1%
Critical	17,958	18,054	1%	18,035	0%	18,065	1%	18,014	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-15. Delta Outflow (cfs) in March, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	49,713	49,699	0%	49,647	0%	49,536	0%	49,588	0%
Wet	87,703	87,782	0%	87,793	0%	87,713	0%	87,801	0%
Above Normal	61,339	61,232	0%	60,883	-1%	60,449	-1%	60,540	-1%
Below Normal	30,415	30,326	0%	30,256	-1%	30,086	-1%	30,183	-1%
Dry	24,640	24,610	0%	24,639	0%	24,645	0%	24,654	0%
Critical	15,896	15,891	0%	15,895	0%	15,936	0%	15,884	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-16. Delta Outflow (cfs) in April, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	34,783	34,798	0%	34,823	0%	34,868	0%	34,833	0%
Wet	60,017	60,020	0%	60,025	0%	60,029	0%	60,019	0%
Above Normal	36,738	36,745	0%	36,745	0%	36,823	0%	36,744	0%
Below Normal	26,403	26,414	0%	26,429	0%	26,537	1%	26,490	0%
Dry	18,315	18,336	0%	18,411	1%	18,463	1%	18,448	1%
Critical	12,635	12,679	0%	12,707	1%	12,726	1%	12,663	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-17. Delta Outflow (cfs) in May, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	27,091	27,044	0%	27,021	0%	27,039	0%	27,029	0%
Wet	46,494	46,473	0%	46,482	0%	46,477	0%	46,476	0%
Above Normal	28,711	28,490	-1%	28,475	-1%	28,514	-1%	28,502	-1%
Below Normal	20,427	20,247	-1%	20,083	-2%	20,140	-1%	20,062	-2%
Dry	14,534	14,591	0%	14,609	1%	14,686	1%	14,686	1%
Critical	10,038	10,109	1%	10,110	1%	10,027	0%	10,065	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-18. Delta Outflow (cfs) in June, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	22,090	22,068	0%	22,042	0%	22,029	0%	22,001	0%
Wet	35,172	35,172	0%	35,190	0%	35,190	0%	35,190	0%
Above Normal	22,776	22,612	-1%	22,423	-2%	22,408	-2%	22,410	-2%
Below Normal	16,941	16,987	0%	17,008	0%	16,932	0%	16,796	-1%
Dry	14,337	14,312	0%	14,278	0%	14,294	0%	14,262	-1%
Critical	10,694	10,694	0%	10,695	0%	10,686	0%	10,696	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-19. Delta Outflow (cfs) in July, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	22,839	22,876	0%	22,906	0%	22,894	0%	22,959	1%
Wet	27,496	27,500	0%	27,491	0%	27,501	0%	27,455	0%
Above Normal	25,065	25,044	0%	25,033	0%	25,015	0%	25,018	0%
Below Normal	23,362	23,347	0%	23,288	0%	23,371	0%	23,338	0%
Dry	20,082	20,160	0%	20,300	1%	20,195	1%	20,408	2%
Critical	14,048	14,215	1%	14,311	2%	14,283	2%	14,544	4%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-20. Delta Outflow (cfs) in August, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	17,026	17,068	0%	17,094	0%	17,122	1%	17,128	1%
Wet	20,154	20,150	0%	20,148	0%	20,146	0%	20,118	0%
Above Normal	18,927	18,935	0%	18,941	0%	18,941	0%	18,941	0%
Below Normal	18,297	18,231	0%	18,232	0%	18,332	0%	18,231	0%
Dry	14,371	14,580	1%	14,688	2%	14,680	2%	14,976	4%
Critical	10,850	10,897	0%	10,913	1%	11,000	1%	10,782	-1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-21. Delta Outflow (cfs) in September, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	9,844	9,858	0%	9,882	0%	9,864	0%	9,898	1%
Wet	19,702	19,707	0%	19,713	0%	19,712	0%	19,736	0%
Above Normal	11,849	11,836	0%	11,836	0%	11,836	0%	11,836	0%
Below Normal	3,913	3,926	0%	3,932	0%	3,945	1%	3,950	1%
Dry	3,442	3,496	2%	3,591	4%	3,491	1%	3,600	5%
Critical	3,005	3,005	0%	3,008	0%	3,020	1%	3,029	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-22. Delta Outflow (cfs) in October, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,000	6,003	0%	6,000	0%	5,981	0%	6,003	0%
Wet	7,633	7,596	0%	7,550	-1%	7,539	-1%	7,558	-1%
Above Normal	5,476	5,550	1%	5,546	1%	5,593	2%	5,536	1%
Below Normal	5,502	5,504	0%	5,510	0%	5,469	-1%	5,546	1%
Dry	5,236	5,238	0%	5,243	0%	5,235	0%	5,253	0%
Critical	4,714	4,732	0%	4,804	2%	4,711	0%	4,757	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-23. Delta Outflow (cfs) in November, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	11,675	11,525	-1%	11,500	-1%	11,484	-2%	11,466	-2%
Wet	17,715	17,484	-1%	17,488	-1%	17,534	-1%	17,494	-1%
Above Normal	12,491	12,084	-3%	11,965	-4%	11,755	-6%	11,755	-6%
Below Normal	8,686	8,579	-1%	8,586	-1%	8,591	-1%	8,557	-1%
Dry	8,414	8,414	0%	8,375	0%	8,384	0%	8,386	0%
Critical	6,150	6,156	0%	6,150	0%	6,131	0%	6,132	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-24. Delta Outflow (cfs) in December, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	21,745	21,592	-1%	21,471	-1%	21,386	-2%	21,324	-2%
Wet	44,661	44,182	-1%	43,902	-2%	43,587	-2%	43,598	-2%
Above Normal	18,562	18,513	0%	18,375	-1%	18,180	-2%	18,271	-2%
Below Normal	12,326	12,402	1%	12,246	-1%	12,070	-2%	12,008	-3%
Dry	8,803	8,710	-1%	8,678	-1%	8,933	1%	8,678	-1%
Critical	5,677	5,774	2%	5,920	4%	6,040	6%	5,954	5%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

2.2 Delta Inflow

Changes in upstream reservoir storage have the potential to affect Delta inflow. Delta inflow may affect hydrologic conditions within Delta channels, hydraulic residence times, salinity gradients, and the transport and movement of various life stages of fish, invertebrates, phytoplankton, and nutrients into and through the Delta. Delta inflow serves as a surrogate metric for a variety of habitat conditions within the Delta that directly or indirectly affect fish and other aquatic resources. Results of the comparison of Delta inflows under existing conditions with and without the proposed project are summarized by month and water year type in Tables 2-25 through 2-36 and those under future conditions are presented in Tables 2-37 through 2-48. The comparison includes the estimated average monthly inflow under the baseline conditions, the average monthly flow under each of the three project alternatives evaluated, and the percentage change between base flows and proposed project operations. For purposes of evaluating the potential effect of changes in Delta inflow on fish habitat within the Delta and Bay, and considering the accuracy and inherent noise within the hydrologic model, it was assumed that changes in the average monthly flows modeled under baseline and with the proposed project that were less than 5 percent (+ or --) would not be expected to result in a significant (detectable) effect on habitat quality or availability, or the transport mechanisms provided by Delta inflow, on resident or migratory fish or the zooplankton and phytoplankton that they rely on for a food resource.

Table 2-25. Delta Inflow (cfs) in January, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	47,426	47,352	0%	47,218	0%	47,165	-1%	47,149	-1%
Wet	89,431	89,259	0%	89,103	0%	88,863	-1%	88,880	-1%
Above Normal	51,611	51,501	0%	51,349	-1%	51,258	-1%	51,213	-1%
Below Normal	27,269	27,281	0%	27,305	0%	27,243	0%	27,240	0%
Dry	20,125	20,017	-1%	19,959	-1%	19,963	-1%	19,962	-1%
Critical	16,699	16,820	1%	16,457	-1%	16,774	0%	16,677	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-26. Delta Inflow (cfs) in February, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	57,835	57,703	0%	57,676	0%	57,646	0%	57,570	0%
Wet	103,140	102,976	0%	102,862	0%	102,862	0%	102,698	0%
Above Normal	65,379	64,882	-1%	64,734	-1%	64,639	-1%	64,552	-1%
Below Normal	41,782	41,832	0%	41,822	0%	41,823	0%	41,781	0%
Dry	26,530	26,459	0%	26,473	0%	26,484	0%	26,384	-1%
Critical	17,818	17,813	0%	18,017	1%	17,886	0%	18,008	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-27. Delta Inflow (cfs) in March, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	49,829	49,786	0%	49,721	0%	49,701	0%	49,675	0%
Wet	87,688	87,728	0%	87,726	0%	87,695	0%	87,738	0%
Above Normal	61,498	61,359	0%	61,010	-1%	60,733	-1%	60,673	-1%
Below Normal	30,569	30,372	-1%	30,281	-1%	30,414	-1%	30,264	-1%
Dry	24,943	24,943	0%	24,955	0%	24,957	0%	24,967	0%
Critical	15,933	15,923	0%	15,916	0%	15,964	0%	15,916	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-28. Delta Inflow (cfs) in April, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	33,962	33,971	0%	33,976	0%	34,036	0%	34,019	0%
Wet	58,684	58,694	0%	58,688	0%	58,715	0%	58,717	0%
Above Normal	35,588	35,575	0%	35,578	0%	35,673	0%	35,595	0%
Below Normal	25,351	25,398	0%	25,447	0%	25,531	1%	25,482	1%
Dry	17,962	17,959	0%	17,939	0%	18,048	0%	18,057	1%
Critical	12,817	12,822	0%	12,837	0%	12,832	0%	12,838	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-29. Delta Inflow (cfs) in May, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	27,383	27,332	0%	27,305	0%	27,315	0%	27,312	0%
Wet	46,973	46,955	0%	46,945	0%	46,945	0%	46,941	0%
Above Normal	28,466	28,372	0%	28,407	0%	28,341	0%	28,354	0%
Below Normal	20,747	20,542	-1%	20,382	-2%	20,384	-2%	20,349	-2%
Dry	14,882	14,908	0%	14,881	0%	14,983	1%	14,988	1%
Critical	10,347	10,333	0%	10,360	0%	10,341	0%	10,351	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-30. Delta Inflow (cfs) in June, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	22,171	22,116	0%	22,118	0%	22,139	0%	22,115	0%
Wet	35,459	35,459	0%	35,457	0%	35,459	0%	35,457	0%
Above Normal	23,124	22,791	-1%	22,687	-2%	22,703	-2%	22,662	-2%
Below Normal	16,884	16,897	0%	16,985	1%	17,003	1%	16,971	1%
Dry	14,095	14,059	0%	14,067	0%	14,134	0%	14,082	0%
Critical	10,710	10,711	0%	10,713	0%	10,710	0%	10,711	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-31. Delta Inflow (cfs) in July, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	23,099	23,111	0%	23,131	0%	23,110	0%	23,160	0%
Wet	27,442	27,449	0%	27,453	0%	27,477	0%	27,430	0%
Above Normal	25,169	25,089	0%	25,083	0%	25,070	0%	25,065	0%
Below Normal	23,282	23,306	0%	23,292	0%	23,400	1%	23,351	0%
Dry	20,937	20,980	0%	20,930	0%	20,904	0%	20,983	0%
Critical	14,647	14,706	0%	14,929	2%	14,661	0%	15,042	3%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-32. Delta Inflow (cfs) in August, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	17,147	17,180	0%	17,158	0%	17,132	0%	17,154	0%
Wet	20,235	20,257	0%	20,253	0%	20,248	0%	20,217	0%
Above Normal	18,784	18,760	0%	18,762	0%	18,759	0%	18,754	0%
Below Normal	18,274	18,272	0%	18,171	-1%	18,212	0%	18,202	0%
Dry	15,066	15,274	1%	15,288	1%	15,066	0%	15,348	2%
Critical	10,626	10,517	-1%	10,472	-1%	10,593	0%	10,404	-2%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-33. Delta Inflow (cfs) in September, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	20,946	21,049	0%	21,074	1%	20,993	0%	21,184	1%
Wet	31,918	31,920	0%	31,921	0%	32,081	1%	32,076	0%
Above Normal	23,912	23,930	0%	23,931	0%	23,913	0%	23,902	0%
Below Normal	16,518	16,546	0%	16,518	0%	16,542	0%	16,468	0%
Dry	14,440	14,703	2%	14,839	3%	14,329	-1%	14,960	4%
Critical	9,130	9,386	3%	9,383	3%	9,237	1%	9,707	6%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-34. Delta Inflow (cfs) in October, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	14,407	14,445	0%	14,455	0%	14,469	0%	14,469	0%
Wet	17,072	17,016	0%	16,986	-1%	17,057	0%	17,019	0%
Above Normal	13,176	13,364	1%	13,416	2%	13,412	2%	13,391	2%
Below Normal	14,044	14,180	1%	14,203	1%	14,065	0%	14,251	1%
Dry	13,133	13,243	1%	13,270	1%	13,241	1%	13,264	1%
Critical	12,196	12,070	-1%	12,079	-1%	12,234	0%	12,085	-1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-35. Delta Inflow (cfs) in November, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	19,512	19,531	0%	19,583	0%	19,550	0%	19,554	0%
Wet	26,429	26,521	0%	26,528	0%	26,571	1%	26,491	0%
Above Normal	20,269	19,726	-3%	19,859	-2%	19,609	-3%	19,631	-3%
Below Normal	16,984	17,051	0%	17,053	0%	17,037	0%	17,064	0%
Dry	15,771	15,942	1%	16,039	2%	16,027	2%	16,056	2%
Critical	12,330	12,467	1%	12,530	2%	12,494	1%	12,595	2%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-36. Delta Inflow (cfs) in December, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	30,984	30,833	0%	30,850	0%	30,666	-1%	30,673	-1%
Wet	53,758	53,345	-1%	53,401	-1%	52,982	-1%	53,109	-1%
Above Normal	28,431	28,505	0%	28,303	0%	28,381	0%	28,177	-1%
Below Normal	21,958	21,855	0%	21,784	-1%	21,520	-2%	21,606	-2%
Dry	18,560	18,501	0%	18,520	0%	18,516	0%	18,550	0%
Critical	13,363	13,358	0%	13,607	2%	13,498	1%	13,322	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-37. Delta Inflow (cfs) in January, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	47,457	47,275	0%	47,194	-1%	47,099	-1%	47,115	-1%
Wet	89,328	88,930	0%	88,690	-1%	88,512	-1%	88,469	-1%
Above Normal	51,267	51,100	0%	51,113	0%	51,016	0%	51,053	0%
Below Normal	27,576	27,609	0%	27,603	0%	27,612	0%	27,598	0%
Dry	20,371	20,221	-1%	20,094	-1%	20,093	-1%	20,094	-1%
Critical	16,749	16,724	0%	16,872	1%	16,701	0%	16,882	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-38. Delta Inflow (cfs) in February, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	57,623	57,478	0%	57,385	0%	57,342	0%	57,250	-1%
Wet	102,606	102,393	0%	102,252	0%	102,190	0%	102,066	-1%
Above Normal	65,574	65,008	-1%	64,768	-1%	64,664	-1%	64,598	-1%
Below Normal	41,374	41,419	0%	41,385	0%	41,367	0%	41,253	0%
Dry	26,431	26,356	0%	26,332	0%	26,290	-1%	26,214	-1%
Critical	17,958	18,054	1%	18,035	0%	18,065	1%	18,014	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-39. Delta Inflow (cfs) in March, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	49,713	49,699	0%	49,647	0%	49,536	0%	49,588	0%
Wet	87,703	87,782	0%	87,793	0%	87,713	0%	87,801	0%
Above Normal	61,339	61,232	0%	60,883	-1%	60,449	-1%	60,540	-1%
Below Normal	30,415	30,326	0%	30,256	-1%	30,086	-1%	30,183	-1%
Dry	24,640	24,610	0%	24,639	0%	24,645	0%	24,654	0%
Critical	15,896	15,891	0%	15,895	0%	15,936	0%	15,884	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-40. Delta Inflow (cfs) in April, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	34,783	34,798	0%	34,823	0%	34,868	0%	34,833	0%
Wet	60,017	60,020	0%	60,025	0%	60,029	0%	60,019	0%
Above Normal	36,738	36,745	0%	36,745	0%	36,823	0%	36,744	0%
Below Normal	26,403	26,414	0%	26,429	0%	26,537	1%	26,490	0%
Dry	18,315	18,336	0%	18,411	1%	18,463	1%	18,448	1%
Critical	12,635	12,679	0%	12,707	1%	12,726	1%	12,663	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-41. Delta Inflow (cfs) in May, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	27,091	27,044	0%	27,021	0%	27,039	0%	27,029	0%
Wet	46,494	46,473	0%	46,482	0%	46,477	0%	46,476	0%
Above Normal	28,711	28,490	-1%	28,475	-1%	28,514	-1%	28,502	-1%
Below Normal	20,427	20,247	-1%	20,083	-2%	20,140	-1%	20,062	-2%
Dry	14,534	14,591	0%	14,609	1%	14,686	1%	14,686	1%
Critical	10,038	10,109	1%	10,110	1%	10,027	0%	10,065	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-42. Delta Inflow (cfs) in June, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	22,090	22,068	0%	22,042	0%	22,029	0%	22,001	0%
Wet	35,172	35,172	0%	35,190	0%	35,190	0%	35,190	0%
Above Normal	22,776	22,612	-1%	22,423	-2%	22,408	-2%	22,410	-2%
Below Normal	16,941	16,987	0%	17,008	0%	16,932	0%	16,796	-1%
Dry	14,337	14,312	0%	14,278	0%	14,294	0%	14,262	-1%
Critical	10,694	10,694	0%	10,695	0%	10,686	0%	10,696	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-43. Delta Inflow (cfs) in July, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	22,839	22,876	0%	22,906	0%	22,894	0%	22,959	1%
Wet	27,496	27,500	0%	27,491	0%	27,501	0%	27,455	0%
Above Normal	25,065	25,044	0%	25,033	0%	25,015	0%	25,018	0%
Below Normal	23,362	23,347	0%	23,288	0%	23,371	0%	23,338	0%
Dry	20,082	20,160	0%	20,300	1%	20,195	1%	20,408	2%
Critical	14,048	14,215	1%	14,311	2%	14,283	2%	14,544	4%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-44. Delta Inflow (cfs) in August, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	17,026	17,068	0%	17,094	0%	17,122	1%	17,128	1%
Wet	20,154	20,150	0%	20,148	0%	20,146	0%	20,118	0%
Above Normal	18,927	18,935	0%	18,941	0%	18,941	0%	18,941	0%
Below Normal	18,297	18,231	0%	18,232	0%	18,332	0%	18,231	0%
Dry	14,371	14,580	1%	14,688	2%	14,680	2%	14,976	4%
Critical	10,850	10,897	0%	10,913	1%	11,000	1%	10,782	-1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-45. Delta Inflow (cfs) in September, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	21,145	21,292	1%	21,396	1%	21,272	1%	21,461	1%
Wet	32,428	32,431	0%	32,422	0%	32,495	0%	32,518	0%
Above Normal	24,747	24,856	0%	24,859	0%	24,917	1%	24,877	1%
Below Normal	16,563	16,569	0%	16,592	0%	16,650	1%	16,652	1%
Dry	14,233	14,683	3%	15,081	6%	14,437	1%	15,039	6%
Critical	8,809	9,013	2%	9,118	4%	8,957	2%	9,332	6%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-46. Delta Inflow (cfs) in October, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	21,145	21,292	1%	21,396	1%	21,272	1%	21,461	1%
Wet	32,428	32,431	0%	32,422	0%	32,495	0%	32,518	0%
Above Normal	24,747	24,856	0%	24,859	0%	24,917	1%	24,877	1%
Below Normal	16,563	16,569	0%	16,592	0%	16,650	1%	16,652	1%
Dry	14,233	14,683	3%	15,081	6%	14,437	1%	15,039	6%
Critical	8,809	9,013	2%	9,118	4%	8,957	2%	9,332	6%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-47. Delta Inflow (cfs) in November, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	19,463	19,442	0%	19,510	0%	19,534	0%	19,503	0%
Wet	26,536	26,397	0%	26,428	0%	26,504	0%	26,433	0%
Above Normal	20,052	19,854	-2%	19,788	-2%	19,676	-3%	19,651	-3%
Below Normal	16,980	16,884	-1%	16,986	0%	16,947	0%	16,972	0%
Dry	15,705	15,909	1%	16,074	2%	16,163	2%	16,116	2%
Critical	12,081	12,244	-1%	12,339	0%	12,364	0%	12,372	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-48. Delta Inflow (cfs) in December, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	30,988	30,838	0%	30,692	-1%	30,568	-1%	30,568	-1%
Wet	53,516	53,042	-1%	52,765	-1%	52,445	-2%	52,482	-2%
Above Normal	28,223	28,197	0%	28,079	-1%	27,886	-1%	27,981	-1%
Below Normal	22,143	22,223	0%	22,046	0%	21,965	-1%	21,842	-1%
Dry	18,837	18,743	-1%	18,696	-1%	18,715	-1%	18,696	-1%
Critical	13,484	13,565	1%	13,560	1%	13,666	1%	13,666	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

2.3 Sacramento River Inflow

Flow within the Sacramento River has been identified as an important factor affecting the survival of emigrating juvenile Chinook salmon, important to the downstream transport of planktonic fish eggs and larvae such as delta and longfin smelt, striped bass and shad, and important for seasonal floodplain inundation that has been identified as important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon and steelhead. Sacramento River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in Sacramento River flow as a result of proposed project operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

Results of the comparative analysis of model results, by month and year type, for baseline conditions and under the three project alternatives of Sacramento River flow under existing conditions are summarized in Tables 2-49 through 2-60, while those under future conditions are presented in Tables 2-61 through 2-72.

