Detailed Description of Recent OCAP Biological Opinions and Delta Wetlands Fishery Resources Effect Assessment Methods and Results

Introduction

This appendix describes in detail the Reasonable and Prudent Alternatives detailed in the Biological Opinions in the Operations, Criteria, and Plan (OCAP) for the State Water Project (SWP) and Central Valley Project (CVP) (USFWS 2008; NMFS 2009), and also describes the methods and results of the fishery resources effects analysis (Section 3.4) for the Delta Wetlands Project.

Recent OCAP Biological Opinions

The recently issued Biological Opinions (USWFS 2008; NMFS 2009) on the long-term coordinated operations of the SWP and CVP represent considerable potential changes to the affected the environment in which the Delta Wetlands project must operate. The main aspects of the Reasonable and Prudent Alternatives (RPA) detailed in the BOs are described below.

USFWS (2008) OCAP Biological Opinion

The USFWS (2008, 276) OCAP BO concluded that “the coordinated operations of the CVP and SWP, as proposed, are likely to jeopardize the continued existence of the delta smelt” and prescribed a RPA to allow continued SWP and CVP operations under the jeopardy opinion. The following details the actions associated with the RPA.

Action 1. Adult Migration and Entrainment (First Flush)

Action 1 aims to protect pre-spawning adult delta smelt from entrainment during the first flush (high Delta outflow caused by elevated river flow that triggers upstream migration), and also aims to provide advantageous hydrodynamic conditions early in the migration period (Table F-1).

Table F-1. Timing, Triggers, and Actions Related to the USFWS (2008) RPA Action 1

Date	Triggers	Action
December 1–20	Examination of relevant turbidity, salvage, flow, survey, and other data by the Smelt Working Group, with a recommendation to USFWS.	Exports are limited so that average daily Old and Middle River (OMR) flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 %).
After December 20	Three-day average turbidity of 12 NTU or greater at measurement stations at Prisoner's Point, Holland Cut, and Victoria Canal; or three days of delta smelt salvage at either SWP or CVP fish facility or cumulative daily salvage count that is above a risk threshold based upon the "daily salvage index" approach reflected in a daily salvage index value ≥0.5 (daily delta smelt salvage > one-half prior year fall midwater trawl [FMWT] index value)	Exports are limited so that average daily Old and Middle River (OMR) flow is no more negative than -2,000 cfs for a total duration of 14 days, with a 5-day running average no more negative than -2,500 cfs (within 25 %).
Determined from Monitoring	Water temperature reaches 12°C based on a three-station daily mean at Mossdale, Antioch, and Rio Vista; or onset of spawning (presence of spent females in Spring Kodiak Trawl [SKT] or at SWP/CVP fish facilities)	Progression to Action 2 or 3
Source: ICF 2010:Appendix B		

Action 2. Adult Migration and Entrainment

Action 2 also aims to protect pre-spawning adult delta smelt from entrainment adverse hydrodynamic conditions (Table F-2). The limits on exports are determined by USFWS based on recommendations by the SWG and reflect distribution of delta smelt in the Delta from monitoring data.

Table F-2. Timing, Triggers, and Actions Related to the USFWS (2008) RPA Action 2

Date	Triggers	Action
Following Action 1 or upon determination by SWG/USFWS	Examination of relevant turbidity, salvage, flow, survey, and other data by the Smelt Working Group, with a recommendation to USFWS.	Exports are limited so that average daily Old and Middle River (OMR) flow is no more negative than -1,250 cfs to -5,000 cfs
Determined from River Flow Monitoring	OMR flow requirements do not apply whenever a three-day flow average is greater than or equal to 90,000 cfs in Sacramento River at Rio Vista and 10,000 cfs in San Joaquin River at Vernalis. Once such flows have abated, the OMR flow requirements of the Action are again in place.	Suspension of Action
Determined from Monitoring	Water temperature reaches 12°C based on a three-station daily mean at Mossdale, Antioch, and Rio Vista; or onset of spawning (presence of spent females in Spring Kodiak Trawl [SKT] or at SWP/CVP fish facilities)	Progression to Action 3
Source: ICF 2010:Appendix B		

Action 3. Entrainment Protection of Larval Smelt

Action 3 aims to minimize the number of larval smelt entrained at the fish facilities by reducing export pumping during an appropriate time period (Table F-3). The limits on exports are determined by USFWS based on recommendations by the SWG and reflect distribution of delta smelt in the Delta from monitoring data.