Table 2-49. Sacramento River Inflow (cfs) in January, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	31,139	31,144	0%	31,061	0%	31,068	0%	31,046	0%
Wet	50,173	50,145	0%	50,083	0%	50,005	0%	50,011	0%
Above Normal	38,122	38,073	0%	38,034	0%	38,012	0%	37,945	0%
Below Normal	22,370	22,461	0%	22,485	1%	22,422	0%	22,420	0%
Dry	16,980	16,924	0%	16,886	-1%	16,885	-1%	16,884	-1%
Critical	14,384	14,505	1%	14,145	-2%	14,459	1%	14,362	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-50. Sacramento River Inflow (cfs) in February, Modeled for Existing Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	36,608	36,567	0%	36,596	0%	36,578	0%	36,559	0%
Wet	56,740	56,763	0%	56,769	0%	56,783	0%	56,751	0%
Above Normal	44,453	44,104	-1%	44,029	-1%	43,988	-1%	43,913	-1%
Below Normal	30,911	31,023	0%	31,054	0%	31,056	0%	31,090	1%
Dry	21,249	21,178	0%	21,192	0%	21,203	0%	21,103	-1%
Critical	14,830	14,824	0%	15,028	1%	14,897	0%	15,020	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-51. Sacramento River Inflow (cfs) in March, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	32,396	32,367	0%	32,332	0%	32,342	0%	32,301	0%
Wet	49,248	49,287	0%	49,293	0%	49,279	0%	49,293	0%
Above Normal	44,060	44,017	0%	43,860	0%	43,726	-1%	43,672	-1%
Below Normal	23,188	22,992	-1%	22,900	-1%	23,053	-1%	22,866	-1%
Dry	20,390	20,389	0%	20,400	0%	20,405	0%	20,414	0%
Critical	12,971	12,961	0%	12,954	0%	13,002	0%	12,954	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-52. Sacramento River Inflow (cfs) in April, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	23,232	23,241	0%	23,246	0%	23,280	0%	23,290	0%
Wet	37,918	37,929	0%	37,923	0%	37,951	0%	37,953	0%
Above Normal	26,053	26,041	0%	26,044	0%	25,963	0%	26,062	0%
Below Normal	17,518	17,565	0%	17,613	1%	17,697	1%	17,648	1%
Dry	13,205	13,202	0%	13,182	0%	13,290	1%	13,300	1%
Critical	10,295	10,300	0%	10,314	0%	10,309	0%	10,316	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-53. Sacramento River Inflow (cfs) in May, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	19,417	19,369	0%	19,341	0%	19,352	0%	19,349	0%
Wet	32,095	32,084	0%	32,075	0%	32,075	0%	32,071	0%
Above Normal	21,204	21,110	0%	21,145	0%	21,080	-1%	21,092	-1%
Below Normal	14,530	14,326	-1%	14,166	-3%	14,168	-2%	14,133	-3%
Dry	11,226	11,252	0%	11,225	0%	11,327	1%	11,332	1%
Critical	8,148	8,134	0%	8,161	0%	8,142	0%	8,152	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-54. Sacramento River Inflow (cfs) in June, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	16,508	16,454	0%	16,455	0%	16,475	0%	16,452	0%
Wet	24,092	24,092	0%	24,089	0%	24,092	0%	24,090	0%
Above Normal	16,598	16,264	-2%	16,160	-3%	16,176	-3%	16,136	-3%
Below Normal	13,792	13,805	0%	13,894	1%	13,911	1%	13,879	1%
Dry	12,283	12,247	0%	12,256	0%	12,323	0%	12,271	0%
Critical	9,492	9,493	0%	9,494	0%	9,491	0%	9,493	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-55. Sacramento River Inflow (cfs) in July, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	19,518	19,531	0%	19,551	0%	19,529	0%	19,579	0%
Wet	20,071	20,077	0%	20,081	0%	20,104	0%	20,058	0%
Above Normal	22,070	21,990	0%	21,983	0%	21,970	0%	21,966	0%
Below Normal	21,232	21,256	0%	21,242	0%	21,349	1%	21,301	0%
Dry	19,577	19,620	0%	19,571	0%	19,544	0%	19,623	0%
Critical	13,683	13,741	0%	13,964	2%	13,695	0%	14,077	3%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-56. Sacramento River Inflow (cfs) in August, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	14,710	14,743	0%	14,721	0%	14,695	0%	14,717	0%
Wet	16,285	16,306	0%	16,303	0%	16,297	0%	16,266	0%
Above Normal	16,418	16,393	0%	16,396	0%	16,393	0%	16,388	0%
Below Normal	16,112	16,110	0%	16,010	-1%	16,050	0%	16,040	0%
Dry	13,632	13,841	2%	13,855	2%	13,632	0%	13,915	2%
Critical	9,570	9,461	-1%	9,416	-2%	9,536	0%	9,348	-2%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-57. Sacramento River Inflow (cfs) in September, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	18,211	18,313	1%	18,338	1%	18,257	0%	18,449	1%
Wet	27,839	27,841	0%	27,841	0%	28,002	1%	27,997	1%
Above Normal	21,244	21,261	0%	21,262	0%	21,244	0%	21,234	0%
Below Normal	14,088	14,116	0%	14,088	0%	14,112	0%	14,038	0%
Dry	12,522	12,779	2%	12,915	3%	12,404	-1%	13,036	4%
Critical	7,664	7,920	3%	7,917	3%	7,771	1%	8,241	8%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-58. Sacramento River Inflow (cfs) in October, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	11,309	11,389	1%	11,401	1%	11,416	1%	11,416	1%
Wet	13,419	13,493	1%	13,472	0%	13,543	1%	13,506	1%
Above Normal	10,499	10,687	2%	10,738	2%	10,734	2%	10,714	2%
Below Normal	11,053	11,188	1%	11,211	1%	11,074	0%	11,259	2%
Dry	10,150	10,260	1%	10,287	1%	10,258	1%	10,281	1%
Critical	9,587	9,461	-1%	9,471	-1%	9,626	0%	9,477	-1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-59. Sacramento River Inflow (cfs) in November, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	15,640	15,677	0%	15,735	1%	15,703	0%	15,710	0%
Wet	20,726	20,866	1%	20,893	1%	20,936	1%	20,867	1%
Above Normal	16,893	16,375	-3%	16,497	-2%	16,259	-4%	16,281	-4%
Below Normal	13,755	13,819	0%	13,823	0%	13,809	0%	13,833	1%
Dry	12,720	12,890	1%	12,988	2%	12,975	2%	13,004	2%
Critical	9,948	10,086	1%	10,149	2%	10,113	2%	10,214	3%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-60. Sacramento River Inflow (cfs) in December, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	23,248	23,182	0%	23,227	0%	23,156	0%	23,143	0%
Wet	37,645	37,420	-1%	37,487	0%	37,341	-1%	37,387	-1%
Above Normal	22,604	22,694	0%	22,586	0%	22,634	0%	22,532	0%
Below Normal	16,930	16,961	0%	16,956	0%	16,871	0%	16,902	0%
Dry	15,760	15,701	0%	15,720	0%	15,716	0%	15,750	0%
Critical	11,303	11,299	0%	11,547	2%	11,439	1%	11,262	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-61. Sacramento River Inflow (cfs) in January, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	31,167	31,136	0%	31,107	0%	31,061	0%	31,076	0%
Wet	50,164	50,098	0%	49,991	0%	49,930	0%	49,899	-1%
Above Normal	38,006	37,960	0%	37,988	0%	37,955	0%	37,975	0%
Below Normal	22,540	22,654	1%	22,649	0%	22,658	1%	22,643	0%
Dry	17,109	17,025	0%	16,929	-1%	16,936	-1%	16,929	-1%
Critical	14,322	14,291	0%	14,442	1%	14,274	0%	14,455	1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-62. Sacramento River Inflow (cfs) in February, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	36,618	36,586	0%	36,563	0%	36,535	0%	36,490	0%
Wet	56,637	56,661	0%	56,659	0%	56,660	0%	56,637	0%
Above Normal	44,672	44,295	-1%	44,176	-1%	44,089	-1%	44,028	-1%
Below Normal	30,780	30,909	0%	30,923	0%	30,838	0%	30,832	0%
Dry	21,237	21,144	0%	21,120	-1%	21,095	-1%	21,002	-1%
Critical	15,075	15,168	1%	15,152	1%	15,179	1%	15,129	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-63. Sacramento River Inflow (cfs) in March, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	32,352	32,343	0%	32,319	0%	32,262	0%	32,284	0%
Wet	49,403	49,461	0%	49,461	0%	49,448	0%	49,459	0%
Above Normal	43,972	43,939	0%	43,783	0%	43,573	-1%	43,624	-1%
Below Normal	23,068	22,978	0%	22,928	-1%	22,758	-1%	22,855	-1%
Dry	20,138	20,107	0%	20,135	0%	20,143	0%	20,151	0%
Critical	12,942	12,938	0%	12,941	0%	12,982	0%	12,930	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-64. Sacramento River Inflow (cfs) in April, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	23,206	23,222	0%	23,247	0%	23,292	0%	23,257	0%
Wet	38,019	38,024	0%	38,030	0%	38,035	0%	38,025	0%
Above Normal	26,039	26,048	0%	26,049	0%	26,128	0%	26,048	0%
Below Normal	17,439	17,450	0%	17,465	0%	17,573	1%	17,526	0%
Dry	13,164	13,185	0%	13,261	1%	13,313	1%	13,297	1%
Critical	10,067	10,111	0%	10,140	1%	10,158	1%	10,095	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-65. Sacramento River Inflow (cfs) in May, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	19,114	19,069	0%	19,046	0%	19,064	0%	19,054	0%
Wet	31,800	31,785	0%	31,795	0%	31,790	0%	31,789	0%
Above Normal	21,080	20,859	-1%	20,843	-1%	20,882	-1%	20,871	-1%
Below Normal	14,144	13,965	-1%	13,801	-2%	13,858	-2%	13,780	-3%
Dry	10,836	10,893	1%	10,911	1%	10,987	1%	10,987	1%
Critical	7,874	7,945	1%	7,946	1%	7,863	0%	7,901	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-66. Sacramento River Inflow (cfs) in June, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	16,511	16,488	0%	16,462	0%	16,449	0%	16,420	-1%
Wet	23,905	23,902	0%	23,920	0%	23,920	0%	23,920	0%
Above Normal	16,533	16,369	-1%	16,179	-2%	16,165	-2%	16,166	-2%
Below Normal	13,822	13,868	0%	13,889	0%	13,812	0%	13,677	-1%
Dry	12,569	12,544	0%	12,509	0%	12,525	0%	12,493	-1%
Critical	9,516	9,516	0%	9,517	0%	9,507	0%	9,517	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-67. Sacramento River Inflow (cfs) in July, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	19,266	19,303	0%	19,333	0%	19,320	0%	19,386	1%
Wet	20,058	20,062	0%	20,052	0%	20,063	0%	20,016	0%
Above Normal	21,976	21,954	0%	21,942	0%	21,924	0%	21,927	0%
Below Normal	21,374	21,359	0%	21,301	0%	21,383	0%	21,350	0%
Dry	18,788	18,866	0%	19,006	1%	18,900	1%	19,113	2%
Critical	13,100	13,267	1%	13,363	2%	13,334	2%	13,596	4%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-68. Sacramento River Inflow (cfs) in August, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	14,596	14,637	0%	14,663	0%	14,690	1%	14,697	1%
Wet	16,189	16,185	0%	16,182	0%	16,180	0%	16,152	0%
Above Normal	16,561	16,569	0%	16,574	0%	16,575	0%	16,575	0%
Below Normal	16,170	16,104	0%	16,106	0%	16,205	0%	16,105	0%
Dry	12,968	13,177	2%	13,284	2%	13,276	2%	13,572	5%
Critical	9,785	9,831	0%	9,847	1%	9,933	2%	9,716	-1%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-69. Sacramento River Inflow (cfs) in September, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	18,417	18,563	1%	18,667	1%	18,544	1%	18,733	2%
Wet	28,337	28,340	0%	28,331	0%	28,403	0%	28,426	0%
Above Normal	22,088	22,197	0%	22,200	1%	22,257	1%	22,218	1%
Below Normal	14,147	14,152	0%	14,175	0%	14,233	1%	14,236	1%
Dry	12,341	12,792	4%	13,189	7%	12,545	2%	13,147	7%
Critical	7,347	7,550	3%	7,655	4%	7,494	2%	7,869	7%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-70. Sacramento River Inflow (cfs) in October, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	11,117	11,184	1%	11,210	1%	11,219	1%	11,230	1%
Wet	13,040	13,099	0%	13,056	0%	13,070	0%	13,080	0%
Above Normal	10,571	10,707	1%	10,760	2%	10,781	2%	10,790	2%
Below Normal	11,195	11,174	0%	11,211	0%	11,228	0%	11,242	0%
Dry	9,830	9,972	1%	10,100	3%	10,085	3%	10,120	3%
Critical	9,333	9,340	0%	9,325	0%	9,334	0%	9,313	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-71. Sacramento River Inflow (cfs) in November, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	15,605	15,629	0%	15,699	1%	15,724	1%	15,694	1%
Wet	20,832	20,821	0%	20,854	0%	20,929	0%	20,860	0%
Above Normal	16,666	16,506	-1%	16,449	-1%	16,344	-2%	16,319	-2%
Below Normal	13,793	13,695	-1%	13,798	0%	13,759	0%	13,784	0%
Dry	12,723	12,926	2%	13,091	3%	13,181	4%	13,134	3%
Critical	9,653	9,815	2%	9,911	3%	9,935	3%	9,944	3%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-72. Sacramento River Inflow (cfs) in December, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	23,229	23,174	0%	23,124	0%	23,096	-1%	23,090	-1%
Wet	37,434	37,236	-1%	37,188	-1%	37,045	-1%	37,102	-1%
Above Normal	22,461	22,468	0%	22,378	0%	22,287	-1%	22,282	-1%
Below Normal	17,103	17,193	1%	17,134	0%	17,196	1%	17,083	0%
Dry	15,934	15,839	-1%	15,793	-1%	15,811	-1%	15,792	-1%
Critical	11,310	11,390	1%	11,386	1%	11,492	2%	11,492	2%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

2.4 San Joaquin River Flow at Vernalis

Flow within the San Joaquin River has been identified as an important factor affecting the survival of juvenile Chinook salmon migrating downstream from the tributaries through the mainstem San Joaquin River and Delta, important to the downstream transport of planktonic fish eggs and larvae such as striped bass, and important for seasonal floodplain inundation that is considered to be important habitat for successful spawning and larval rearing by species such as Sacramento splittail and as seasonal foraging habitat for juvenile Chinook salmon. San Joaquin River flows are also important in the transport of organic material and nutrients from the upper regions of the watershed downstream into the Delta. A reduction in San Joaquin River flow as a result of proposed project operations, depending on the season and magnitude of change, could adversely affect habitat conditions for both resident and migratory fish species. An increase in river flow is generally considered to be beneficial for aquatic resources within the normal range of typical project operations and flood control. Very large changes in river flow could also affect sediment erosion, scour, deposition, suspended and bedload transport, and other geomorphic processes within the river and watershed.

Results of the comparative analysis of model results, by month and year type, for baseline conditions and under the three project alternatives of San Joaquin River flow under existing conditions are summarized in Tables 2-73 through 2-84, and those under future conditions are presented in Tables 2-85 through 2-96.

Table 2-73. San Joaquin River Flow (cfs) at Vernalis in January, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	4,770	4,770	0%	4,770	0%	4,770	0%	4,770	0%
Wet	9,273	9,273	0%	9,273	0%	9,273	0%	9,273	0%
Above Normal	4,223	4,223	0%	4,223	0%	4,223	0%	4,223	0%
Below Normal	2,986	2,986	0%	2,986	0%	2,986	0%	2,986	0%
Dry	2,084	2,084	0%	2,084	0%	2,084	0%	2,084	0%
Critical	1,673	1,673	0%	1,673	0%	1,673	0%	1,673	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-74. San Joaquin River Flow (cfs) at Vernalis in February, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,265	6,265	0%	6,265	0%	6,265	0%	6,265	0%
Wet	11,036	11,036	0%	11,036	0%	11,036	0%	11,036	0%
Above Normal	6,047	6,047	0%	6,047	0%	6,047	0%	6,047	0%
Below Normal	5,767	5,767	0%	5,767	0%	5,767	0%	5,767	0%
Dry	2,642	2,642	0%	2,642	0%	2,642	0%	2,642	0%
Critical	2,161	2,161	0%	2,161	0%	2,161	0%	2,161	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-75. San Joaquin River Flow (cfs) at Vernalis in March, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	7,133	7,133	0%	7,133	0%	7,133	0%	7,133	0%
Wet	13,443	13,443	0%	13,443	0%	13,443	0%	13,443	0%
Above Normal	6,788	6,788	0%	6,788	0%	6,787	0%	6,787	0%
Below Normal	5,322	5,322	0%	5,322	0%	5,322	0%	5,322	0%
Dry	2,963	2,963	0%	2,963	0%	2,963	0%	2,963	0%
Critical	2,176	2,176	0%	2,176	0%	2,176	0%	2,176	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-76. San Joaquin River Flow (cfs) at Vernalis in April, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,720	6,720	0%	6,720	0%	6,720	0%	6,720	0%
Wet	11,420	11,420	0%	11,420	0%	11,420	0%	11,420	0%
Above Normal	6,671	6,671	0%	6,671	0%	6,671	0%	6,671	0%
Below Normal	5,852	5,852	0%	5,852	0%	5,852	0%	5,852	0%
Dry	3,726	3,726	0%	3,726	0%	3,726	0%	3,726	0%
Critical	2,087	2,087	0%	2,088	0%	2,088	0%	2,087	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-77. San Joaquin River Flow (cfs) at Vernalis in May, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,204	6,204	0%	6,204	0%	6,204	0%	6,204	0%
Wet	11,268	11,268	0%	11,268	0%	11,267	0%	11,267	0%
Above Normal	5,611	5,611	0%	5,611	0%	5,611	0%	5,611	0%
Below Normal	5,010	5,010	0%	5,009	0%	5,009	0%	5,009	0%
Dry	3,070	3,070	0%	3,069	0%	3,070	0%	3,069	0%
Critical	1,920	1,920	0%	1,921	0%	1,921	0%	1,920	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-78. San Joaquin River Flow (cfs) at Vernalis in June, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	4,739	4,739	0%	4,740	0%	4,740	0%	4,739	0%
Wet	9,451	9,451	0%	9,451	0%	9,451	0%	9,451	0%
Above Normal	5,608	5,609	0%	5,609	0%	5,609	0%	5,609	0%
Below Normal	2,424	2,424	0%	2,423	0%	2,424	0%	2,424	0%
Dry	1,598	1,598	0%	1,597	0%	1,598	0%	1,597	0%
Critical	1,076	1,076	0%	1,077	0%	1,077	0%	1,076	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-79. San Joaquin River Flow (cfs) at Vernalis in July, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	3,202	3,202	0%	3,202	0%	3,203	0%	3,202	0%
Wet	6,556	6,556	0%	6,557	0%	6,557	0%	6,557	0%
Above Normal	2,783	2,784	0%	2,784	0%	2,784	0%	2,784	0%
Below Normal	1,775	1,775	0%	1,775	0%	1,776	0%	1,775	0%
Dry	1,282	1,282	0%	1,282	0%	1,282	0%	1,282	0%
Critical	898	898	0%	899	0%	899	0%	898	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-80. San Joaquin River Flow (cfs) at Vernalis in August, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,029	2,029	0%	2,029	0%	2,029	0%	2,029	0%
Wet	3,099	3,099	0%	3,099	0%	3,099	0%	3,099	0%
Above Normal	2,020	2,020	0%	2,020	0%	2,020	0%	2,020	0%
Below Normal	1,828	1,828	0%	1,828	0%	1,828	0%	1,828	0%
Dry	1,342	1,342	0%	1,342	0%	1,342	0%	1,342	0%
Critical	984	984	0%	984	0%	984	0%	984	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-81. San Joaquin River Flow (cfs) at Vernalis in September, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,331	2,331	0%	2,331	0%	2,331	0%	2,331	0%
Wet	3,274	3,274	0%	3,274	0%	3,274	0%	3,274	0%
Above Normal	2,328	2,328	0%	2,328	0%	2,328	0%	2,328	0%
Below Normal	2,109	2,109	0%	2,109	0%	2,109	0%	2,109	0%
Dry	1,795	1,795	0%	1,794	0%	1,795	0%	1,794	0%
Critical	1,358	1,358	0%	1,358	0%	1,358	0%	1,358	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-82. San Joaquin River Flow (cfs) at Vernalis in October, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,757	2,757	0%	2,757	0%	2,757	0%	2,757	0%
Wet	3,112	3,112	0%	3,112	0%	3,112	0%	3,112	0%
Above Normal	2,446	2,446	0%	2,446	0%	2,446	0%	2,446	0%
Below Normal	2,749	2,749	0%	2,749	0%	2,749	0%	2,749	0%
Dry	2,686	2,686	0%	2,686	0%	2,687	0%	2,687	0%
Critical	2,416	2,416	0%	2,416	0%	2,416	0%	2,416	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-83. San Joaquin River Flow (cfs) at Vernalis in November, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,633	2,633	0%	2,633	0%	2,633	0%	2,633	0%
Wet	3,372	3,372	0%	3,372	0%	3,372	0%	3,372	0%
Above Normal	2,213	2,213	0%	2,213	0%	2,213	0%	2,213	0%
Below Normal	2,412	2,412	0%	2,412	0%	2,412	0%	2,412	0%
Dry	2,388	2,388	0%	2,388	0%	2,388	0%	2,388	0%
Critical	2,075	2,075	0%	2,075	0%	2,075	0%	2,075	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-84. San Joaquin River Flow (cfs) at Vernalis in December, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	3,199	3,199	0%	3,199	0%	3,199	0%	3,199	0%
Wet	5,081	5,081	0%	5,081	0%	5,081	0%	5,081	0%
Above Normal	2,916	2,916	0%	2,916	0%	2,916	0%	2,916	0%
Below Normal	2,705	2,705	0%	2,705	0%	2,705	0%	2,705	0%
Dry	2,047	2,047	0%	2,047	0%	2,047	0%	2,047	0%
Critical	1,710	1,710	0%	1,710	0%	1,710	0%	1,710	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-85. San Joaquin River Flow (cfs) at Vernalis in January, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	4,764	4,764	0%	4,764	0%	4,764	0%	4,764	0%
Wet	9,097	9,097	0%	9,097	0%	9,097	0%	9,097	0%
Above Normal	4,259	4,259	0%	4,259	0%	4,259	0%	4,259	0%
Below Normal	3,081	3,081	0%	3,081	0%	3,081	0%	3,081	0%
Dry	2,160	2,160	0%	2,160	0%	2,160	0%	2,160	0%
Critical	1,746	1,746	0%	1,746	0%	1,746	0%	1,746	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-86. San Joaquin River Flow (cfs) at Vernalis in February, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,143	6,143	0%	6,143	0%	6,143	0%	6,143	0%
Wet	10,845	10,845	0%	10,845	0%	10,845	0%	10,845	0%
Above Normal	6,179	6,179	0%	6,179	0%	6,179	0%	6,179	0%
Below Normal	5,565	5,565	0%	5,565	0%	5,565	0%	5,565	0%
Dry	2,528	2,528	0%	2,528	0%	2,528	0%	2,528	0%
Critical	2,014	2,014	0%	2,014	0%	2,014	0%	2,014	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-87. San Joaquin River Flow (cfs) at Vernalis in March, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	7,003	7,003	0%	7,003	0%	7,003	0%	7,003	0%
Wet	13,170	13,170	0%	13,170	0%	13,170	0%	13,170	0%
Above Normal	6,674	6,673	0%	6,673	0%	6,673	0%	6,673	0%
Below Normal	5,293	5,293	0%	5,293	0%	5,293	0%	5,293	0%
Dry	2,895	2,895	0%	2,895	0%	2,895	0%	2,895	0%
Critical	2,129	2,129	0%	2,129	0%	2,129	0%	2,129	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-88. San Joaquin River Flow (cfs) at Vernalis in April, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	7,533	7,533	0%	7,533	0%	7,533	0%	7,533	0%
Wet	12,614	12,614	0%	12,614	0%	12,614	0%	12,614	0%
Above Normal	7,799	7,798	0%	7,798	0%	7,798	0%	7,798	0%
Below Normal	6,910	6,910	0%	6,910	0%	6,910	0%	6,910	0%
Dry	4,112	4,112	0%	4,112	0%	4,112	0%	4,112	0%
Critical	2,118	2,118	0%	2,118	0%	2,119	0%	2,118	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-89. San Joaquin River Flow (cfs) at Vernalis in May, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	6,234	6,234	0%	6,234	0%	6,234	0%	6,234	0%
Wet	11,135	11,135	0%	11,135	0%	11,135	0%	11,135	0%
Above Normal	5,987	5,987	0%	5,987	0%	5,987	0%	5,987	0%
Below Normal	5,108	5,108	0%	5,108	0%	5,108	0%	5,108	0%
Dry	3,111	3,111	0%	3,112	0%	3,112	0%	3,112	0%
Critical	1,862	1,862	0%	1,862	0%	1,862	0%	1,862	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-90. San Joaquin River Flow (cfs) at Vernalis in June, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	4,671	4,671	0%	4,671	0%	4,671	0%	4,671	0%
Wet	9,390	9,390	0%	9,390	0%	9,390	0%	9,390	0%
Above Normal	5,326	5,326	0%	5,326	0%	5,326	0%	5,326	0%
Below Normal	2,471	2,470	0%	2,470	0%	2,471	0%	2,471	0%
Dry	1,554	1,554	0%	1,554	0%	1,554	0%	1,554	0%
Critical	1,035	1,035	0%	1,035	0%	1,036	0%	1,035	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-91. San Joaquin River Flow (cfs) at Vernalis in July, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	3,208	3,208	0%	3,209	0%	3,209	0%	3,209	0%
Wet	6,660	6,660	0%	6,660	0%	6,660	0%	6,660	0%
Above Normal	2,767	2,768	0%	2,768	0%	2,768	0%	2,768	0%
Below Normal	1,733	1,733	0%	1,733	0%	1,734	0%	1,733	0%
Dry	1,216	1,216	0%	1,217	0%	1,217	0%	1,217	0%
Critical	880	880	0%	880	0%	882	0%	881	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-92. San Joaquin River Flow (cfs) at Vernalis in August, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,040	2,041	0%	2,041	0%	2,041	0%	2,041	0%
Wet	3,158	3,159	0%	3,159	0%	3,159	0%	3,159	0%
Above Normal	2,014	2,015	0%	2,015	0%	2,015	0%	2,015	0%
Below Normal	1,817	1,816	0%	1,816	0%	1,817	0%	1,816	0%
Dry	1,315	1,315	0%	1,315	0%	1,316	0%	1,316	0%
Critical	993	993	0%	993	0%	994	0%	993	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-93. San Joaquin River Flow (cfs) at Vernalis in September, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,340	2,340	0%	2,340	0%	2,340	0%	2,340	0%
Wet	3,317	3,317	0%	3,317	0%	3,318	0%	3,318	0%
Above Normal	2,312	2,312	0%	2,312	0%	2,312	0%	2,312	0%
Below Normal	2,119	2,119	0%	2,119	0%	2,119	0%	2,119	0%
Dry	1,774	1,775	0%	1,775	0%	1,775	0%	1,775	0%
Critical	1,355	1,355	0%	1,355	0%	1,355	0%	1,355	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-94. San Joaquin River Flow (cfs) at Vernalis in October, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,753	2,753	0%	2,753	0%	2,754	0%	2,754	0%
Wet	3,107	3,107	0%	3,107	0%	3,107	0%	3,107	0%
Above Normal	2,424	2,424	0%	2,424	0%	2,424	0%	2,424	0%
Below Normal	2,718	2,718	0%	2,718	0%	2,718	0%	2,718	0%
Dry	2,710	2,710	0%	2,710	0%	2,710	0%	2,710	0%
Critical	2,423	2,423	0%	2,423	0%	2,423	0%	2,423	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-95. San Joaquin River Flow (cfs) at Vernalis in November, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	2,603	2,603	0%	2,603	0%	2,603	0%	2,603	0%
Wet	3,340	3,340	0%	3,340	0%	3,340	0%	3,340	0%
Above Normal	2,176	2,176	0%	2,176	0%	2,176	0%	2,176	0%
Below Normal	2,360	2,360	0%	2,360	0%	2,360	0%	2,360	0%
Dry	2,355	2,355	0%	2,355	0%	2,355	0%	2,355	0%
Critical	2,088	2,088	0%	2,088	0%	2,088	0%	2,088	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-96. San Joaquin River Flow (cfs) at Vernalis in December, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	3,263	3,263	0%	3,263	0%	3,263	0%	3,263	0%
Wet	5,178	5,178	0%	5,178	0%	5,178	0%	5,178	0%
Above Normal	2,899	2,899	0%	2,899	0%	2,899	0%	2,899	0%
Below Normal	2,753	2,753	0%	2,753	0%	2,753	0%	2,753	0%
Dry	2,123	2,123	0%	2,123	0%	2,123	0%	2,123	0%
Critical	1,785	1,785	0%	1,785	0%	1,785	0%	1,785	0%

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

2.5 Entrapment Zone Location and X2

In many segments of the Bay-Delta, but particularly in Suisun Bay and the Delta, salinity is controlled by the balance of salt water intrusion from San Francisco Bay and freshwater flow from the tributaries to the Delta by altering the timing and volume of flows, water development has affected salinity patterns in the Delta and in parts of San Francisco Bay (SFEP 1992). Under natural conditions, the Carquinez Strait/Suisun Bay region marked the approximate boundary between salt and fresh water in the Bay-Delta during much of the year. In the late summer and fall of drier years, when Delta outflow was minimal, seawater moved into the Delta from San Francisco Bay. Beginning in the 1920s, following several dry years and because of increased upstream storage and diversions, salinity intrusions became more frequent and extensive.

Since the 1940s, releases of fresh water from upstream storage facilities have increased Delta outflows during summer and fall. These flows have correspondingly limited the extent of salinity intrusion into the Delta. Reservoir releases have helped to ensure that the salinity of water diverted from the Delta is acceptable during the summer and late fall for farming, municipal, and industrial uses (SFEP 1992).

Salinity is an important habitat factor in the Bay-Delta. All estuarine species are assumed to have optimal salinity ranges, and their survival may be affected by the amount of habitat available within the species' optimal salinity range. Because the salinity field in the Bay-Delta is largely controlled by freshwater outflows, the level of outflow may determine the surface area of optimal salinity habitat that is available to the species (Hieb and Baxter 1993, Unger 1994).

The transition area between saline waters within the Bay and freshwater within the rivers, frequently referred to as the low salinity zone, is located within Suisun Bay and the western Delta. The low salinity zone has also been associated with the entrapment zone, a region of the Bay-Delta characterized by higher levels of particulates, higher abundances of several types of organisms, and a turbidity maximum. It is commonly associated with the position of the 2 ppt salinity isopleth (X2), but actually occurs over a broader range of salinities (Kimmerer 1992). Originally, the primary mechanism responsible for this region was thought to be gravitational circulation, a circulation pattern formed when freshwater flows seaward over a dense, landward-flowing marine tidal current. However, recent studies have shown that gravitational circulation does not occur in the entrapment zone in all years, nor is it always associated with X2 (Burau et al. 1998). Lateral circulation within the Bay-Delta or chemical flocculation may play a role in the formation of the turbidity maximum of the entrapment zone.

As a consequence of higher levels of particulates, the entrapment zone may be biologically significant to some species. Mixing and circulation in this zone concentrates plankton and other organic material, thus increasing food biomass and production. Larval fish such as striped bass, delta smelt, and longfin smelt may benefit from enhanced food resources. Since about 1987, however, the introduced Asian overbite clam population has cropped much of the primary production in the Bay-Delta and there has been virtually no enhancement of phytoplankton production or biomass in the entrapment zone (CUWA 1994).

Although the base of the food chain may not have been enhanced in the entrapment zone during the past decade, this region continues to have relatively high levels of invertebrates and larval fish. Vertical migration of these organisms through the water column at different parts of the tidal cycle has been proposed as a possible mechanism to maintain high abundance in this region, but recent evidence suggests that vertical migration does not provide a complete explanation (Kimmerer, pers. comm.).

Although recent evidence indicates that X2 and the entrapment zone are not as closely related as previously believed (Burau et al. 1998), X2 continues to be used as an index of the location of the entrapment zone and area/or of increased biological productivity. Historically, X2 has varied between San Pablo Bay (River Kilometer (km) 50) during high Delta outflow and Rio Vista (River km 100) during low Delta outflow. In recent years, it has typically been located between approximately Honker Bay and Sherman Island (River km 70 to 85). X2 is controlled directly by the volume of Delta outflow, although changes in X2 lag behind changes in outflow. Minor modifications in outflow do not greatly alter X2.

Jassby et al. (1995) showed that when X2 is in the vicinity of Suisun Bay, several estuarine organisms tend to show increased abundance. However, it is by no means certain that X2 has a direct effect on any of the species. The observed correlations may result from a close relationship between X2 and other factors that affect these species.

Operations of upstream storage reservoirs have the potential to affect the location of X2 as a result of changes in freshwater flows from the upstream tributaries through the Delta. For purposes of evaluating changes in habitat quantity and quality for estuarine species, a significance criterion of an upstream change in X2 location within 1 km of the baseline condition was considered to be less than significant. The criterion was applied to a comparison of hydrologic model results for baseline conditions and project alternatives, by month and water year, for the months from February through May. Results of the comparison for existing conditions are summarized in Tables 2-97 through 2-108, and those under future conditions are presented in Tables 2-109 through 2-120. These results showed that changes in X2 location under the three alternatives were less than 1 km (all were less than 0.5 km) with both variable upstream and downstream movement of the X2 location depending on month and water year. These results are consistent with model results for Delta outflow that showed a less-than-significant change in flows under existing conditions as well.

Table 2-97. X2 Location (km) in January, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	76.1	76.2	0.1	76.1	0.0	76.2	0.1	76.2	0.1
Wet	62.9	63.0	0.1	63.0	0.1	63.1	0.1	63.0	0.1
Above Normal	76.4	76.7	0.3	76.8	0.4	76.8	0.4	76.9	0.4
Below Normal	81.4	81.3	0.0	81.3	0.0	81.4	0.0	81.4	0.0
Dry	82.8	82.9	0.1	82.8	0.0	82.9	0.1	82.8	0.0
Critical	87.9	87.9	0.0	87.6	-0.3	87.7	-0.2	87.8	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-98. X2 Location (km) in February, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	67.5	67.5	0.0	67.5	0.0	67.5	0.0	67.5	0.0
Wet	53.6	53.6	0.0	53.7	0.0	53.7	0.1	53.7	0.1
Above Normal	61.7	61.7	0.0	61.7	0.0	61.7	0.0	61.7	0.0
Below Normal	72.1	72.0	-0.1	72.0	-0.1	72.0	-0.1	72.0	-0.1
Dry	77.9	78.0	0.1	78.0	0.1	78.0	0.1	78.0	0.1
Critical	82.2	82.0	-0.1	82.2	0.0	82.2	0.1	82.1	-0.1

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-99. X2 Location (km) in March, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	60.9	60.9	0.0	61.0	0.1	61.0	0.0	61.0	0.0
Wet	50.4	50.4	0.0	50.4	0.0	50.4	0.0	50.4	0.0
Above Normal	54.8	54.8	0.0	54.8	0.0	54.8	0.0	54.8	0.0
Below Normal	61.0	60.9	0.0	61.0	0.0	61.0	0.0	61.0	0.0
Dry	70.1	70.1	0.0	70.1	0.0	70.1	0.0	70.2	0.1
Critical	76.2	76.2	0.0	76.5	0.3	76.3	0.1	76.2	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-100. X2 Location (km) in April, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	60.9	60.9	0.0	61.0	0.0	60.9	0.0	61.0	0.0
Wet	52.1	52.1	0.0	52.1	0.0	52.1	0.0	52.1	0.0
Above Normal	53.6	53.7	0.0	53.7	0.0	53.7	0.0	53.8	0.0
Below Normal	63.3	63.4	0.1	63.4	0.0	63.3	0.0	63.4	0.0
Dry	67.1	67.0	-0.1	67.0	0.0	67.0	0.0	67.0	0.0
Critical	75.2	75.3	0.1	75.3	0.0	75.2	0.0	75.3	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-101. X2 Location (km) in May, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	63.5	63.5	0.0	63.5	0.0	63.5	0.0	63.5	0.0
Wet	54.5	54.5	0.0	54.5	0.0	54.5	0.0	54.5	0.0
Above Normal	58.6	58.6	0.0	58.6	0.0	58.6	0.0	58.6	0.0
Below Normal	64.5	64.5	0.0	64.5	0.0	64.4	-0.1	64.5	0.0
Dry	69.9	69.9	0.0	69.9	0.0	69.8	-0.1	69.8	-0.1
Critical	77.5	77.5	0.0	77.5	0.0	77.5	0.0	77.4	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-102. X2 Location (km) in June, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	67.5	67.5	0.0	67.5	0.0	67.5	0.0	67.5	0.0
Wet	57.6	57.6	0.0	57.6	0.0	57.6	0.0	57.6	0.0
Above Normal	62.7	62.7	0.0	62.7	0.0	62.7	0.0	62.7	0.0
Below Normal	68.3	68.4	0.1	68.4	0.1	68.3	0.1	68.4	0.1
Dry	74.4	74.4	0.0	74.4	0.0	74.2	-0.2	74.2	-0.2
Critical	82.5	82.5	0.0	82.5	0.0	82.5	0.0	82.5	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-103. X2 Location (km) in July, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	74.5	74.6	0.0	74.6	0.0	74.5	0.0	74.6	0.0
Wet	65.0	65.0	0.0	65.0	0.0	65.0	0.0	65.0	0.0
Above Normal	72.6	72.8	0.2	72.8	0.2	72.8	0.2	72.8	0.2
Below Normal	76.6	76.6	0.0	76.6	0.1	76.6	0.0	76.6	0.0
Dry	80.4	80.5	0.0	80.5	0.0	80.3	-0.1	80.4	-0.1
Critical	85.9	85.9	0.0	85.9	0.0	85.9	0.0	85.8	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-104. X2 Location (km) in August, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	80.5	80.5	0.0	80.5	0.0	80.5	0.0	80.5	0.0
Wet	74.4	74.4	0.0	74.4	0.0	74.4	0.0	74.4	0.0
Above Normal	78.1	78.2	0.1	78.3	0.2	78.3	0.2	78.3	0.2
Below Normal	81.7	81.7	0.0	81.7	0.0	81.7	0.0	81.7	0.0
Dry	84.8	84.9	0.0	84.9	0.0	84.8	-0.1	84.8	0.0
Critical	88.1	88.1	0.0	88.1	0.0	88.1	0.0	88.0	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-105. X2 Location (km) in September, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	85.6	85.6	0.0	85.5	0.0	85.6	0.0	85.5	0.0
Wet	82.7	82.6	0.0	82.6	0.0	82.6	0.0	82.7	0.0
Above Normal	83.7	83.8	0.0	83.8	0.0	83.8	0.0	83.8	0.0
Below Normal	85.6	85.6	0.0	85.5	0.0	85.5	0.0	85.5	0.0
Dry	87.8	87.8	0.0	87.8	0.0	87.8	0.0	87.8	0.0
Critical	90.4	90.3	-0.1	90.3	-0.2	90.4	0.0	90.2	-0.2

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-106. X2 Location (km) in October, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	83.5	83.5	0.0	83.4	0.0	83.5	0.0	83.4	0.0
Wet	80.7	80.7	0.0	80.7	0.0	80.7	0.0	80.7	0.0
Above Normal	83.0	83.0	0.0	83.0	0.0	83.1	0.1	82.9	-0.1
Below Normal	84.1	84.1	0.0	84.1	0.0	84.1	0.0	84.1	0.0
Dry	84.4	84.3	0.0	84.3	-0.1	84.4	0.0	84.3	-0.1
Critical	87.9	87.8	-0.1	87.9	0.0	87.9	0.0	87.8	-0.1

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-107. X2 Location (km) in November, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	83.9	83.9	0.0	83.9	0.0	83.9	0.0	83.8	-0.1
Wet	80.4	80.4	0.0	80.4	0.0	80.4	0.0	80.4	0.0
Above Normal	83.6	83.5	-0.1	83.6	0.0	83.6	0.0	83.5	-0.1
Below Normal	84.9	84.9	0.0	84.9	-0.1	84.9	0.0	84.9	-0.1
Dry	85.2	85.2	0.0	85.1	-0.1	85.2	0.0	85.1	-0.1
Critical	88.6	88.6	0.0	88.5	-0.1	88.6	0.0	88.5	-0.1

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-108. X2 Location (km) in December, Modeled for Existing Project Alternatives

Year Type	Base Location (km)	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	82.2	82.3	0.1	82.3	0.1	82.3	0.1	82.3	0.1
Wet	76.6	76.6	0.0	76.6	0.1	76.6	0.0	76.6	0.1
Above Normal	80.5	81.0	0.5	81.0	0.5	81.2	0.7	81.2	0.7
Below Normal	84.9	84.9	0.0	84.9	0.0	84.9	0.0	84.9	0.0
Dry	85.2	85.2	0.0	85.1	0.0	85.1	0.0	85.1	-0.1
Critical	88.6	88.6	0.0	88.6	0.0	88.6	0.0	88.5	-0.1

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-109. X2 Location (km) in January, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	76.0	76.0	0.0	76.1	0.1	76.0	0.0	76.1	0.1
Wet	63.0	63.1	0.1	63.1	0.1	63.2	0.1	63.2	0.2
Above Normal	76.4	76.6	0.2	76.7	0.3	76.8	0.4	76.8	0.4
Below Normal	81.1	81.1	0.0	81.1	0.0	81.1	0.0	81.2	0.0
Dry	82.6	82.7	0.1	82.7	0.1	82.4	-0.1	82.7	0.1
Critical	87.8	87.7	-0.1	87.6	-0.3	87.5	-0.4	87.5	-0.3

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-110. X2 Location (km) in February, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	67.3	67.3	0.0	67.3	0.0	67.2	0.0	67.3	0.0
Wet	53.7	53.7	0.0	53.7	0.1	53.7	0.1	53.8	0.1
Above Normal	61.6	61.6	0.0	61.5	0.0	61.6	0.0	61.5	0.0
Below Normal	71.7	71.6	-0.1	71.6	-0.1	71.6	-0.1	71.6	-0.1
Dry	77.4	77.6	0.1	77.6	0.2	77.4	-0.1	77.6	0.2
Critical	81.9	82.1	0.2	81.8	-0.1	81.9	0.0	81.8	-0.2

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-111. X2 Location (km) in March, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	60.8	60.9	0.0	60.8	0.0	60.9	0.0	60.9	0.1
Wet	50.4	50.4	0.0	50.4	0.0	50.4	0.0	50.4	0.0
Above Normal	54.6	54.6	0.1	54.6	0.0	54.6	0.1	54.6	0.1
Below Normal	60.9	60.9	0.0	60.9	0.0	60.9	0.0	60.9	0.0
Dry	69.9	70.0	0.0	70.0	0.1	69.9	0.0	70.0	0.1
Critical	75.9	76.1	0.2	75.9	0.0	76.1	0.2	75.9	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-112. X2 Location (km) in April, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	60.9	60.9	0.0	60.9	0.0	61.0	0.0	60.9	0.0
Wet	52.1	52.1	0.0	52.1	0.0	52.1	0.0	52.1	0.0
Above Normal	53.7	53.7	0.0	53.7	0.0	53.7	0.1	53.7	0.0
Below Normal	63.3	63.4	0.0	63.4	0.1	63.5	0.2	63.5	0.1
Dry	67.2	67.1	0.0	67.1	0.0	67.1	0.0	67.1	0.0
Critical	75.1	75.1	0.1	75.1	0.0	75.1	0.1	75.1	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-113. X2 Location (km) in May, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	63.4	63.4	0.0	63.4	0.0	63.3	0.0	63.4	0.0
Wet	54.3	54.3	0.0	54.3	0.0	54.3	0.0	54.3	0.0
Above Normal	58.4	58.4	0.0	58.4	0.0	58.4	0.0	58.4	0.0
Below Normal	64.1	64.1	0.0	64.2	0.0	64.1	0.0	64.1	0.0
Dry	69.9	69.8	-0.1	69.7	-0.1	69.7	-0.1	69.7	-0.1
Critical	77.6	77.6	0.0	77.6	0.0	77.6	0.0	77.7	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-114. X2 Location (km) in June, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	67.7	67.7	0.0	67.6	0.0	67.6	-0.1	67.6	0.0
Wet	57.7	57.7	0.0	57.7	0.0	57.7	0.0	57.7	0.0
Above Normal	62.6	62.6	0.1	62.6	0.1	62.6	0.0	62.6	0.0
Below Normal	68.3	68.4	0.1	68.5	0.1	68.4	0.0	68.4	0.1
Dry	74.8	74.7	-0.1	74.7	-0.1	74.6	-0.2	74.6	-0.2
Critical	82.9	82.8	-0.1	82.8	-0.1	82.7	-0.1	82.9	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-115. X2 Location (km) in July, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	74.7	74.7	0.0	74.8	0.0	74.7	0.0	74.8	0.1
Wet	65.2	65.2	0.0	65.2	0.0	65.2	0.0	65.2	0.0
Above Normal	72.7	72.8	0.1	72.9	0.2	72.9	0.2	72.9	0.2
Below Normal	76.7	76.8	0.1	76.8	0.1	76.8	0.1	76.9	0.3
Dry	80.7	80.7	0.0	80.7	0.0	80.6	-0.1	80.6	-0.1
Critical	86.0	86.0	0.0	86.0	0.0	86.0	-0.1	86.1	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-116. X2 Location (km) in August, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	80.5	80.5	0.0	80.5	0.0	80.5	0.0	80.6	0.0
Wet	74.5	74.5	0.0	74.5	0.0	74.5	0.0	74.5	0.0
Above Normal	78.4	78.4	0.1	78.5	0.1	78.5	0.2	78.5	0.1
Below Normal	81.6	81.6	0.0	81.6	0.0	81.7	0.0	81.7	0.1
Dry	84.8	84.8	0.0	84.8	0.0	84.8	0.0	84.8	0.1
Critical	88.0	88.0	0.0	88.0	0.0	88.0	0.0	88.0	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-117. X2 Location (km) in September, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	85.6	85.5	0.0	85.5	0.0	85.5	0.0	85.5	0.0
Wet	82.8	82.8	0.0	82.8	0.0	82.8	0.0	82.9	0.0
Above Normal	83.9	83.9	0.0	83.9	0.0	83.9	0.0	83.9	0.0
Below Normal	85.5	85.4	0.0	85.4	0.0	85.4	0.0	85.4	-0.1
Dry	87.5	87.5	0.0	87.5	0.0	87.5	0.0	87.5	0.0
Critical	90.2	90.2	0.0	90.1	-0.1	90.3	0.0	90.1	-0.1

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-118. X2 Location (km) in October, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	83.4	83.4	0.0	83.4	-0.1	83.4	0.0	83.4	-0.1
Wet	80.7	80.7	0.0	80.6	-0.1	80.7	0.0	80.6	-0.1
Above Normal	83.0	83.0	0.0	83.0	0.0	83.0	0.0	82.9	-0.1
Below Normal	84.1	84.0	0.0	84.0	-0.1	84.1	0.0	84.0	-0.1
Dry	84.3	84.2	0.0	84.2	-0.1	84.2	0.0	84.1	-0.1
Critical	87.8	87.8	0.0	87.8	0.0	87.9	0.0	87.8	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-119. X2 Location (km) in November, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	83.9	83.9	0.0	83.8	-0.1	83.9	0.0	83.8	-0.1
Wet	80.5	80.5	0.0	80.5	0.0	80.6	0.0	80.5	-0.1
Above Normal	83.4	83.3	-0.1	83.3	-0.1	83.3	-0.1	83.3	-0.1
Below Normal	84.9	84.8	0.0	84.8	0.0	84.9	0.0	84.8	-0.1
Dry	85.1	85.1	0.0	85.1	-0.1	85.1	-0.1	85.0	-0.1
Critical	88.7	88.6	0.0	88.6	-0.1	88.7	0.0	88.6	0.0

Key:
CP = Comprehensive Plan
km = kilometer

Table 2-120. X2 Location (km) in December, Modeled for Future Project Alternatives

Year Type	Base Location (km)	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		km	Difference (km)	km	Difference (km)	km	Difference (km)	km	Difference (km)
Average	82.2	82.3	0.1	82.3	0.1	82.3	0.1	82.3	0.1
Wet	76.6	76.7	0.1	76.7	0.1	76.7	0.1	76.7	0.1
Above Normal	80.5	80.8	0.2	80.8	0.3	80.9	0.4	80.9	0.4
Below Normal	84.7	84.8	0.1	84.8	0.1	84.8	0.1	84.8	0.1
Dry	85.2	85.2	0.0	85.2	0.0	85.2	0.0	85.2	0.0
Critical	88.7	88.7	0.0	88.6	-0.1	88.7	0.0	88.7	0.0

Key:
CP = Comprehensive Plan
km = kilometer

2.6 Old and Middle Rivers Reverse Flows

Reverse flows occur when Delta exports and agricultural demands exceed San Joaquin River inflow plus Sacramento River inflow through the DCC, Georgiana Slough, and Three Mile Slough. The capacities of the DCC, Georgiana Slough, and Three Mile Slough are fixed, so if pumping rates exceed that total capacity plus flows in Old River and Eastside streams, the pumping causes Sacramento River water to flow around the west end of Sherman Island and then eastward up the San Joaquin River. This condition occurs frequently during dry years with low Delta inflows and high levels of export at the SWP and CVP pumps. Reverse flows are particularly common during summer and fall when nearly all exported water is drawn across the Delta from the Sacramento River (DWR and Reclamation 1994). The reverse flow condition within the lower San Joaquin River is typically referred to as Qwest. As second reverse flow condition occurs within Old and Middle rivers as the rate of water diverted at the SWP and CVP export facilities exceeds tidal and downstream flows within the central region of the Delta.