Table F-3. Timing, Triggers, and Actions Related to the USFWS (2008) RPA Action 3

Date	Triggers	Action
Determined from Monitoring	Water temperature reaches 12°C based on a three-station daily mean at Mossdale, Antioch, and Rio Vista; or onset of spawning (presence of spent females in Spring Kodiak Trawl [SKT] or at SWP/CVP fish facilities)	Net daily OMR flow will be no more negative than -1,250 to -5,000 cfs based on a 14-day running average with a simultaneous 5-day running average within 25 percent of the applicable requirement for OMR.
June 30	June 30; or water temperature in Clifton Court Forebay reaches a 3-day daily average of 25°C.	Action ceases.
Source: ICF 2010:Appendix B		

Action 4. Estuarine Habitat during Fall

Action 4 aims to improve the fall habitat for delta smelt by managing X2 through an adaptive process by increasing outflow when the preceding water year was wetter than normal (Table F-4).

Table F-4. Timing, Triggers, and Actions Related to the USFWS (2008) RPA Action 4

Date	Triggers	Action
September 1–November 30	Wet and above normal Water Year (WY) type classification from the 1995 Water Quality Control Plan that is used to implement D-1641.	Provide sufficient Delta outflow to maintain average X2 for September and October no greater (more eastward) than 74 km in the fall following wet years and 81km in the fall following above normal years. The monthly average X2 must be maintained at or seaward of these values for each individual month and not averaged over the two month period. In November, the inflow to CVP/SWP reservoirs in the Sacramento Basin will be added to reservoir releases to provide an added increment of Delta inflow and to augment Delta outflow up to the fall target
Source: ICF 2010:Appendix B		

Action 5. Temporary Spring Head of Old River Barrier (HORB) and the Temporary Barrier Project

Action 5 aims to minimize the entrainment of larval and juvenile delta smelt by the SWP and CVP export facilities by limiting operation of the TBP (Table F-5). In 2009, an experimental non-physical barrier ('bubble curtain') is being tested at the HORB sites; this may diminish the need for Action 5 if it proves to be successful at deterring migrating Chinook salmon from entering Old River from the San Joaquin River.

Table F-5. Timing, Triggers, and Actions Related to the USFWS (2008) RPA Action 5

Date	Triggers	Action
Variable, generally April	Installation of HORB will only occur when Particle Tracking Model results show that entrainment levels of delta smelt will not increase beyond 1% at Trawl Station 815 as a result of installing the HORB.	Do not install the HORB if delta smelt entrainment is a concern. If installation of the HORB is not allowed, the agricultural barriers would be installed as described in the Project Description. If installation of the HORB is allowed, the TBP flap gates would be tied in the open position until May 15.
May 15 or end of Action 3		Action ceases
Source: ICF 2010:Appendix B		

Action 6. Habitat Restoration

Action 6 aims to improve habitat conditions for delta smelt by enhancing food production and availability. The action involves creation or restoration of at least 8,000 acres of intertidal and associate subtidal habitat in the Delta and Suisun Marsh with a 10-year period commencing one year from the issuance of the USFWS (2008) BO. Associated with the restoration is the development of a monitoring program to assess the restoration's effectiveness.

NMFS (2009) OCAP Biological Opinion

The NMFS OCAP BO released in June 2009 concluded that the CVP and SWP OCAP would jeopardize the continued existence of federally listed Endangered Sacramento River winter-run Chinook salmon, Threatened Central Valley spring-run Chinook salmon, Threatened Central Valley steelhead, Threatened Southern Distinct Population Segment (DPS) of North American green sturgeon, and Endangered Southern Resident Killer Whales. The 2009 NMFS BO contained several suites of RPA measures to avoid the likelihood of jeopardy to the species and to avoid adverse modification of designated and proposed critical habitat. The RPA grouped action measures according to geographic divisions of the SWP/CVP project area, including the Sacramento River Division, American River Division, East Side Division, and Delta Division, as well as a Fish Passage Program incorporating Near- and Long-Term measures (Table F-6).