There have been concerns regarding the effects of reverse flows on fish populations and their food supply, as well as the effects of reverse flows on delta smelt salvage (DWR and Reclamation 1994). Reverse flows in Old and Middle rivers, resulting from low San Joaquin River inflows and increased exports to the SWP and CVP, have been identified as a potential cause of increased delta smelt take at the SWP and CVP fish facilities, within recent years (Simi and Ruhl 2005, Ruhl et al. 2006, Wanger 2007 Case 1:05-cv-01207-OWW-NEW). Results of analyses of the relationship between the magnitude of reverse flows in Old and Middle rivers and salvage of adult delta smelt in the late winter shows a substantial increase in salvage as reverse flows exceed approximately -5,000 cfs. Concerns regarding reverse flows in Old and Middle rivers have also focused on planktonic egg and larval stages of striped bass, splittail, and on Chinook salmon smolts, in addition to delta smelt, and while these species do not spawn to a significant extent in the southern Delta, eggs and larvae may be transported into the area by reverse flows in Old and Middle rivers. As discussed previously, these early life stages are generally entrained, since they are too small to be effectively screened from export waters.

Reverse flows in Old and Middle rivers have been calculated for project alternatives that equate San Joaquin River flow at Vernalis and exports to Old and Middle rivers flows. Reverse flow summaries for Old and Middle rivers are included for base conditions, future base conditions, and for the three existing and three future project alternatives, by month and water year type. The most biologically sensate period when the potential effects of reverse flows could affect delta smelt, Chinook salmon, and many other species extends from the late winter through early summer. For purposes of these analyses a comparison of reverse flows within Old and Middle rivers under baseline and proposed alternative project operations was prepared for the seasonal period extending from January through June. Results for the comparison under existing conditions are summarized in Tables 2-121 through 2-132 and in Tables 2-133 through 2-144 for future conditions. A two-step analysis was performed first to determine those occasions when a change in flows greater than 5 percent was detected and for those conditions examining the seasonal period and potential vulnerability of delta smelt and other fish to potential increases in losses.

Table 2-121. Old and Middle Rivers Reverse Flows (cfs) in January, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-3,542	-3,544	0%	-3,550	0%	-3,575	1%	-3,526	0%
Wet	-2,034	-2,034	0%	-2,034	0%	-2,034	0%	-2,034	0%
Above Normal	-3,654	-3,645	0%	-3,598	-2%	-3,592	-2%	-3,586	-2%
Below Normal	-4,240	-4,240	0%	-4,240	0%	-4,240	0%	-4,240	0%
Dry	-4,773	-4,791	0%	-4,813	1%	-4,802	1%	-4,814	1%
Critical	-4,033	-4,029	0%	-4,086	1%	-4,282	6%	-3,936	-2%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-122. Old and Middle Rivers Reverse Flows (cfs) in February, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-3,293	-3,255	-1%	-3,289	0%	-3,287	0%	-3,300	0%
Wet	-2,745	-2,738	0%	-2,735	0%	-2,734	0%	-2,735	0%
Above Normal	-3,248	-3,061	-6%	-3,011	-7%	-3,012	-7%	-3,035	-7%
Below Normal	-3,335	-3,303	-1%	-3,401	2%	-3,464	4%	-3,437	3%
Dry	-4,016	-4,001	0%	-4,028	0%	-4,033	0%	-4,036	0%
Critical	-3,391	-3,393	0%	-3,527	4%	-3,433	1%	-3,528	4%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-123. Old and Middle Rivers Reverse Flows (cfs) in March, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-2,784	-2,810	1%	-2,814	1%	-2,799	1%	-2,817	1%
Wet	-1,792	-1,780	-1%	-1,786	0%	-1,789	0%	-1,808	1%
Above Normal	-4,021	-4,227	5%	-4,230	5%	-4,230	5%	-4,230	5%
Below Normal	-4,005	-4,001	0%	-4,015	0%	-4,008	0%	-4,002	0%
Dry	-2,951	-2,873	-3%	-2,873	-3%	-2,872	-3%	-2,872	-3%
Critical	-2,023	-2,138	6%	-2,136	6%	-2,038	1%	-2,125	5%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-124. Old and Middle Rivers Reverse Flows (cfs) in April, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	955	955	0%	954	0%	955	0%	954	0%
Wet	2,706	2,706	0%	2,706	0%	2,706	0%	2,706	0%
Above Normal	1,087	1,087	0%	1,087	0%	1,087	0%	1,087	0%
Below Normal	697	697	0%	697	0%	697	0%	697	0%
Dry	-244	-244	0%	-247	1%	-242	-1%	-249	2%
Critical	-874	-874	0%	-874	0%	-874	0%	-874	0%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-125. Old and Middle Rivers Reverse Flows (cfs) in May, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	491	490	0%	490	0%	492	0%	491	0%
Wet	2,077	2,077	0%	2,077	0%	2,076	0%	2,077	0%
Above Normal	562	562	0%	562	0%	562	0%	562	0%
Below Normal	277	277	0%	277	0%	277	0%	277	0%
Dry	-674	-674	0%	-674	0%	-674	0%	-674	0%
Critical	-1,018	-1,026	1%	-1,028	1%	-1,012	-1%	-1,022	0%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-126. Old and Middle Rivers Reverse Flows (cfs) in June, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-3,654	-3,652	0%	-3,669	0%	-3,669	0%	-3,669	0%
Wet	-4,226	-4,226	0%	-4,226	0%	-4,226	0%	-4,226	0%
Above Normal	-4,825	-4,825	0%	-4,819	0%	-4,819	0%	-4,819	0%
Below Normal	-4,137	-4,126	0%	-4,233	2%	-4,233	2%	-4,233	2%
Dry	-3,079	-3,079	0%	-3,079	0%	-3,079	0%	-3,079	0%
Critical	-1,542	-1,542	0%	-1,542	0%	-1,542	0%	-1,542	0%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-127. Old and Middle Rivers Reverse Flows (cfs) in July, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-9,502	-9,514	0%	-9,526	0%	-9,500	0%	-9,559	1%
Wet	-8,948	-8,947	0%	-8,946	0%	-8,942	0%	-8,943	0%
Above Normal	-9,993	-9,949	0%	-9,935	-1%	-9,935	-1%	-9,936	-1%
Below Normal	-10,886	-10,907	0%	-10,888	0%	-10,982	1%	-10,937	0%
Dry	-10,998	-11,038	0%	-10,992	0%	-10,969	0%	-11,051	0%
Critical	-6,355	-6,397	1%	-6,588	4%	-6,343	0%	-6,672	5%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-128. Old and Middle Rivers Reverse Flows (cfs) in August, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-8,918	-8,935	0%	-8,911	0%	-8,911	0%	-8,916	0%
Wet	-10,334	-10,338	0%	-10,340	0%	-10,340	0%	-10,343	0%
Above Normal	-10,635	-10,612	0%	-10,614	0%	-10,611	0%	-10,607	0%
Below Normal	-10,343	-10,341	0%	-10,248	-1%	-10,286	-1%	-10,277	-1%
Dry	-7,740	-7,944	3%	-7,964	3%	-7,776	0%	-8,017	4%
Critical	-4,236	-4,065	-4%	-3,973	-6%	-4,217	0%	-3,893	-8%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-129. Old and Middle Rivers Reverse Flows (cfs) in September, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-8,048	-8,142	1%	-8,160	1%	-8,095	1%	-8,243	2%
Wet	-8,650	-8,674	0%	-8,675	0%	-8,807	2%	-8,775	1%
Above Normal	-8,852	-8,880	0%	-8,881	0%	-8,864	0%	-8,854	0%
Below Normal	-9,604	-9,621	0%	-9,604	0%	-9,618	0%	-9,574	0%
Dry	-8,180	-8,405	3%	-8,501	4%	-8,098	-1%	-8,590	5%
Critical	-3,923	-4,127	5%	-4,130	5%	-4,002	2%	-4,404	12%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-130. Old and Middle Rivers Reverse Flows (cfs) in October, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-6,184	-6,226	1%	-6,218	1%	-6,254	1%	-6,239	1%
Wet	-6,862	-6,842	0%	-6,836	0%	-6,904	1%	-6,865	0%
Above Normal	-5,848	-5,978	2%	-6,047	3%	-6,015	3%	-6,066	4%
Below Normal	-6,368	-6,461	1%	-6,449	1%	-6,371	0%	-6,486	2%
Dry	-5,779	-5,875	2%	-5,886	2%	-5,862	1%	-5,867	2%
Critical	-5,446	-5,388	-1%	-5,275	-3%	-5,539	2%	-5,323	-2%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-131. Old and Middle Rivers Reverse Flows (cfs) in November, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-6,126	-6,289	3%	-6,339	3%	-6,315	3%	-6,328	3%
Wet	-6,878	-7,052	3%	-7,089	3%	-7,083	3%	-7,053	3%
Above Normal	-6,080	-6,340	4%	-6,326	4%	-6,347	4%	-6,330	4%
Below Normal	-6,713	-6,804	1%	-6,822	2%	-6,778	1%	-6,825	2%
Dry	-5,662	-5,832	3%	-5,906	4%	-5,899	4%	-5,923	5%
Critical	-4,554	-4,668	3%	-4,813	6%	-4,700	3%	-4,784	5%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:

cfs = cubic feet per second

CP = Comprehensive Plan

Table 2-132. Old and Middle Rivers Reverse Flows (cfs) in December, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-6,631	-6,631	0%	-6,627	0%	-6,638	0%	-6,636	0%
Wet	-5,630	-5,633	0%	-5,638	0%	-5,634	0%	-5,642	0%
Above Normal	-7,414	-7,403	0%	-7,438	0%	-7,423	0%	-7,438	0%
Below Normal	-7,249	-7,232	0%	-7,254	0%	-7,277	0%	-7,266	0%
Dry	-7,754	-7,769	0%	-7,744	0%	-7,760	0%	-7,750	0%
Critical	-5,611	-5,612	0%	-5,553	-1%	-5,598	0%	-5,582	-1%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:

cfs = cubic feet per second

CP = Comprehensive Plan

Table 2-133. Old and Middle Rivers Reverse Flows (cfs) in January, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-3,553	-3,568	0%	-3,566	0%	-3,592	1%	-3,572	1%
Wet	-2,151	-2,151	0%	-2,151	0%	-2,161	0%	-2,151	0%
Above Normal	-3,574	-3,488	-2%	-3,479	-3%	-3,626	1%	-3,523	-1%
Below Normal	-4,240	-4,240	0%	-4,240	0%	-4,240	0%	-4,240	0%
Dry	-4,772	-4,772	0%	-4,771	0%	-4,777	0%	-4,771	0%
Critical	-3,940	-4,131	5%	-4,122	5%	-4,129	5%	-4,123	5%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-134. Old and Middle Rivers Reverse Flows (cfs) in February, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-3,358	-3,367	0%	-3,351	0%	-3,375	1%	-3,374	0%
Wet	-2,950	-2,970	1%	-2,970	1%	-2,972	1%	-2,973	1%
Above Normal	-3,165	-3,139	-1%	-3,142	-1%	-3,129	-1%	-3,114	-2%
Below Normal	-3,291	-3,250	-1%	-3,195	-3%	-3,279	0%	-3,312	1%
Dry	-4,045	-4,044	0%	-4,065	0%	-4,063	0%	-4,065	0%
Critical	-3,482	-3,573	3%	-3,497	0%	-3,576	3%	-3,542	2%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-135. Old and Middle Rivers Reverse Flows (cfs) in March, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-2,877	-2,867	0%	-2,867	0%	-2,860	-1%	-2,869	0%
Wet	-2,023	-2,046	1%	-2,044	1%	-2,010	-1%	-2,048	1%
Above Normal	-4,260	-4,272	0%	-4,282	1%	-4,282	1%	-4,281	1%
Below Normal	-3,982	-3,983	0%	-3,979	0%	-3,972	0%	-3,985	0%
Dry	-2,918	-2,834	-3%	-2,834	-3%	-2,834	-3%	-2,838	-3%
Critical	-1,994	-1,991	0%	-1,985	0%	-2,022	1%	-1,979	-1%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-136. Old and Middle Rivers Reverse Flows (cfs) in April, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	1,060	1,059	0%	1,061	0%	1,059	0%	1,063	0%
Wet	2,798	2,793	0%	2,806	0%	2,806	0%	2,806	0%
Above Normal	1,314	1,314	0%	1,314	0%	1,314	0%	1,314	0%
Below Normal	898	898	0%	898	0%	898	0%	898	0%
Dry	-207	-205	-1%	-214	4%	-220	6%	-206	0%
Critical	-872	-872	0%	-872	0%	-872	0%	-872	0%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-137. Old and Middle Rivers Reverse Flows (cfs) in May, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	416	412	-1%	409	-2%	426	2%	409	-2%
Wet	1,781	1,781	0%	1,781	0%	1,781	0%	1,781	0%
Above Normal	646	646	0%	646	0%	646	0%	646	0%
Below Normal	270	270	0%	270	0%	271	0%	270	0%
Dry	-696	-696	0%	-696	0%	-695	0%	-695	0%
Critical	-936	-966	3%	-984	5%	-867	-7%	-984	5%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-138. Old and Middle Rivers Reverse Flows (cfs) in June, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-3,718	-3,736	0%	-3,734	0%	-3,735	0%	-3,737	0%
Wet	-4,354	-4,354	0%	-4,360	0%	-4,359	0%	-4,359	0%
Above Normal	-4,818	-4,818	0%	-4,818	0%	-4,818	0%	-4,818	0%
Below Normal	-4,119	-4,227	3%	-4,227	3%	-4,227	3%	-4,227	3%
Dry	-3,205	-3,204	0%	-3,184	-1%	-3,191	0%	-3,198	0%
Critical	-1,542	-1,542	0%	-1,542	0%	-1,542	0%	-1,542	0%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-139. Old and Middle Rivers Reverse Flows (cfs) in July, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-9,292	-9,325	0%	-9,361	1%	-9,330	0%	-9,402	1%
Wet	-8,905	-8,904	0%	-8,903	0%	-8,901	0%	-8,901	0%
Above Normal	-9,929	-9,916	0%	-9,918	0%	-9,906	0%	-9,906	0%
Below Normal	-10,903	-10,859	0%	-10,826	-1%	-10,908	0%	-10,853	0%
Dry	-10,419	-10,504	1%	-10,638	2%	-10,480	1%	-10,692	3%
Critical	-5,928	-6,089	3%	-6,168	4%	-6,121	3%	-6,354	7%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:

cfs = cubic feet per second

CP = Comprehensive Plan

Table 2-140. Old and Middle Rivers Reverse Flows (cfs) in August, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-8,841	-8,867	0%	-8,879	0%	-8,925	1%	-8,912	1%
Wet	-10,409	-10,409	0%	-10,409	0%	-10,409	0%	-10,409	0%
Above Normal	-10,834	-10,834	0%	-10,832	0%	-10,833	0%	-10,833	0%
Below Normal	-10,409	-10,352	-1%	-10,337	-1%	-10,419	0%	-10,332	-1%
Dry	-6,987	-7,145	2%	-7,230	3%	-7,230	3%	-7,482	7%
Critical	-4,398	-4,411	0%	-4,381	0%	-4,601	5%	-4,233	-4%

Note:

Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.

Key:

cfs = cubic feet per second

CP = Comprehensive Plan

Table 2-141. Old and Middle Rivers Reverse Flows (cfs) in September, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-8,311	-8,434	1%	-8,508	2%	-8,405	1%	-8,553	3%
Wet	-9,189	-9,187	0%	-9,174	0%	-9,241	1%	-9,240	1%
Above Normal	-9,717	-9,830	1%	-9,817	1%	-9,870	2%	-9,834	1%
Below Normal	-9,671	-9,673	0%	-9,687	0%	-9,720	1%	-9,725	1%
Dry	-8,064	-8,432	5%	-8,716	8%	-8,221	2%	-8,669	8%
Critical	-3,783	-3,967	5%	-4,070	8%	-3,873	2%	-4,246	12%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-142. Old and Middle Rivers Reverse Flows (cfs) in October, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-5,989	-6,042	1%	-6,067	1%	-6,089	2%	-6,082	2%
Wet	-6,582	-6,653	1%	-6,650	1%	-6,672	1%	-6,666	1%
Above Normal	-5,722	-5,782	1%	-5,840	2%	-5,801	1%	-5,869	3%
Below Normal	-6,413	-6,390	0%	-6,415	0%	-6,469	1%	-6,404	0%
Dry	-5,450	-5,577	2%	-5,686	4%	-5,682	4%	-5,695	4%
Critical	-5,282	-5,271	0%	-5,196	-2%	-5,280	0%	-5,235	-1%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-143. Old and Middle Rivers Reverse Flows (cfs) in November, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-6,074	-6,193	2%	-6,279	3%	-6,312	4%	-6,304	4%
Wet	-6,933	-7,019	1%	-7,044	2%	-7,069	2%	-7,043	2%
Above Normal	-6,009	-6,203	3%	-6,253	4%	-6,344	6%	-6,320	5%
Below Normal	-6,538	-6,547	0%	-6,637	2%	-6,592	1%	-6,650	2%
Dry	-5,622	-5,809	3%	-5,996	7%	-6,066	8%	-6,025	7%
Critical	-4,412	-4,555	3%	-4,653	5%	-4,678	6%	-4,701	7%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

Table 2-144. Old and Middle Rivers Reverse Flows (cfs) in December, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	-6,608	-6,610	0%	-6,588	0%	-6,552	-1%	-6,610	0%
Wet	-5,641	-5,645	0%	-5,648	0%	-5,643	0%	-5,666	0%
Above Normal	-7,263	-7,284	0%	-7,303	1%	-7,304	1%	-7,309	1%
Below Normal	-7,306	-7,312	0%	-7,295	0%	-7,378	1%	-7,320	0%
Dry	-7,704	-7,701	0%	-7,687	0%	-7,472	-3%	-7,687	0%
Critical	-5,589	-5,573	0%	-5,436	-3%	-5,427	-3%	-5,510	-1%

Note:
Negative percentages indicate an increase in negative flow, whereas positive numbers represent a reduction in negative flow.
Key:
cfs = cubic feet per second
CP = Comprehensive Plan

2.7 SWP and CVP Export Operations

Changes in upstream reservoir storage and operations would be expected to also result in changes in seasonal timing and magnitude of water exports from the Delta. Results of the hydrologic operations model include projections of changes in Delta exports under existing and future conditions for each of the three proposed alternatives. The percentage change in export operations under each of the alternatives by month and water year is shown in Figures 2-1 to 2-4 for existing conditions and Figures 2-5 to 2-8 for future conditions.

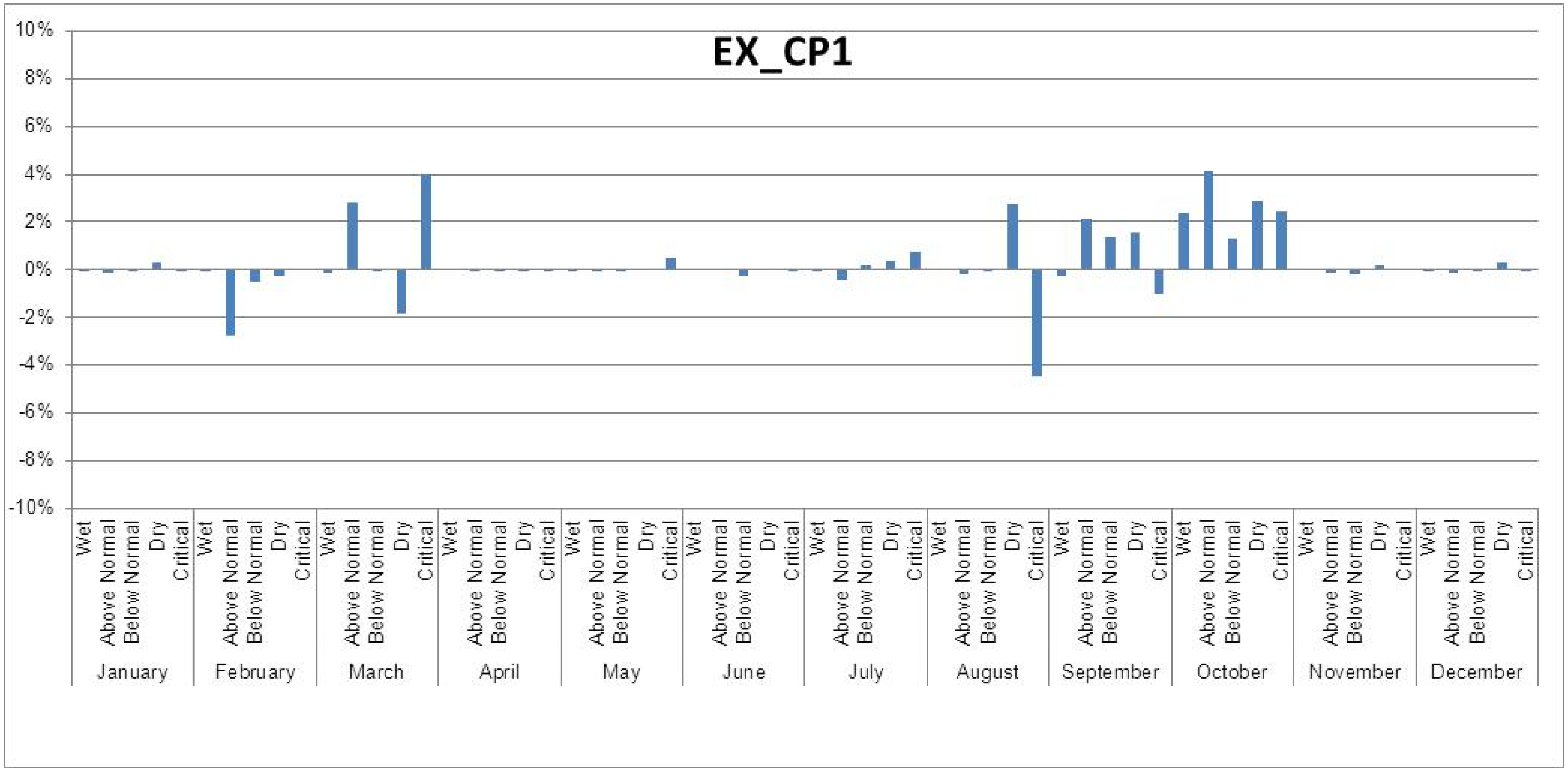


Figure 2-1. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP1 and CP4

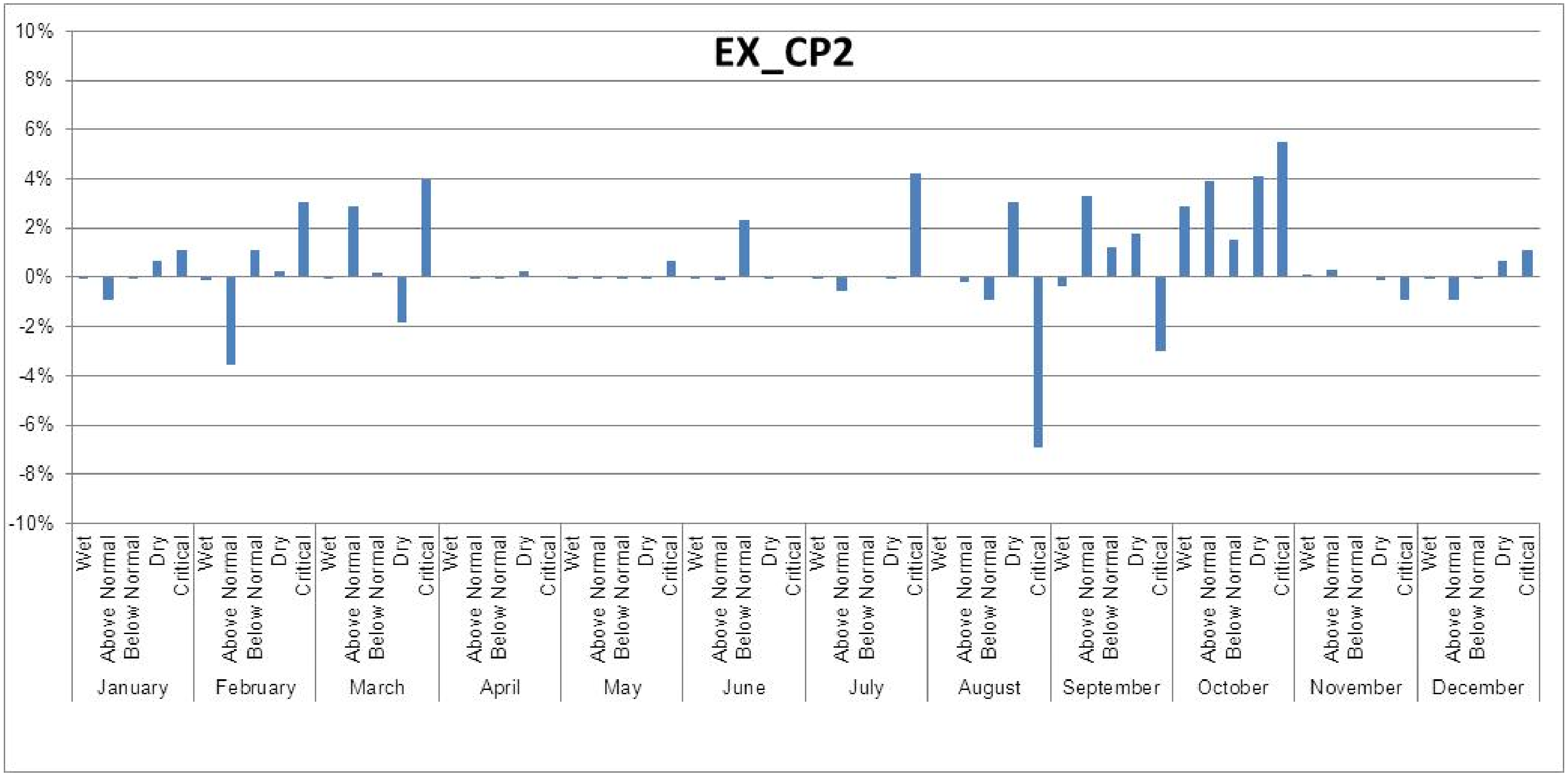


Figure 2-2. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP2

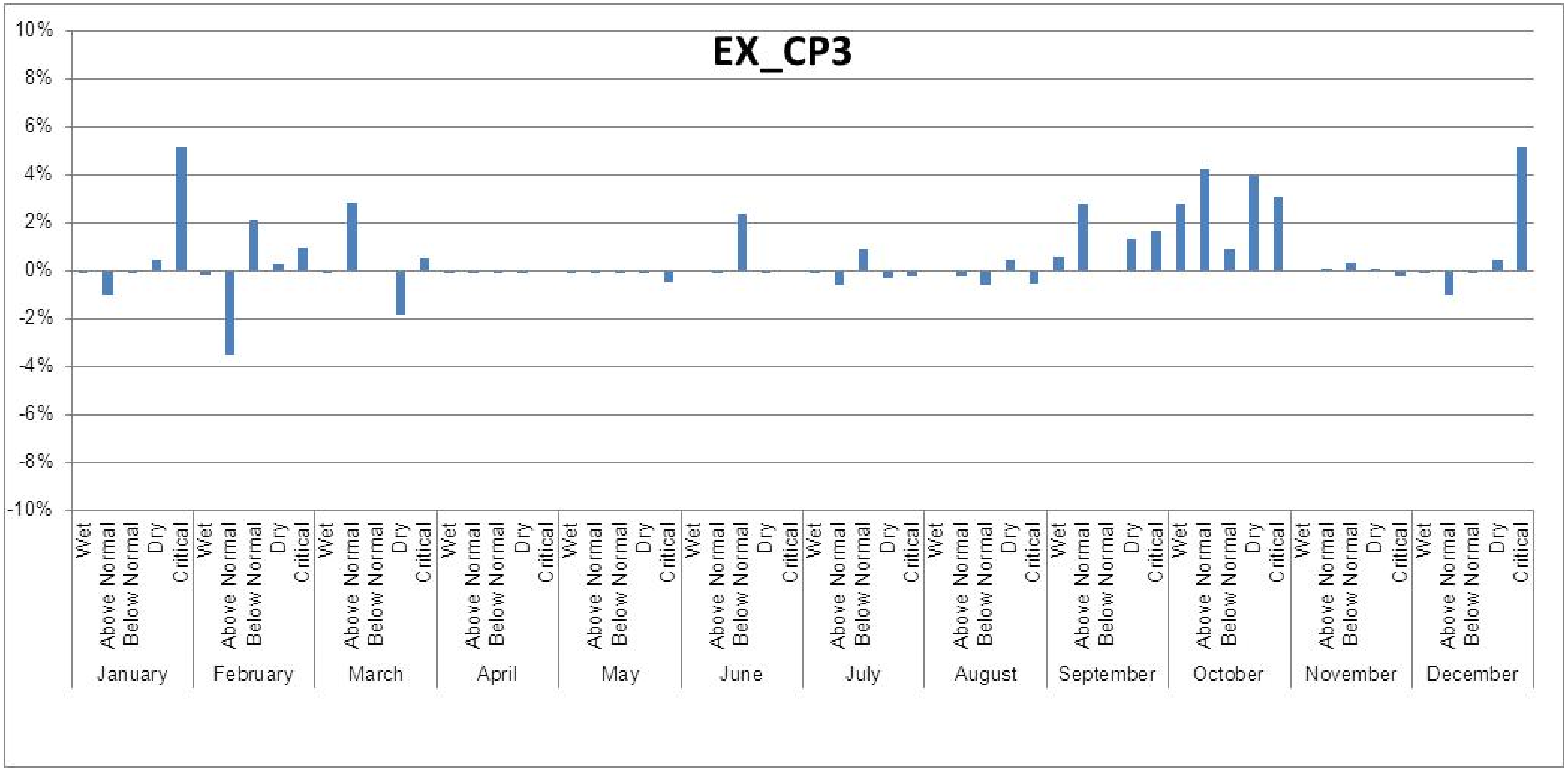


Figure 2-3. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP3

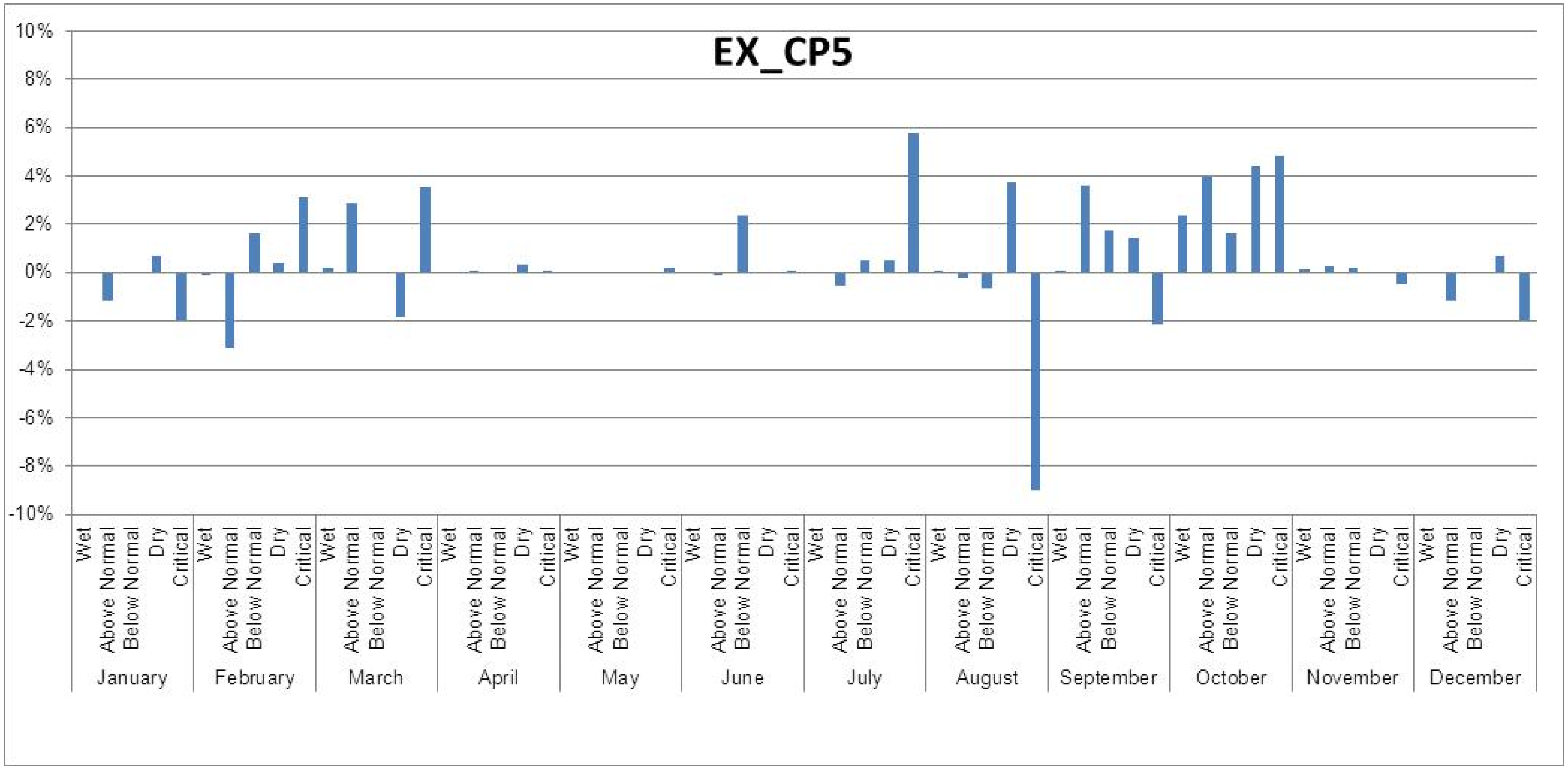


Figure 2-4. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Existing Conditions for CP5

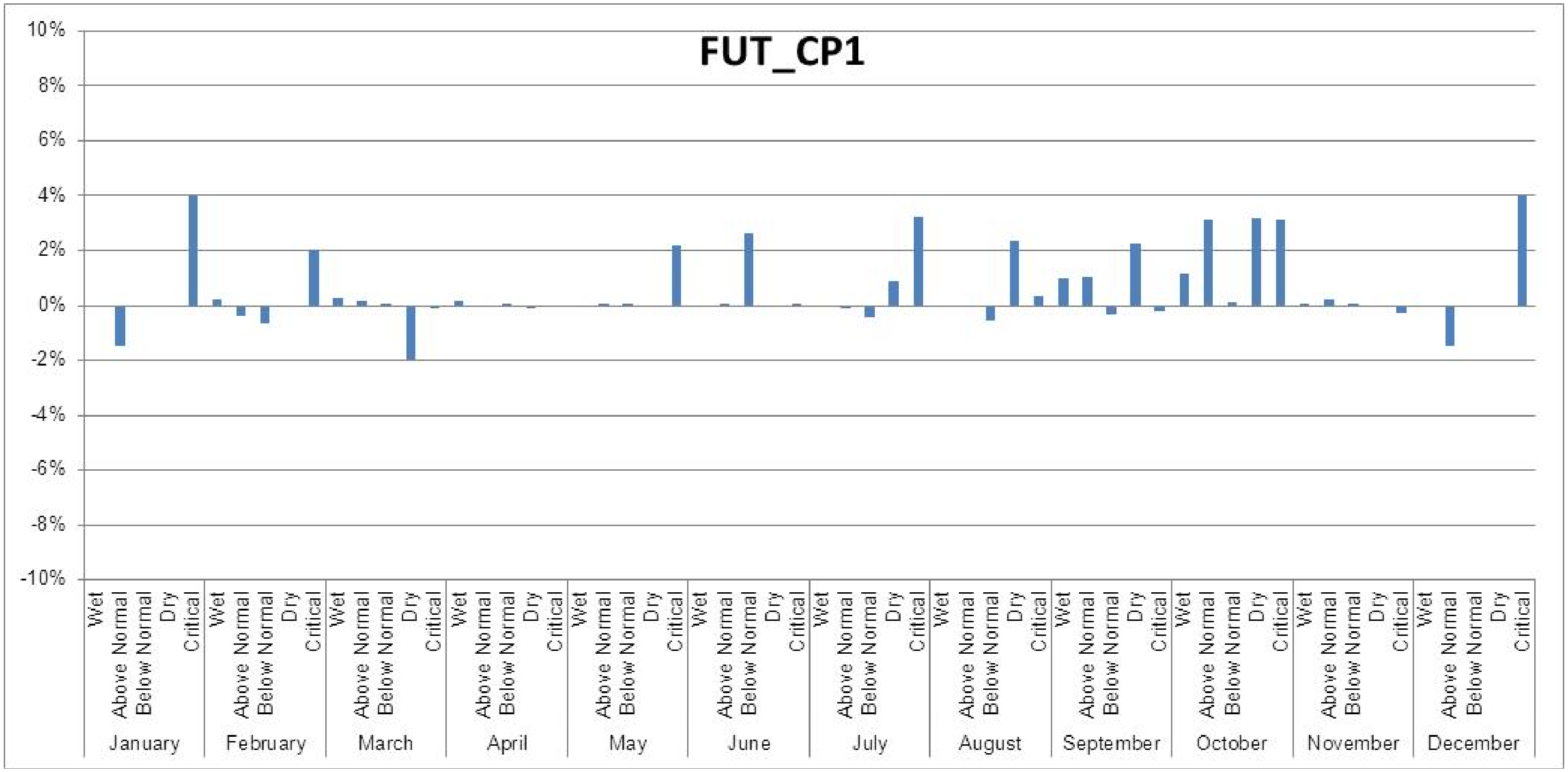


Figure 2-5. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP1 and CP4

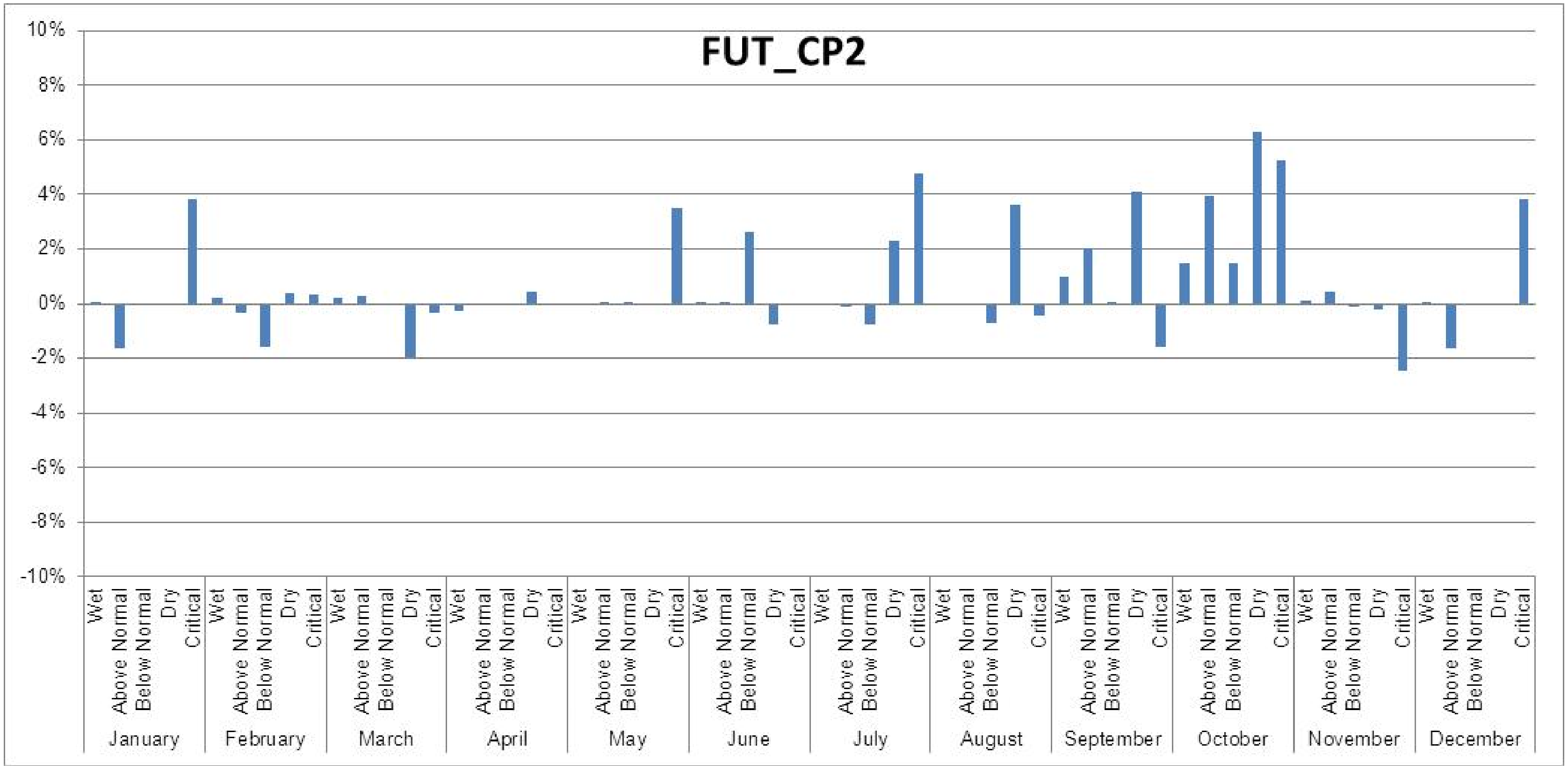


Figure 2-6. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP2

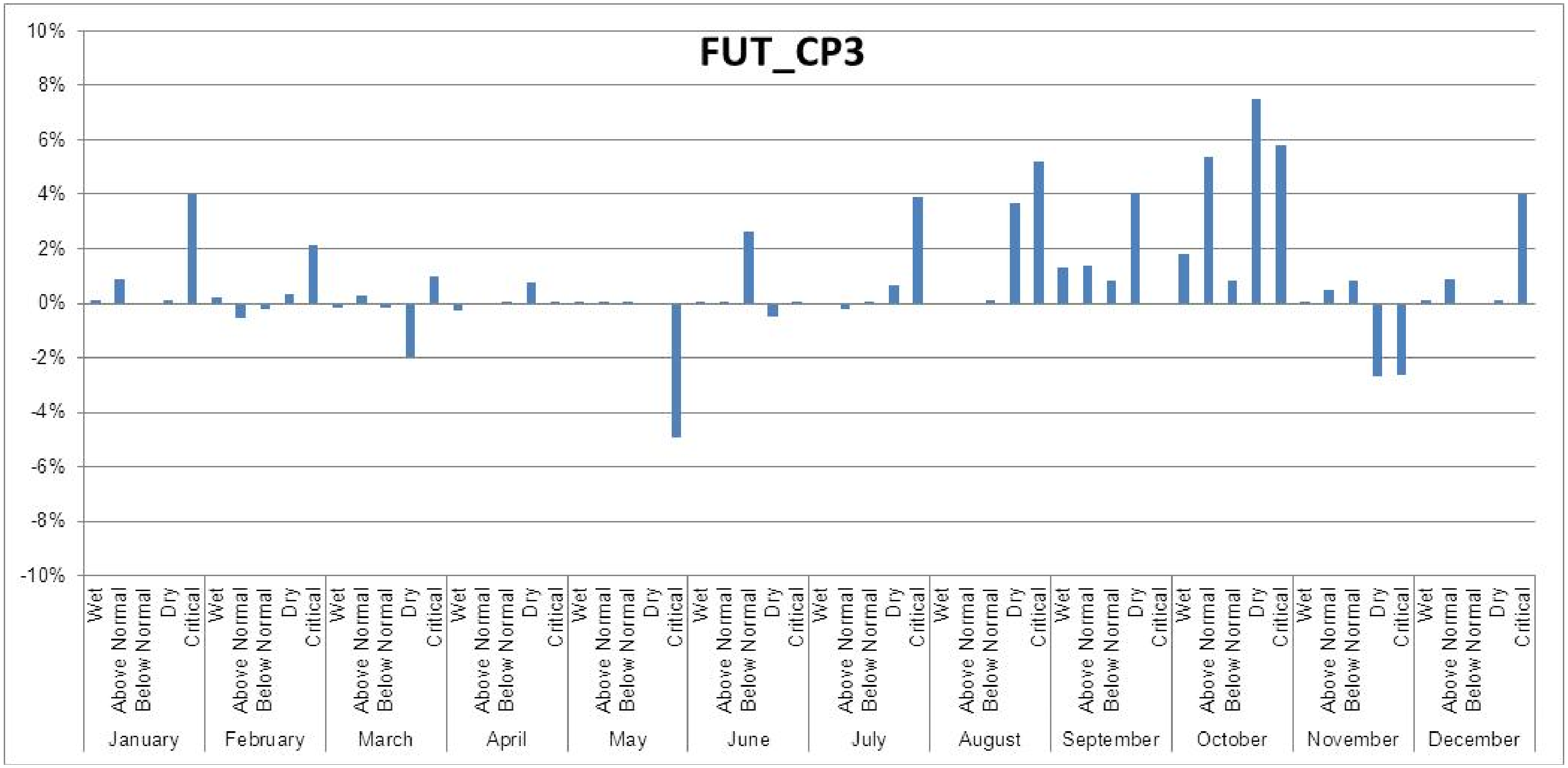


Figure 2-7. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP3

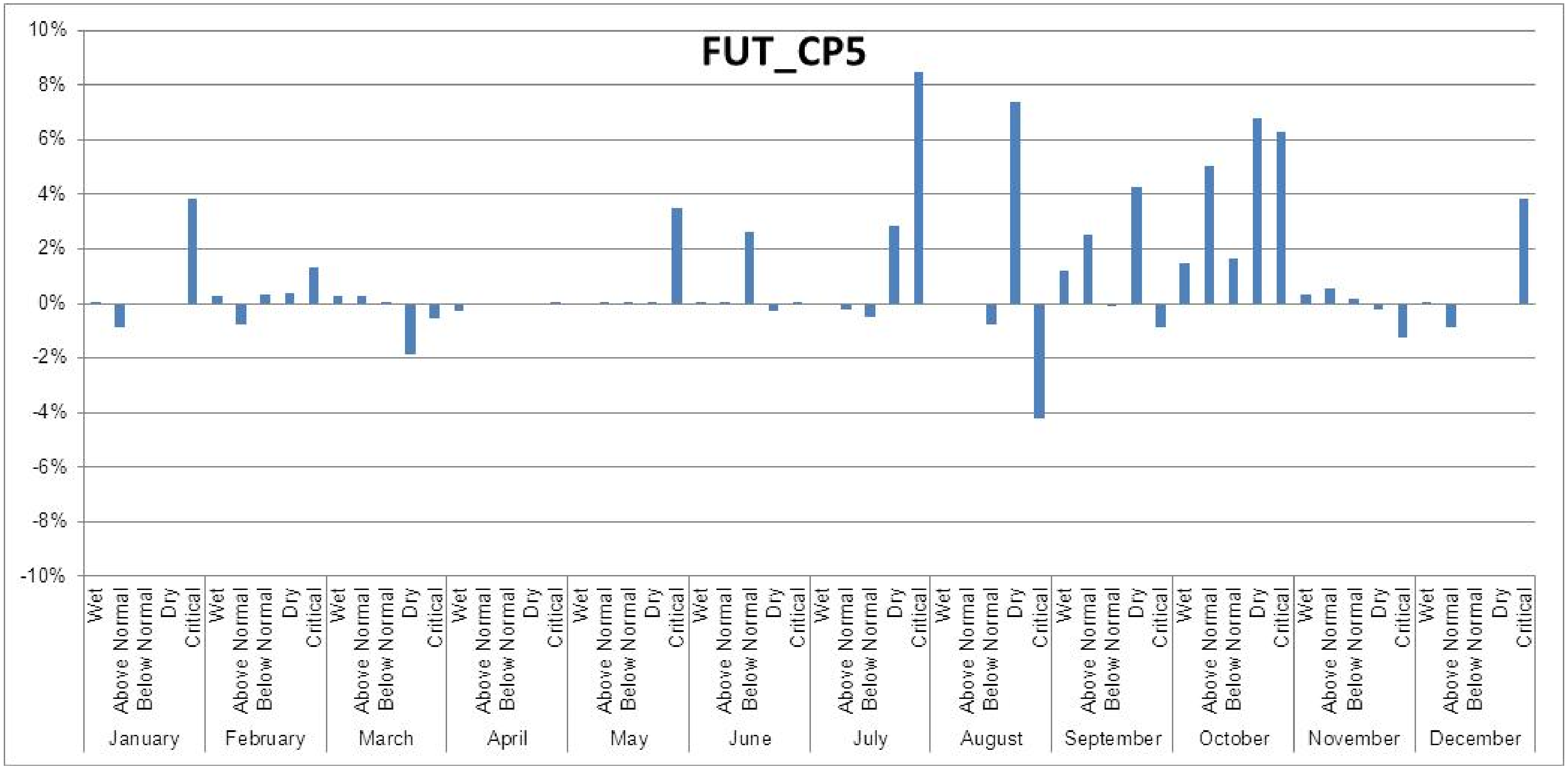


Figure 2-8. Percentage Increase or Decrease in SWP and CVP Combined Exports by Month Due to Operations Under Future Conditions for CP5

Results of the comparison of export operations under existing baseline conditions and under the three proposed alternatives are summarized, by month and water year, in Tables 2-145 through 2-156, and those under future conditions are presented in Tables 2-157 through 2-168. The aquatic resources of the Delta are generally more stressed during drier water years (e.g., reduced freshwater flow, increased salinity intrusion, increased water temperatures) and therefore the incremental stress of increased exports from the SWP and CVP is typically greater in drier water years.

Table 2-145. SWP and CVP Combined Export Flows (acre-feet) in January, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	415,831	415,966	0%	416,406	0%	418,105	1%	414,807	0%
Wet	489,726	489,725	0%	489,724	0%	489,724	0%	489,724	0%
Above Normal	400,556	399,924	0%	396,766	-1%	396,362	-1%	395,968	-1%
Below Normal	390,688	390,687	0%	390,686	0%	390,685	0%	390,686	0%
Dry	397,148	398,357	0%	399,883	1%	399,079	0%	399,900	1%
Critical	328,360	328,105	0%	331,983	1%	345,202	5%	321,825	-2%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-146. SWP and CVP Combined Export Flows (acre-feet) in February, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	399,287	397,040	-1%	399,117	0%	398,994	0%	399,801	0%
Wet	523,523	523,112	0%	522,953	0%	522,869	0%	522,898	0%
Above Normal	397,553	386,543	-3%	383,557	-4%	383,659	-3%	385,018	-3%
Below Normal	376,133	374,201	-1%	380,160	1%	384,022	2%	382,335	2%
Dry	326,187	325,298	0%	326,918	0%	327,216	0%	327,399	0%
Critical	268,505	268,638	0%	276,781	3%	271,071	1%	276,852	3%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-147. SWP and CVP Combined Export Flows (acre-feet) in March, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	423,607	425,321	0%	425,601	0%	424,589	0%	425,783	1%
Wet	588,298	587,508	0%	587,903	0%	588,038	0%	589,353	0%
Above Normal	487,382	501,229	3%	501,402	3%	501,401	3%	501,399	3%
Below Normal	435,234	434,997	0%	435,889	0%	435,461	0%	435,005	0%
Dry	287,901	282,641	-2%	282,625	-2%	282,554	-2%	282,571	-2%
Critical	192,994	200,738	4%	200,605	4%	194,006	1%	199,821	4%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-148. SWP and CVP Combined Export Flows (acre-feet) in April, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	127,799	127,795	0%	127,854	0%	127,775	0%	127,870	0%
Wet	174,488	174,489	0%	174,489	0%	174,486	0%	174,487	0%
Above Normal	110,703	110,703	0%	110,702	0%	110,702	0%	110,704	0%
Below Normal	108,573	108,572	0%	108,572	0%	108,572	0%	108,572	0%
Dry	106,995	106,976	0%	107,227	0%	106,874	0%	107,320	0%
Critical	97,373	97,371	0%	97,398	0%	97,399	0%	97,373	0%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-149. SWP and CVP Combined Export Flows (acre-feet) in May, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	136,124	136,187	0%	136,211	0%	136,055	0%	136,145	0%
Wet	205,736	205,717	0%	205,715	0%	205,728	0%	205,707	0%
Above Normal	103,215	103,212	0%	103,208	0%	103,208	0%	103,213	0%
Below Normal	101,635	101,635	0%	101,633	0%	101,632	0%	101,634	0%
Dry	108,047	108,049	0%	108,038	0%	108,045	0%	108,041	0%
Critical	100,560	101,029	0%	101,222	1%	100,116	0%	100,778	0%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-150. SWP and CVP Combined Export Flows (acre-feet) in June, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	294,994	294,873	0%	295,983	0%	295,996	0%	295,987	0%
Wet	459,912	459,912	0%	459,882	0%	459,916	0%	459,912	0%
Above Normal	390,780	390,795	0%	390,379	0%	390,380	0%	390,371	0%
Below Normal	263,100	262,369	0%	269,273	2%	269,281	2%	269,280	2%
Dry	171,930	171,938	0%	171,922	0%	171,924	0%	171,917	0%
Critical	63,693	63,689	0%	63,724	0%	63,728	0%	63,694	0%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-151. SWP and CVP Combined Export Flows (acre-feet) in July, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	642,297	643,086	0%	643,888	0%	642,173	0%	646,072	1%
Wet	705,224	705,178	0%	705,078	0%	704,861	0%	704,901	0%
Above Normal	664,607	661,684	0%	660,760	-1%	660,777	-1%	660,858	-1%
Below Normal	692,142	693,553	0%	692,281	0%	698,539	1%	695,529	0%
Dry	682,320	684,954	0%	681,881	0%	680,352	0%	685,795	1%
Critical	365,459	368,279	1%	380,989	4%	364,718	0%	386,542	6%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-152. SWP and CVP Combined Export Flows (acre-feet) in August, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	592,822	593,969	0%	592,392	0%	592,413	0%	592,696	0%
Wet	719,615	719,872	0%	720,058	0%	720,047	0%	720,232	0%
Above Normal	711,376	709,841	0%	710,013	0%	709,812	0%	709,527	0%
Below Normal	676,457	676,332	0%	670,152	-1%	672,657	-1%	672,042	-1%
Dry	491,569	505,137	3%	506,462	3%	493,947	0%	509,986	4%
Critical	253,856	242,470	-4%	236,336	-7%	252,553	-1%	231,031	-9%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-153. SWP and CVP Combined Export Flows (acre-feet) in September, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	544,234	550,308	1%	551,531	1%	547,302	1%	556,853	2%
Wet	607,113	608,714	0%	608,758	0%	617,280	2%	615,188	1%
Above Normal	595,689	597,457	0%	597,515	0%	596,454	0%	595,823	0%
Below Normal	635,466	636,578	0%	635,448	0%	636,371	0%	633,538	0%
Dry	542,004	556,530	3%	562,778	4%	536,691	-1%	568,509	5%
Critical	253,451	266,634	5%	266,780	5%	258,537	2%	284,542	12%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-154. SWP and CVP Combined Export Flows (acre-feet) in October, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	428,531	431,251	1%	430,721	1%	433,158	1%	432,124	1%
Wet	479,946	478,617	0%	478,194	0%	482,728	1%	480,131	0%
Above Normal	401,494	410,131	2%	414,684	3%	412,569	3%	415,931	4%
Below Normal	439,729	445,866	1%	445,066	1%	439,891	0%	447,497	2%
Dry	400,402	406,754	2%	407,498	2%	405,871	1%	406,246	1%
Critical	373,294	369,439	-1%	361,995	-3%	379,421	2%	365,186	-2%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-155. SWP and CVP Combined Export Flows (acre-feet) in November, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	413,479	423,895	3%	427,091	3%	425,549	3%	426,399	3%
Wet	474,038	485,222	2%	487,538	3%	487,196	3%	485,234	2%
Above Normal	403,067	419,674	4%	418,797	4%	420,096	4%	419,040	4%
Below Normal	447,459	453,234	1%	454,382	2%	451,604	1%	454,594	2%
Dry	380,361	391,236	3%	395,957	4%	395,504	4%	397,044	4%
Critical	302,711	309,999	2%	319,280	5%	312,101	3%	317,418	5%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-156. SWP and CVP Combined Export Flows (acre-feet) in December, Modeled for Existing Project Alternatives

Year Type	Base Flow	Under Existing Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	547,203	547,212	0%	546,961	0%	547,684	0%	547,560	0%
Wet	549,472	549,692	0%	550,014	0%	549,791	0%	550,293	0%
Above Normal	587,823	587,135	0%	589,470	0%	588,449	0%	589,471	0%
Below Normal	568,812	567,653	0%	569,131	0%	570,674	0%	569,942	0%
Dry	583,300	584,313	0%	582,657	0%	583,721	0%	583,056	0%
Critical	422,312	422,421	0%	418,432	-1%	421,480	0%	420,371	0%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-157. SWP and CVP Combined Export Flows (acre-feet) in January, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	414,626	415,666	0%	415,484	0%	417,295	1%	415,932	0%
Wet	490,234	490,233	0%	490,241	0%	490,880	0%	490,241	0%
Above Normal	397,051	391,266	-1%	390,633	-2%	400,547	1%	393,612	-1%
Below Normal	389,409	389,407	0%	389,408	0%	389,407	0%	389,409	0%
Dry	398,422	398,419	0%	398,395	0%	398,776	0%	398,390	0%
Critical	322,110	335,011	4%	334,419	4%	334,924	4%	334,505	4%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-158. SWP and CVP Combined Export Flows (acre-feet) in February, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	399,870	400,391	0%	399,445	0%	400,923	0%	400,863	0%
Wet	529,526	530,739	0%	530,732	0%	530,816	0%	530,864	0%
Above Normal	397,157	395,611	0%	395,794	0%	395,061	-1%	394,175	-1%
Below Normal	368,356	365,843	-1%	362,506	-2%	367,624	0%	369,582	0%
Dry	324,868	324,786	0%	326,060	0%	325,949	0%	326,073	0%
Critical	270,932	276,462	2%	271,811	0%	276,663	2%	274,559	1%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-159. SWP and CVP Combined Export Flows (acre-feet) in March, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	425,779	425,117	0%	425,044	0%	424,613	0%	425,187	0%
Wet	594,118	595,641	0%	595,415	0%	593,148	0%	595,696	0%
Above Normal	500,337	501,109	0%	501,731	0%	501,749	0%	501,690	0%
Below Normal	433,317	433,396	0%	433,159	0%	432,692	0%	433,514	0%
Dry	283,804	278,157	-2%	278,174	-2%	278,178	-2%	278,461	-2%
Critical	190,651	190,435	0%	190,055	0%	192,542	1%	189,621	-1%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-160. SWP and CVP Combined Export Flows (acre-feet) in April, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	143,947	144,016	0%	143,875	0%	143,966	0%	143,764	0%
Wet	201,348	201,641	0%	200,790	0%	200,802	0%	200,786	0%
Above Normal	126,440	126,435	0%	126,431	0%	126,432	0%	126,431	0%
Below Normal	124,978	124,979	0%	124,977	0%	124,982	0%	124,976	0%
Dry	117,569	117,465	0%	118,055	0%	118,443	1%	117,552	0%
Critical	98,782	98,782	0%	98,781	0%	98,786	0%	98,783	0%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-161. SWP and CVP Combined Export Flows (acre-feet) in May, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	137,427	137,724	0%	137,909	0%	136,753	0%	137,907	0%
Wet	211,134	211,129	0%	211,128	0%	211,140	0%	211,122	0%
Above Normal	105,251	105,253	0%	105,254	0%	105,254	0%	105,253	0%
Below Normal	101,848	101,850	0%	101,850	0%	101,850	0%	101,848	0%
Dry	109,103	109,102	0%	109,100	0%	109,102	0%	109,105	0%
Critical	93,900	95,940	2%	97,203	4%	89,282	-5%	97,203	4%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-162. SWP and CVP Combined Export Flows (acre-feet) in June, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	297,714	298,876	0%	298,726	0%	298,819	0%	298,915	0%
Wet	467,356	467,347	0%	467,731	0%	467,721	0%	467,723	0%
Above Normal	383,698	383,707	0%	383,709	0%	383,717	0%	383,712	0%
Below Normal	264,126	271,064	3%	271,073	3%	271,076	3%	271,080	3%
Dry	179,801	179,704	0%	178,462	-1%	178,873	-1%	179,326	0%
Critical	60,225	60,228	0%	60,222	0%	60,248	0%	60,226	0%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-163. SWP and CVP Combined Export Flows (acre-feet) in July, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	627,114	629,302	0%	631,654	1%	629,668	0%	634,397	1%
Wet	704,260	704,251	0%	704,170	0%	704,014	0%	704,036	0%
Above Normal	660,748	659,942	0%	660,058	0%	659,241	0%	659,240	0%
Below Normal	688,451	685,524	0%	683,343	-1%	688,837	0%	685,143	0%
Dry	641,256	646,900	1%	655,856	2%	645,366	1%	659,431	3%
Critical	333,557	344,285	3%	349,530	5%	346,437	4%	361,914	9%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-164. SWP and CVP Combined Export Flows (acre-feet) in August, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	584,164	585,941	0%	586,719	0%	589,797	1%	588,907	1%
Wet	719,196	719,196	0%	719,195	0%	719,194	0%	719,195	0%
Above Normal	713,474	713,457	0%	713,358	0%	713,387	0%	713,393	0%
Below Normal	679,075	675,293	-1%	674,284	-1%	679,714	0%	673,958	-1%
Dry	444,558	455,027	2%	460,733	4%	460,754	4%	477,519	7%
Critical	260,965	261,836	0%	259,864	0%	274,510	5%	249,985	-4%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-165. SWP and CVP Combined Export Flows (acre-feet) in September, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	555,580	563,593	1%	568,359	2%	561,708	1%	571,286	3%
Wet	633,765	633,639	0%	632,793	0%	637,105	1%	637,065	1%
Above Normal	640,403	647,697	1%	646,867	1%	650,275	2%	647,936	1%
Below Normal	639,824	639,940	0%	640,835	0%	643,000	0%	643,273	1%
Dry	530,101	553,906	4%	572,277	8%	540,282	2%	569,232	7%
Critical	241,289	253,178	5%	259,810	8%	247,076	2%	271,213	12%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-166. SWP and CVP Combined Export Flows (acre-feet) in October, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	413,313	416,851	1%	418,489	1%	419,943	2%	419,486	1%
Wet	460,214	464,875	1%	464,682	1%	466,155	1%	465,721	1%
Above Normal	387,443	391,397	1%	395,264	2%	392,672	1%	397,157	3%
Below Normal	439,827	438,340	0%	439,989	0%	443,511	1%	439,237	0%
Dry	378,004	386,397	2%	393,576	4%	393,340	4%	394,206	4%
Critical	359,595	358,864	0%	353,915	-2%	359,496	0%	356,516	-1%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-167. SWP and CVP Combined Export Flows (acre-feet) in November, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	410,112	417,731	2%	423,222	3%	425,321	4%	424,844	4%
Wet	478,338	483,827	1%	485,393	1%	487,041	2%	485,358	1%
Above Normal	398,206	410,665	3%	413,830	4%	419,653	5%	418,159	5%
Below Normal	435,553	436,130	0%	441,893	1%	439,038	1%	442,740	2%
Dry	378,384	390,316	3%	402,286	6%	406,776	8%	404,164	7%
Critical	292,108	301,246	3%	307,531	5%	309,079	6%	310,555	6%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

Table 2-168. SWP and CVP Combined Export Flows (acre-feet) in December, Modeled for Future Project Alternatives

Year Type	Base Flow	Under Future Conditions with Project							
		CP1/CP4		CP2		CP3		CP5	
		Flow	% change	Flow	% change	Flow	% change	Flow	% change
Average	547,604	547,754	0%	546,245	0%	543,829	-1%	547,711	0%
Wet	554,065	554,352	0%	554,533	0%	554,205	0%	555,770	0%
Above Normal	578,162	579,590	0%	580,825	0%	580,922	0%	581,230	1%
Below Normal	572,982	573,405	0%	572,252	0%	577,818	1%	573,944	0%
Dry	582,493	582,228	0%	581,322	0%	566,792	-3%	581,282	0%
Critical	421,106	419,983	0%	410,751	-2%	410,156	-3%	415,768	-1%

Key:
CP = Comprehensive Plan
CVP = Central Valley Project
SWP = State Water Project

2.8 Estimated Fish Entrainment/ Losses

Changes in the volume of water exported at the SWP and CVP facilities is assumed to result in a direct proportional increase or decrease in the risk of fish being entrained and salvaged at the facilities. Using information from the hydrodynamic operations model, in combination with information on the densities of various fish species observed at the salvage facilities, an index in the form of a change in the numbers of a fish species theoretically affected by a change in export operations can be developed. Fish lost to entrainment/salvage at the SWP and CVP were estimated based on monthly estimated combined exports. The project alternatives were modeled in CalSim-II and assume, for each alternative, that the project would be implemented under existing conditions, and under future conditions. Both the existing conditions, or “existing base” conditions, and future base conditions, or “future no-action” conditions—which assumes no project was implemented, were assessed.

Data sources used to calculate fish losses at the SWP and CVP consisted of 1995 to 2005 monthly average density data, collected by DWR (DWR 2006) at the Skinner Fish Facility and at the Tracy Fish Facility located at each export facility, respectively. These density data were calculated for delta smelt, longfin smelt, Chinook salmon, steelhead, striped bass, and splittail. Green sturgeon were considered for this analysis, however they are seldom collected at the fish facilities and thus, have not been modeled in the entrainment loss estimates. Fish density data was combined with CalSim results export flows modeled from 1922 to 2003 data.

From CalSim modeling results, average monthly flows, and average flows per each year from 1922 to 2003 in cfs were converted to acre-feet per each month (January through December), and were then multiplied by monthly average densities (number of fish per acre-foot), for each of the selected fish species. Average monthly fish losses calculated for each year (1922 to 2003, based on CalSim modeling results) were then averaged by water year type (e.g., wet, above normal, normal, below normal, dry, and critical) for each month, as well as an average across all years (all water year types), for each month. Fish losses, for each species, were totaled across months to show the total fish loss for a given species for an average year (all water year types), wet, above normal, normal, below normal, dry, and critical year.

Fish losses resulting from entrainment were calculated two ways, which both produced identical entrainment indices to represent the change in entrainment based on changes in SWP and CVP exports as a result of proposed project alternatives:

1. Fish losses were estimated by calculating losses under the base conditions, and then by calculating losses under the project alternative,

from CalSim modeling. The total number of fish lost under the base case was subtracted from the number lost under the project alternative, indicating whether a net benefit (negative number) or a net loss (positive number) would result from the project alternatives.

2. Fish losses were estimated by calculating losses directly from the “Alt minus Base” modeling results in CalSim.

The general calculation of the change in entrainment/salvage risk is show below:

A = density of fish per acre-foot for a given fish species (e.g., delta smelt, longfin smelt, salmon, striped bass, steelhead, and splittail)

B = Monthly cfs, by year

C = [B x 1.983 x (no. days/month)] = average monthly exports (for SWP+CVP) for a given year, 1922 to 2003, in acre-feet

D = [A] [C] = average monthly fish loss, per species, in a given year

D_A = $\sum (D_{1922,} D_{1923} \ldots D_{2003})$ = average monthly fish losses at the SWP + CVP

D_W = $\sum$ (*wet water years*) = fish losses, by month, at the SWP + CVP, based on wet water years, 1922 to 2003

D_{AN} = $\sum$ (*above normal water years*) = fish losses, by month, at the SWP + CVP, based on above normal water years, 1922 to 2003

D_N = $\sum$ (*normal water years*) = fish losses, by month, at the SWP + CVP, based on normal water years, 1922 to 2003

D_{BN} = $\sum$ (*below normal water years*)) = fish losses, by month, at the SWP + CVP, based on below normal water years, 1922 to 2003

D_D = $\sum$ (*dry water years*) fish losses, by month, at the SWP + CVP, based on dry water years, 1922 to 2003

D_C = $\sum$ (*critical water years*) fish losses, by month, at the SWP + CVP, based on critical water years, 1922 to 2003

E_A = $(D_{A\text{-}JANUARY} + D_{A\text{-}FEBRUARY\ldots} + D_{A\text{-}DECEMBER})$ = Total yearly average fish losses, based on monthly average 1922 to 2003 fish losses

E_W = $(D_{W\text{-}JANUARY} + D_{W\text{-}FEBRUARY\ldots} + D_{W\text{-}DECEMBER})$ = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

$E_{AN} = (D_{AN\text{-}JANUARY} + D_{AN\text{-}FEBRUARY...} + D_{AN\text{-}DECEMBER})$ = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

$E_{N} = (D_{N\text{-}JANUARY} + D_{N\text{-}FEBRUARY...} + D_{N\text{-}DECEMBER})$ = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

$E_{BN} = (D_{BN\text{-}JANUARY} + D_{BN\text{-}FEBRUARY...} + D_{BN\text{-}DECEMBER})$ = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

$E_{D} = (D_{D\text{-}JANUARY} + D_{D\text{-}FEBRUARY...} + D_{D\text{-}DECEMBER})$ = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

$E_{C} = (D_{C\text{-}JANUARY} + D_{C\text{-}FEBRUARY...} + D_{C\text{-}DECEMBER})$ = Total yearly fish losses in a wet year, based on monthly average 1922 to 2003 fish losses

Results of the entrainment loss modeling at the SWP and CVP are presented in Tables 2-169 and 2-170, under the project alternatives under existing conditions, and future conditions, respectively. These indices were calculated for wet, above normal, below normal, dry, and critical water year types, and for an average across all years (no water year type specified). Tables 2-169 and 2-170 also include a percentage net increase or decrease, which represents what percentage each species risk of loss would increase or decrease as compared to the base. The difference between the base and project fish losses is represented as the entrainment index, shown in the tables, to represent the effect of project operations on each fish species at the SWP and CVP.

Table 2-169. Summary of Entrainment Indices for Selected Species under Existing Conditions

Delta Smelt – Entrainment Summary Under Existing Conditions

Year Type	# Fish	CP1/4		CP2		CP3		CP5	
		Change	% Change	Change	% Change	Change	% Change	Change	% Change
Average	41,937	6	+0.0%	68	+0.2%	42	+0.1%	60	+0.1%
Wet	61,905	-6	-0.0%	-7	-0.0%	-4	-0.0%	-4	-0.0%
Above Normal	40,543	-16	-0.0%	-58	-0.1%	-60	-0.1%	-56	-0.1%
Below Normal	34,787	-33	-0.1%	273	+0.8%	305	+0.9%	289	+0.8%
Dry	31,573	1	+0.0%	0	+0.0%	-6	-0.0%	15	+0.0%
Critical	23,958	105	+0.4%	219	+0.9%	10	+0.0%	114	+0.5%

Longfin Smelt – Entrainment Summary Under Existing Conditions

Year Type	# Fish	CP1/4		CP2		CP3		CP5	
		Change	% Change	Change	% Change	Change	% Change	Change	% Change
Average	7,319	3	+0.0%	5	+0.1%	-2	-0.0%	2	+0.0%
Wet	10,883	-1	-0.0%	-1	-0.0%	0	-0.0%	-1	-0.0%
Above Normal	5,794	2	+0.0%	1	+0.0%	1	+0.0%	2	+0.0%
Below Normal	5,633	0	-0.0%	3	+0.1%	3	+0.1%	3	+0.1%
Dry	5,828	-1	-0.0%	1	+0.0%	-2	-0.0%	2	+0.0%
Critical	5,326	22	+0.4%	32	+0.6%	-17	-0.3%	11	+0.2%

Chinook Salmon – Entrainment Summary Under Existing Conditions

Year Type	# Fish	CP1/4		CP2		CP3		CP5	
		Change	% Change	Change	% Change	Change	% Change	Change	% Change
Average	53,767	-8	-0.0%	77	+0.1%	53	+0.1%	67	+0.1%
Wet	75,910	-23	-0.0%	-20	-0.0%	-16	-0.0%	4	+0.0%
Above Normal	50,939	-8	-0.0%	-118	-0.2%	-123	-0.2%	-96	-0.2%
Below Normal	46,614	-59	-0.1%	223	+0.5%	302	+0.6%	257	+0.6%
Dry	42,134	-88	-0.2%	-24	-0.1%	-47	-0.1%	-8	-0.0%
Critical	34,410	206	+0.6%	464	+1.3%	235	+0.7%	255	+0.7%

Steelhead – Entrainment Summary Under Existing Conditions

Year Type	# Fish	CP1/4		CP2		CP3		CP5	
		Change	% Change	Change	% Change	Change	% Change	Change	% Change
Average	4,316	-4	-0.1%	7	+0.2%	7	+0.2%	7	+0.2%
Wet	5,638	-4	-0.1%	-3	-0.1%	-3	-0.1%	1	+0.0%
Above Normal	4,420	-10	-0.2%	-30	-0.7%	-31	-0.7%	-26	-0.6%
Below Normal	4,137	-9	-0.2%	21	+0.5%	36	+0.9%	28	+0.7%
Dry	3,511	-15	-0.4%	-4	-0.1%	-5	-0.2%	-2	-0.1%
Critical	2,768	22	+0.8%	68	+2.4%	55	+2.0%	41	+1.5%

Table 2-169. Summary of Entrainment Indices for Selected Species under Existing Conditions (contd.)

Striped Bass – Entrainment Summary Under Existing Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	1,326,425	2533	+0.2%	5229	+0.4%	3981	+0.3%	7044	+0.5%
Wet	1,717,228	1518	+0.1%	1762	+0.1%	2316	+0.1%	1854	+0.1%
Above Normal	1,508,667	837	+0.1%	-322	-0.0%	-513	-0.0%	-214	-0.0%
Below Normal	1,322,487	1092	+0.1%	10781	+0.8%	15204	+1.1%	13841	+1.0%
Dry	1,115,407	6826	+0.6%	5807	+0.5%	1563	+0.1%	9518	+0.9%
Critical	618,562	1671	+0.3%	10946	+1.8%	2616	+0.4%	13907	+2.2%
Sacramento Splittail – Entrainment Summary Under Existing Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	269,448	503	+0.2%	766	+0.3%	507	+0.2%	1075	+0.4%
Wet	374,405	-6	-0.0%	-33	-0.0%	-36	-0.0%	-31	-0.0%
Above Normal	318,601	-380	-0.1%	-737	-0.2%	-738	-0.2%	-727	-0.2%
Below Normal	256,001	-182	-0.1%	3196	+1.2%	4107	+1.6%	3671	+1.4%
Dry	206,694	435	+0.2%	13	+0.0%	-283	-0.1%	588	+0.3%
Critical	102,707	451	+0.4%	2294	+2.2%	-83	-0.1%	2976	+2.9%

Note:

Negative number represents a net reduction or project benefit, while a positive number represents an increase in fish lost.

Key:

CP = Comprehensive Plan

Table 2-170. Summary of Entrainment Indices for Selected Species under Future Conditions

Delta Smelt – Entrainment Summary Under Future Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	42,239	111	+0.3%	138	+0.3%	-49	-0.1%	162	+0.4%
Wet	63,184	7	+0.0%	21	+0.0%	20	+0.0%	22	+0.0%
Above Normal	40,596	-29	-0.1%	-28	-0.1%	12	+0.0%	-22	-0.1%
Below Normal	34,835	273	+0.8%	255	+0.7%	292	+0.8%	286	+0.8%
Dry	31,953	1	+0.0%	-19	-0.1%	-43	-0.1%	30	+0.1%
Critical	22,564	452	+2.0%	656	+2.9%	-665	-2.9%	707	+3.1%
Longfin Smelt – Entrainment Summary Under Future Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	7,495	14	+0.2%	22	+0.3%	-29	-0.4%	21	+0.3%
Wet	11,323	2	+0.0%	-4	-0.0%	-4	-0.0%	-4	-0.0%
Above Normal	5,997	-1	-0.0%	0	-0.0%	1	+0.0%	0	-0.0%
Below Normal	5,761	3	+0.1%	3	+0.1%	4	+0.1%	3	+0.1%
Dry	5,954	-2	-0.0%	2	+0.0%	5	+0.1%	0	-0.0%
Critical	5,037	93	+1.8%	149	+2.9%	-202	-4.0%	149	+3.0%
Chinook Salmon – Entrainment Summary Under Future Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	54,716	88	+0.2%	83	+0.2%	-37	-0.1%	124	+0.2%
Wet	78,223	66	+0.1%	34	+0.0%	8	+0.0%	42	+0.1%
Above Normal	51,921	-92	-0.2%	-84	-0.2%	33	+0.1%	-79	-0.2%
Below Normal	47,129	83	+0.2%	6	+0.0%	116	+0.2%	169	+0.4%
Dry	42,787	-98	-0.2%	-62	-0.1%	-52	-0.1%	-59	-0.1%
Critical	33,325	597	+1.8%	665	+2.0%	-360	-1.1%	728	+2.2%
Steelhead – Entrainment Summary Under Future Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	4,336	4	+0.1%	-1	-0.0%	8	+0.2%	7	+0.2%
Wet	5,710	10	+0.2%	9	+0.2%	4	+0.1%	10	+0.2%
Above Normal	4,459	-18	-0.4%	-17	-0.4%	4	+0.1%	-17	-0.4%
Below Normal	4,108	-10	-0.2%	-25	-0.6%	-3	-0.1%	7	+0.2%
Dry	3,506	-16	-0.4%	-9	-0.3%	-10	-0.3%	-8	-0.2%
Critical	2,749	57	+2.1%	35	+1.3%	57	+2.1%	47	+1.7%

Table 2-170. Summary of Entrainment Indices for Selected Species under Future Conditions (contd.)

Striped Bass – Entrainment Summary Under Future Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	1,317,285	5,666	+0.4%	8231	+0.6%	7305	+0.6%	11575	+0.9%
Wet	1,730,927	1,399	+0.1%	2140	+0.1%	2465	+0.1%	2393	+0.1%
Above Normal	1,494,314	1,533	+0.1%	2527	+0.2%	3333	+0.2%	2958	+0.2%
Below Normal	1,320,280	8,237	+0.6%	7230	+0.5%	12919	+1.0%	9181	+0.7%
Dry	1,087,584	8,789	+0.8%	17295	+1.6%	8672	+0.8%	24383	+2.2%
Critical	585,088	11,359	+1.9%	14704	+2.5%	13162	+2.2%	23669	+4.0%
Sacramento Splittail – Entrainment Summary Under Future Conditions									
Year Type	**# Fish**	**CP1/4**		**CP2**		**CP3**		**CP5**	
		Change	**% Change**	**Change**	**% Change**	**Change**	**% Change**	**Change**	**% Change**
Average	269,017	967	+0.4%	1247	+0.5%	886	+0.3%	1753	+0.7%
Wet	379,138	11	+0.0%	187	+0.0%	158	+0.0%	171	+0.0%
Above Normal	314,899	-110	-0.0%	-88	-0.0%	-171	-0.1%	-195	-0.1%
Below Normal	256,197	3,141	+1.2%	2823	+1.1%	3650	+1.4%	3108	+1.2%
Dry	204,951	796	+0.4%	1479	+0.7%	164	+0.1%	2498	+1.2%
Critical	95,595	1,835	+1.9%	2694	+2.8%	1378	+1.4%	4432	+4.6%

Note:

A negative number represents a net reduction or project benefit, while a positive number represents an increase in fish lost.

Key:

CP = Comprehensive Plan

Chapter 3
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EXHIBIT A

SWP and CVP Entrainment/ Modeling Results by Month

Existing: Monthly Entrainment/Losses

Existing Conditions vs. CP1

Table A-1. Delta Smelt Net Entrainment Indices, Under Existing Conditions vs. CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	0	1	-7	4	0	11	-5	2	0	0	**6**
Wet	0	1	0	0	-1	-2	0	-3	0	0	0	0	**-6**
Above Normal	0	1	-1	-3	-35	31	0	-1	1	-9	0	0	**-16**
Below Normal	0	0	-1	0	-6	-1	0	0	-31	4	0	0	**-33**
Dry	0	1	1	5	-3	-12	0	0	0	8	0	0	**1**
Critical	0	0	0	-1	0	17	0	79	0	9	0	0	**105**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-2. Longfin Smelt Net Entrainment Indices, Under Existing Conditions vs. CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	0	3	0	0	0	0	**3**
Wet	0	0	0	0	0	0	0	-1	0	0	0	0	**-1**
Above Normal	0	0	0	0	0	3	0	0	0	0	0	0	**2**
Below Normal	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Dry	0	0	0	0	0	-1	0	0	0	0	0	0	**-1**
Critical	0	0	0	0	0	2	0	21	0	0	0	0	**22**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-3. Chinook Salmon Net Entrainment Indices, Under Existing Conditions vs. CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	2	0	2	-49	30	0	9	-2	0	0	1	**-8**
Wet	0	2	0	0	-9	-14	0	-3	0	0	0	0	**-23**
Above Normal	1	3	-1	-8	-241	239	0	0	0	-1	0	0	**-8**
Below Normal	1	1	-1	0	-42	-4	0	0	-14	0	0	0	**-59**
Dry	1	2	1	16	-19	-91	-1	0	0	1	0	2	**-88**
Critical	-1	1	0	-3	3	133	0	70	0	1	0	2	**206**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-4. Steelhead Net Entrainment Indices, Under Existing Conditions vs. CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	-10	5	0	0	0	0	0	0	**-4**
Wet	0	0	0	0	-2	-2	0	0	0	0	0	0	**-4**
Above Normal	0	0	0	-2	-48	39	0	0	0	0	0	0	**-10**
Below Normal	0	0	0	0	-8	-1	0	0	0	0	0	0	**-9**
Dry	0	0	0	3	-4	-15	0	0	0	0	0	0	**-15**
Critical	0	0	0	-1	1	22	0	0	0	0	0	0	**22**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-5. Striped Bass Net Entrainment Indices, Under Existing Conditions vs. CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	271	1520	1	10	-126	72	0	20	-195	572	195	194	**2533**
Wet	-133	1632	20	0	-23	-33	0	-6	0	-34	44	51	**1518**
Above Normal	861	2423	-62	-45	-617	579	0	-1	24	-2119	-261	56	**837**
Below Normal	612	843	-105	0	-108	-10	0	0	-1176	1023	-21	35	**1092**
Dry	633	1587	92	87	-50	-220	0	1	14	1909	2310	463	**6826**
Critical	-384	1063	10	-18	7	324	0	152	-8	2044	-1939	420	**1671**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-6. Sacramento Splittail Net Entrainment Indices, Under Existing Conditions vs. CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	0	1	-7	4	0	11	-5	2	0	0	**6**
Wet	0	1	0	0	-1	-2	0	-3	0	0	0	0	**-6**
Above Normal	0	1	-1	-3	-35	31	0	-1	1	-9	0	0	**-16**
Below Normal	0	0	-1	0	-6	-1	0	0	-31	4	0	0	**-33**
Dry	0	1	1	5	-3	-12	0	0	0	8	0	0	**1**
Critical	0	0	0	-1	0	17	0	79	0	9	0	0	**105**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Existing Conditions vs. CP2

Table A-7. Delta Smelt Net Entrainment Indices, Under Existing Conditions vs. CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	0	3	-1	4	0	15	41	5	0	0	**68**
Wet	0	1	0	0	-2	-1	0	-4	-1	0	0	0	**-7**
Above Normal	0	1	1	-17	-45	31	0	-1	-17	-12	0	0	**-58**
Below Normal	0	0	0	0	13	1	0	0	258	0	0	0	**273**
Dry	0	1	-1	12	2	-12	0	-2	0	-1	0	0	**0**
Critical	0	1	-3	16	27	17	0	112	1	48	0	0	**219**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-8. Longfin Smelt Net Entrainment Indices, Under Existing Conditions vs. CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	0	4	0	0	0	0	**5**
Wet	0	0	0	0	0	0	0	-1	0	0	0	0	**-1**
Above Normal	0	0	0	-1	0	3	0	0	0	0	0	0	**1**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**3**
Dry	0	0	0	0	0	-1	2	0	0	0	0	0	**1**
Critical	0	0	0	1	0	2	0	29	0	0	0	0	**32**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-9. Chinook salmon Net Entrainment Indices, Under Existing Conditions vs. CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	3	0	8	-4	34	2	13	19	0	0	1	**77**
Wet	0	3	0	0	-12	-7	0	-3	-1	0	0	0	**-20**
Above Normal	2	3	1	-50	-306	242	0	-1	-8	-1	0	0	**-118**
Below Normal	1	1	0	0	88	11	0	0	122	0	0	0	**223**
Dry	1	3	0	36	16	-91	10	-1	0	0	0	3	**-24**
Critical	-2	3	-3	48	181	131	1	99	1	4	-1	2	**464**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-10. Steelhead Net Entrainment Indices, Under Existing Conditions vs. CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	1	-1	6	0	0	0	0	0	0	**7**
Wet	0	0	0	0	-2	-1	0	0	0	0	0	0	**-3**
Above Normal	0	0	0	-9	-61	39	0	0	0	0	0	0	**-30**
Below Normal	0	0	0	0	18	2	0	0	1	0	0	0	**21**
Dry	0	0	0	7	3	-15	0	0	0	0	0	0	**-4**
Critical	0	0	0	9	36	21	0	1	0	1	0	0	**68**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-11. Striped Bass Net Entrainment Indices, Under Existing Conditions vs. CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	218	1986	-22	41	-10	83	0	28	1590	1153	-73	232	**5229**
Wet	-175	1970	49	0	-32	-17	0	-7	-49	-106	75	52	**1762**
Above Normal	1315	2295	150	-272	-784	586	0	-2	-646	-2789	-232	58	**-322**
Below Normal	532	1010	29	0	226	27	0	-1	9931	101	-1074	-1	**10781**
Dry	708	2275	-58	197	41	-221	2	-3	-12	-319	2536	662	**5807**
Critical	-1126	2418	-352	260	464	318	0	215	49	11260	-2983	425	**10946**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Table A-12. Sacramento Splittail Net Entrainment Indices, Under Existing Conditions vs. CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	1	6	0	1	-1	8	1	11	510	225	-2	6	**766**
Wet	-1	6	1	0	-2	-2	0	-3	-16	-21	2	1	**-33**
Above Normal	4	7	3	-10	-44	60	0	-1	-207	-544	-6	2	**-737**
Below Normal	2	3	0	0	13	3	0	0	3183	20	-27	0	**3196**
Dry	2	6	-1	7	2	-22	3	-1	-4	-62	65	18	**13**
Critical	-4	7	-6	9	26	32	0	81	16	2196	-76	12	**2294**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment

Existing Conditions vs. CP3

Table A-13. Delta Smelt Net Entrainment Indices, Under Existing Conditions vs. CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	0	10	-1	2	0	-12	42	0	0	0	**42**
Wet	0	1	0	0	-2	-1	0	-1	0	-1	0	0	**-4**
Above Normal	0	1	0	-19	-45	31	0	-1	-17	-12	0	0	**-60**
Below Normal	0	0	1	0	25	1	0	0	258	20	0	0	**305**
Dry	0	1	0	9	3	-12	0	0	0	-6	0	0	**-6**
Critical	0	1	-1	75	8	2	0	-75	1	-2	0	0	**10**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-14. Longfin Smelt Net Entrainment Indices, Under Existing Conditions vs. CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	0	-3	0	0	0	0	**-2**
Wet	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Above Normal	0	0	0	-1	0	3	0	0	0	0	0	0	**1**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**3**
Dry	0	0	0	0	0	-1	-1	0	0	0	0	0	**-2**
Critical	0	0	0	3	0	0	0	-20	0	0	0	0	**-17**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-15. Chinook salmon Net Entrainment Indices, Under Existing Conditions vs. CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	1	2	0	30	-6	17	-1	-10	20	0	0	0	**53**
Wet	0	3	0	0	-14	-4	0	-1	0	0	0	1	**-16**
Above Normal	2	3	0	-56	-304	242	0	-1	-8	-1	0	0	**-123**
Below Normal	0	1	1	0	173	4	0	0	122	2	0	0	**302**
Dry	1	3	0	26	23	-92	-5	0	0	-1	0	-1	**-47**
Critical	1	2	-1	223	56	17	1	-66	1	0	0	1	**235**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-16. Steelhead Net Entrainment Indices, Under Existing Conditions vs. CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	6	-1	3	0	0	0	0	0	0	**7**
Wet	0	0	0	0	-3	-1	0	0	0	0	0	0	**-3**
Above Normal	0	1	0	-10	-61	39	0	0	0	0	0	0	**-31**
Below Normal	0	0	0	0	35	1	0	0	1	0	0	0	**36**
Dry	0	0	0	5	5	-15	0	0	0	0	0	0	**-5**
Critical	0	0	0	41	11	3	0	0	0	0	0	0	**55**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-17. Striped Bass Net Entrainment Indices, Under Existing Conditions vs. CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	461	1761	44	163	-16	41	0	-23	1612	-90	-70	98	**3981**
Wet	277	1920	29	0	-37	-11	0	-3	6	-264	74	324	**2316**
Above Normal	1104	2485	57	-301	-779	586	0	-2	-644	-2777	-266	24	**-513**
Below Normal	16	605	169	0	442	10	0	-1	9944	4638	-647	29	**15204**
Dry	545	2209	38	139	58	-224	-1	-1	-9	-1427	405	-169	**1563**
Critical	611	1370	-76	1210	144	42	0	-144	56	-538	-222	162	**2616**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-18. Sacramento Splittail Net Entrainment Indices, Under Existing Conditions vs. CP3(2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	2	5	1	6	-1	4	0	-9	517	-18	-2	3	**507**
Wet	1	5	0	0	-2	-1	0	-1	2	-51	2	9	**-36**
Above Normal	4	7	1	-11	-44	60	0	-1	-206	-542	-7	1	**-738**
Below Normal	0	2	3	0	25	1	0	0	3188	904	-16	1	**4107**
Dry	2	6	1	5	3	-23	-1	0	-3	-278	10	-5	**-283**
Critical	2	4	-1	43	8	4	0	-55	18	-105	-6	4	**-83**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Existing Conditions vs. CP5

Table A-19. Delta Smelt Net Entrainment Indices, Under Existing Conditions vs. CP5 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	0	1	0	-5	2	5	0	4	41	12	0	0	**60**
Wet	0	1	1	0	-2	2	0	-5	0	-1	0	0	**-4**
Above Normal	0	1	1	-21	-40	31	0	0	-17	-12	0	0	**-56**
Below Normal	0	0	1	0	20	-1	0	0	258	11	0	0	**289**
Dry	0	1	0	12	4	-12	0	-1	-1	11	0	0	**15**
Critical	0	1	-2	-29	27	15	0	37	0	66	0	0	**114**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-20. Longfin Smelt Net Entrainment Indices, Under Existing Conditions vs. CP5 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	0	0	0	0	0	0	1	1	0	0	0	0	**2**
Wet	0	0	0	0	0	0	0	-1	0	0	0	0	**-1**
Above Normal	0	0	0	-1	0	3	0	0	0	0	0	0	**2**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**3**
Dry	0	0	0	0	0	-1	2	0	0	0	0	0	**2**
Critical	0	0	0	-1	0	1	0	10	0	0	0	0	**11**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-21. Chinook Salmon Net Entrainment Indices, Under Existing Conditions vs. CP5 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Total**
Average	0	3	0	-14	11	37	3	3	20	1	0	2	**67**
Wet	0	2	1	0	-14	18	0	-4	0	0	0	1	**4**
Above Normal	2	3	1	-61	-274	242	0	0	-8	-1	0	0	**-96**
Below Normal	1	1	1	0	136	-4	0	0	122	1	0	0	**257**
Dry	1	3	0	36	27	-92	14	-1	0	1	1	3	**-8**
Critical	-1	3	-1	-87	183	118	0	32	0	5	-1	4	**255**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-22. Steelhead Net Entrainment Indices, Under Existing Conditions vs. CP5 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	-2	2	6	0	0	0	0	0	0	**7**
Wet	0	0	0	0	-3	3	0	0	0	0	0	0	**1**
Above Normal	0	0	0	-11	-55	39	0	0	0	0	0	0	**-26**
Below Normal	0	0	0	0	27	-1	0	0	1	0	0	0	**28**
Dry	0	0	0	7	5	-15	0	0	0	0	0	0	**-2**
Critical	0	0	0	-16	37	19	0	0	0	1	0	0	**41**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-23. Striped Bass Net Entrainment Indices, Under Existing Conditions vs. CP5 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	358	1885	32	-74	29	91	1	7	1597	2737	-22	402	**7044**
Wet	18	1634	75	0	-35	44	0	-9	0	-234	105	257	**1854**
Above Normal	1439	2331	150	-330	-702	586	0	0	-659	-2718	-315	4	**-214**
Below Normal	774	1041	103	0	348	-10	0	0	9942	2456	-752	-61	**13841**
Dry	583	2434	-22	198	68	-223	2	-2	-20	2519	3136	844	**9518**
Critical	-808	2146	-176	-470	468	286	0	71	1	15286	-3887	990	**13907**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-24. Sacramento Splittail Net Entrainment Indices, Under Existing Conditions vs. CP5 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	1	5	1	-3	2	9	1	3	512	534	-1	11	**1075**
Wet	0	5	1	0	-2	4	0	-4	0	-46	3	7	**-31**
Above Normal	5	7	3	-12	-40	60	0	0	-211	-530	-8	0	**-727**
Below Normal	3	3	2	0	20	-1	0	0	3187	479	-19	-2	**3671**
Dry	2	7	0	7	4	-23	4	-1	-6	491	80	23	**588**
Critical	-3	6	-3	-17	26	29	0	27	0	2981	-99	27	**2976**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Future: Monthly Entrainment/ Losses

Future No-Action vs. Future CP1

Table A-25. Delta Smelt Net Entrainment Indices, Under Future No-Action Conditions vs. Future CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	5	2	-1	0	50	49	7	0	0	**6**
Wet	0	0	0	0	4	3	0	-1	0	0	0	0	**-6**
Above Normal	0	1	1	-26	-5	2	0	0	0	-3	0	0	**-16**
Below Normal	0	0	0	0	-8	0	0	0	290	-9	0	0	**-33**
Dry	0	1	0	0	0	-13	0	0	-4	18	0	0	**1**
Critical	0	1	-1	58	18	0	0	344	0	33	0	0	**105**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-26. Longfin Smelt Net Entrainment Indices, Under Future No-Action Conditions vs. Future CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	1	13	1	0	0	0	**3**
Wet	0	0	0	0	0	0	2	0	0	0	0	0	**-1**
Above Normal	0	0	0	-1	0	0	0	0	0	0	0	0	**2**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**0**
Dry	0	0	0	0	0	-1	-1	0	0	0	0	0	**-1**
Critical	0	0	0	2	0	0	0	91	0	0	0	0	**22**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-27. Chinook salmon Net Entrainment Indices, Under Existing Future No-Action Conditions vs. Future CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	2	0	14	11	-11	3	44	23	1	0	1	**-8**
Wet	1	1	0	0	27	26	12	-1	0	0	0	0	**-23**
Above Normal	1	2	1	-77	-34	13	0	0	0	0	0	1	**-8**
Below Normal	0	0	0	0	-55	1	0	0	137	-1	0	0	**-59**
Dry	1	2	0	0	-2	-97	-4	0	-2	1	0	3	**-88**
Critical	0	2	-1	171	121	-4	0	304	0	3	0	1	**206**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-28. Steelhead Net Entrainment Indices, Under Existing Future No-Action Conditions vs. Future CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	3	2	-2	0	0	0	0	0	0	**-4**
Wet	0	0	0	0	5	4	0	0	0	0	0	0	**-4**
Above Normal	0	0	0	-14	-7	2	0	0	0	0	0	0	**-10**
Below Normal	0	0	0	0	-11	0	0	0	1	0	0	0	**-9**
Dry	0	0	0	0	0	-16	0	0	0	0	0	0	**-15**
Critical	0	0	0	31	24	-1	0	2	0	0	0	0	**22**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-29. Striped Bass Net Entrainment Indices, Under Future No-Action Conditions vs. Future CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	353	1112	14	75	29	-28	1	96	1870	1587	303	255	**2533**
Wet	465	801	26	0	68	64	2	-2	-15	-6	0	-4	**1518**
Above Normal	394	1818	130	-416	-87	32	0	1	16	-585	-3	232	**837**
Below Normal	-148	84	38	0	-141	3	0	1	11162	-2122	-644	4	**1092**
Dry	837	1741	-24	0	-5	-236	-1	-1	-156	4093	1783	758	**6826**
Critical	-73	1333	-102	927	310	-9	0	662	5	7778	148	379	**1671**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-30. Sacramento Splittail Net Entrainment Indices, Under Future No-Action Conditions vs. Future CP1 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	5	2	-1	0	50	49	7	0	0	**6**
Wet	0	0	0	0	4	3	0	-1	0	0	0	0	**-6**
Above Normal	0	1	1	-26	-5	2	0	0	0	-3	0	0	**-16**
Below Normal	0	0	0	0	-8	0	0	0	290	-9	0	0	**-33**
Dry	0	1	0	0	0	-13	0	0	-4	18	0	0	**1**
Critical	0	1	-1	58	18	0	0	344	0	33	0	0	**105**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Future No-Action vs. Future CP2

Table A-31. Delta Smelt Net Entrainment Indices, Under Future Conditions vs. Future CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	-1	4	-1	-2	0	81	42	14	0	0	**68**
Wet	0	0	0	0	4	3	0	-1	16	0	0	0	**-7**
Above Normal	0	1	2	-29	-4	3	0	0	0	-2	0	0	**-58**
Below Normal	0	0	-1	0	-19	0	0	0	290	-16	0	0	**273**
Dry	0	1	-1	0	4	-13	0	-1	-56	45	0	0	**0**
Critical	0	1	-8	55	3	-1	0	557	0	50	0	0	**219**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-32. Longfin Smelt Net Entrainment Indices, Under Future Conditions vs. Future CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	-1	21	1	0	0	0	**5**
Wet	0	0	0	0	0	0	-4	0	0	0	0	0	**-1**
Above Normal	0	0	0	-1	0	0	0	0	0	0	0	0	**1**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**3**
Dry	0	0	0	0	0	-1	4	0	-1	0	0	0	**1**
Critical	0	0	0	2	0	0	0	147	0	0	0	0	**32**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-33. Chinook salmon Net Entrainment Indices, Under Future Conditions vs. Future CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	1	3	-1	11	-9	-13	-3	72	20	1	0	2	**77**
Wet	1	1	0	0	26	22	-23	-1	7	0	0	0	**-20**
Above Normal	1	3	2	-85	-30	24	0	0	0	0	0	1	**-118**
Below Normal	0	1	-1	0	-128	-3	0	0	137	-1	0	0	**223**
Dry	2	5	-1	0	26	-97	20	-1	-26	4	0	5	**-24**
Critical	-1	3	-8	163	19	-10	0	492	0	4	0	2	**464**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-34. Steelhead Net Entrainment Indices, Under Future Conditions vs. Future CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	2	-2	-2	0	0	0	0	0	0	**7**
Wet	0	0	0	0	5	4	0	0	0	0	0	0	**-3**
Above Normal	0	0	0	-16	-6	4	0	0	0	0	0	0	**-30**
Below Normal	0	0	0	0	-26	0	0	0	1	0	0	0	**21**
Dry	0	1	0	0	5	-16	0	0	0	1	0	0	**-4**
Critical	0	0	-1	30	4	-2	0	3	0	1	0	0	**68**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-35. Striped Bass Net Entrainment Indices, Under Future Conditions vs. Future CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	516	1913	-123	62	-24	-31	-1	156	1628	3292	435	407	**5229**
Wet	446	1029	42	1	68	54	-4	-2	603	-66	0	-31	**1762**
Above Normal	780	2280	242	-461	-76	58	0	1	18	-500	-20	206	**-322**
Below Normal	16	925	-66	0	-328	-7	0	1	11176	-3704	-816	32	**10781**
Dry	1552	3487	-106	-2	67	-235	4	-1	-2154	10586	2754	1344	**5807**
Critical	-566	2250	-940	885	49	-25	0	1072	-5	11581	-187	590	**10946**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-36. Sacramento Splittail Net Entrainment Indices, Under Future Conditions vs. Future CP2 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	2	5	-2	2	-1	-3	-1	59	522	642	11	11	**766**
Wet	1	3	1	0	4	6	-6	-1	193	-13	0	-1	**-33**
Above Normal	3	6	4	-16	-4	6	0	0	6	-98	-1	6	**-737**
Below Normal	0	3	-1	0	-19	-1	0	0	3583	-722	-21	1	**3196**
Dry	5	10	-2	0	4	-24	5	0	-691	2064	70	37	**13**
Critical	-2	6	-16	31	3	-3	0	406	-1	2258	-5	16	**2294**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Future No-Action vs. Future CP3

Table A-37. Delta Smelt Net Entrainment Indices, Under Future Conditions vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	-3	12	3	-3	0	-114	46	8	0	0	**42**
Wet	0	1	0	3	4	-2	0	1	15	-1	0	0	**-4**
Above Normal	0	1	2	16	-7	3	0	0	1	-5	0	0	**-60**
Below Normal	0	0	4	0	-2	-1	0	0	290	1	0	0	**305**
Dry	0	2	-12	2	3	-13	1	0	-39	13	0	0	**-6**
Critical	0	1	-9	57	18	4	0	-779	1	40	0	0	**10**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-38. Longfin Smelt Net Entrainment Indices, Under Future Conditions vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	0	-30	1	0	0	0	**-2**
Wet	0	0	0	0	0	0	-4	0	0	0	0	0	**0**
Above Normal	0	0	0	1	0	0	0	0	0	0	0	0	**1**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**3**
Dry	0	0	0	0	0	-1	6	0	0	0	0	0	**-2**
Critical	0	0	0	2	0	0	0	-205	0	0	0	0	**-17**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-39. Chinook salmon Net Entrainment Indices, Under Future Conditions vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	1	3	-3	35	23	-20	1	-100	22	1	0	1	**53**
Wet	1	2	0	9	28	-17	-23	1	7	0	0	0	**-16**
Above Normal	1	4	2	46	-46	24	0	0	0	0	0	1	**-123**
Below Normal	1	1	4	0	-16	-11	0	0	137	0	0	0	**302**
Dry	2	6	-12	5	24	-97	36	0	-18	1	0	1	**-47**
Critical	0	3	-8	170	125	33	0	-688	0	3	0	1	**235**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-40. Steelhead Net Entrainment Indices, Under Future Conditions vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	6	5	-3	0	-1	0	0	0	0	**7**
Wet	0	0	0	2	6	-3	0	0	0	0	0	0	**-3**
Above Normal	0	1	0	8	-9	4	0	0	0	0	0	0	**-31**
Below Normal	0	0	0	0	-3	-2	0	0	1	0	0	0	**36**
Dry	0	1	-1	1	5	-16	1	0	0	0	0	0	**-5**
Critical	0	1	-1	31	25	5	0	-5	0	0	0	0	**55**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-41. Striped Bass Net Entrainment Indices, Under Future No-Action Conditions vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	661	2219	-343	192	59	-49	0	-219	1778	1852	959	195	**3981**
Wet	592	1270	13	46	72	-41	-4	2	587	-179	0	106	**2316**
Above Normal	521	3129	251	251	-117	59	0	1	31	-1093	-15	314	**-513**
Below Normal	367	508	439	0	-41	-26	0	1	11181	280	109	101	**15204**
Dry	1529	4143	-1426	25	61	-235	6	0	-1492	2980	2758	324	**1563**
Critical	-10	2476	-994	921	321	79	0	-1499	38	9339	2307	184	**2616**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-42. Sacramento Splittail Net Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	2	6	-6	7	3	-5	0	-83	570	361	24	5	**507**
Wet	2	4	0	2	4	-4	-6	1	188	-35	0	3	**-36**
Above Normal	2	9	4	9	-7	6	0	0	10	-213	0	9	**-738**
Below Normal	1	1	8	0	-2	-3	0	0	3584	55	3	3	**4107**
Dry	5	12	-25	1	3	-24	10	0	-478	581	70	9	**-283**
Critical	0	7	-17	33	18	8	0	-568	12	1821	59	5	**-83**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Future No-Action vs. Future CP5

Table A-43. Delta Smelt Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	1	0	6	3	-1	0	81	50	23	0	0	**60**
Wet	0	0	1	0	4	4	0	-2	15	-1	0	0	**-4**
Above Normal	0	1	2	-15	-10	3	0	0	1	-5	0	0	**-56**
Below Normal	0	0	1	0	4	0	0	0	290	-10	0	0	**289**
Dry	0	2	-1	0	4	-12	0	0	-20	56	0	0	**15**
Critical	0	1	-4	55	12	-2	0	557	0	88	0	0	**114**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-44. Longfin Smelt Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	0	0	0	-1	21	1	0	0	0	**2**
Wet	0	0	0	0	0	0	-4	-1	0	0	0	0	**-1**
Above Normal	0	0	0	-1	0	0	0	0	0	0	0	0	**2**
Below Normal	0	0	0	0	0	0	0	0	3	0	0	0	**3**
Dry	0	0	0	0	0	-1	0	0	0	0	0	0	**2**
Critical	0	0	0	2	0	0	0	147	0	1	0	0	**11**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-45. Chinook Salmon Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	1	3	0	17	22	-10	-8	72	24	2	0	2	**67**
Wet	1	1	1	0	29	27	-23	-2	7	0	0	0	**4**
Above Normal	1	4	2	-46	-65	23	0	0	0	0	0	1	**-96**
Below Normal	0	1	1	0	27	3	0	0	137	-1	0	0	**257**
Dry	2	5	-1	0	26	-92	-1	0	-9	5	1	5	**-8**
Critical	0	4	-4	164	79	-18	0	492	0	7	0	4	**255**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-46. Steelhead Net Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	0	0	0	3	4	-2	0	0	0	0	0	0	**7**
Wet	0	0	0	0	6	4	0	0	0	0	0	0	**1**
Above Normal	0	1	0	-8	-13	4	0	0	0	0	0	0	**-26**
Below Normal	0	0	0	0	5	1	0	0	1	0	0	0	**28**
Dry	0	1	0	0	5	-15	0	0	0	1	0	0	**-2**
Critical	0	1	0	30	16	-3	0	3	0	1	0	0	**41**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-47. Striped Bass Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	615	2149	10	94	56	-25	-1	156	1933	5281	808	500	**7044**
Wet	549	1024	155	1	75	66	-4	-4	590	-162	0	105	**1854**
Above Normal	969	2911	279	-247	-167	57	0	1	23	-1093	-14	240	**-214**
Below Normal	-59	1049	87	0	69	8	0	0	11186	-2398	-871	110	**13841**
Dry	1615	3762	-110	-2	68	-223	0	1	-764	13178	5613	1247	**9518**
Critical	-307	2691	-485	891	203	-43	0	1072	3	20561	-1870	953	**13907**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

Table A-48. Sacramento Splittail Net Entrainment Indices, Under Future No-Action vs. Future CP3 (2005), Based on 1922-2003 CalSim Modeling Results

Year Type	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Average	2	6	0	3	3	-3	-2	59	620	1030	21	14	**1075**
Wet	2	3	3	0	4	7	-6	-1	189	-32	0	3	**-31**
Above Normal	3	8	5	-9	-9	6	0	0	7	-213	0	7	**-727**
Below Normal	0	3	2	0	4	1	0	0	3586	-468	-22	3	**3671**
Dry	5	11	-2	0	4	-23	0	0	-245	2570	143	35	**588**
Critical	-1	8	-8	31	11	-4	0	406	1	4009	-48	26	**2976**

Note:
Negative number represents a net reduction in entrainment. A positive number represents an increase in entrainment.

EXHIBIT B
SWP and CVP Fish Facility Densities Used in Entrainment/Modeling

EXHIBIT B
SWP and CVP Fish Facility Densities Used in Entrainment/Modeling

SWP + CVP Average Densities
Based on 1995-2005 data

DELTA SMELT		
MONTH	NO/ACRE-FOOT	NO/THOUSAND ACRE-FOOT
January	0.004475	4.474788
February	0.003211	3.210665
March	0.002233	2.233294
April	0.00085	0.850389
May	0.168653	168.6528
June	0.041763	41.76288
July	0.003108	3.10799
August	8.04E-06	0.00804
September	3.32E-06	0.003321
October	4.05E-06	0.004048
November	6.14E-05	0.061447
December	0.00079	0.78997
CHINOOK SALMON		
MONTH	NO/ACRE-FOOT	NO/THOUSAND ACRE-FOOT
January	0.013248	13.24766
February	0.021891	21.89108
March	0.017231	17.23107
April	0.041669	41.66908
May	0.148915	148.9151
June	0.019685	19.6853
July	0.000258	0.257568
August	3.06E-05	0.030554
September	0.000123	0.122862
October	0.000138	0.137636
November	0.000200	0.2002
December	0.000771	0.771426
LONGFIN SMELT		
MONTH	NO/ACRE-FOOT	NO/THOUSAND ACRE-FOOT
January	0.000149	0.148986
February	3.08E-05	0.030816
March	0.000198	0.198036
April	0.007278	7.278173
May	0.044403	44.40266
June	0.000496	0.496155
July	2.19E-05	0.021854
August	1.13E-05	0.011257
September	3.32E-06	0.003321
October	6.07E-06	0.006072
November	3.96E-06	0.003964
December	2.41E-05	0.024107

Source: Department of Water Resources, 2006

STEELHEAD		
MONTH	NO/ACRE-FOOT	NO/THOUSAND ACRE-FOOT
January	0.002425	2.42536
February	0.004376	4.375904
March	0.002808	2.807794
April	0.00082	0.819565
May	0.001013	1.013127
June	0.000134	0.134096
July	3.43E-05	0.034342
August	0	0
September	0	0
October	1.42E-05	0.014168
November	2.97E-05	0.029733
December	8.9E-05	0.089011
STRIPED BASS		
MONTH	NO/ACRE-FOOT	NO/THOUSAND ACRE-FOOT
January	0.071858	71.85821
February	0.056041	56.04123
March	0.041823	41.82279
April	0.0074	7.399658
May	0.324529	324.5286
June	1.608785	1608.785
July	0.725067	725.067
August	0.170291	170.2907
September	0.031858	31.85788
October	0.099699	99.69882
November	0.145906	145.906
December	0.090815	90.81502
SPLITTAIL		
MONTH	NO/ACRE-FOOT	NO/THOUSAND ACRE-FOOT
January	0.0025363	2.5362602
February	0.0031705	3.1705192
March	0.0042627	4.2626926
April	0.0110807	11.0806671
May	0.1229534	122.9534202
June	0.5157013	515.7013091
July	0.1413917	141.3917034
August	0.0043390	4.3389655
September	0.0008819	0.8819048
October	0.0003356	0.3356129
November	0.0004157	0.4156885
December	0.0015645	1.5644857

Note:
Average density data for splittail does not include December 2005.