Table F-6. NMFS 2009 BO Actions to be Included as Part of the RPA to the SWP/CVP OCAP

Actions	Objectives
I. Sacramento River Division	
Action Suite I.1. Clear Creek	Address adverse effects of flow and water temperature that reduce viability of spring-run Chinook and steelhead in Clear Creek
Action Suite I.2. Shasta Operations	1. Sufficient cold water for winter-run spawning between Balls Ferry and Bend Bridge in most years; 2. Suitable spring-run temperatures, esp. in Sep–Oct; 3. Establishment of a second population of winter-run Chinook salmon, in Battle Creek; 4. Passage restoration at Shasta Reservoir (winter-run in upper Sacramento and/or McCloud rivers)
Action Suite I.3. Red Bluff Diversion Dam (RBDD) Operations	Reduce mortality and delay of juvenile and adult migrations of listed anadromous species at RBDD
Action I.4. Wilkins Slough Operations	Enhancement of water temperature management ability for anadromous fish below Shasta Dam
Action I.5. Funding for CVPIA Anadromous Fish Screen Program (AFSP)	Reduction of entrainment of juvenile anadromous fish in unscreened diversions
Action Suite I.6. Sacramento River Basin Salmonid Rearing Habitat Improvements	Restoration of floodplain rearing habitat for juvenile winter-run and spring-run Chinook salmon and steelhead in the lower Sacramento River basin
Action I.7. Reduce Migratory Delays and Loss of Salmon, Steelhead, and Sturgeon at Fremont Weir and Other Structures in the Yolo Bypass	Reduce migratory delays and loss of listed anadromous fish within the Yolo Bypass
II. American River Division	
Action II.1. Lower American River Flow Management	Provision of minimum flows for all steelhead life stages
Action II.2. Lower American River Temperature Management	Maintenance of suitable temperatures to support over-summer rearing of juvenile steelhead in the lower American River
Action II.3. Structural Improvements	Through dam improvements, improvement of the ability to manage the cold water pool for suitable temperatures for listed species
Action II.4. Minimize Flow Fluctuation Effects	Reduce stranding and isolation of juvenile steelhead
Action II.5. Fish Passage at Nimbus and Folsom Dams	Access provision to above-dam, historic cold water habitat for steelhead
Action Suite II.6. Actions to Reduce Genetic Effects of Nimbus and Trinity River Fish Hatchery Operations	1. Reduction of introgression of out-of-basin hatchery stock with wild steelhead in the Central Valley; 2. Increase in diversity of fall-run production to increase Southern Resident Killer Whale prey availability and reduction of adverse effects of hatchery fall-run Chinook straying on genetic diversity of natural fall-run and spring-run Chinook
III. East Side Division	
Actions III.1.1–III.1.3.	Definition of operational criteria for East Side division to ensure viability of the Stanislaus River steelhead population
Action Suite III.2. Stanislaus River CV Steelhead Habitat Restoration	Partial alleviation of adverse modification of steelhead critical habitat (i.e., dam-related channel-forming flow suppression and normal sediment transportation)

Actions	Objectives
IV. Delta Division	
Action Suite IV.1. Delta Cross Channel (DCC) Gate Operation, and Engineering Studies of Methods to Reduce Loss of Salmonids in Georgiana Slough and Interior Delta	Reduction of the proportion of emigrating listed salmonids and green sturgeon that enter the interior delta either through the open DCC gates or Georgiana Slough
Action Suite IV.2. Delta Flow Management	Maintenance of adequate flows in the Sacramento/San Joaquin rivers to increase survival of steelhead emigrating to the estuary from the San Joaquin River and of winter-run and spring-run Chinook, steelhead, and green sturgeon emigrating from the Sacramento River through the Delta to Chipps Island
Action IV.3. Reduce Likelihood of Entrainment or Salvage at the Export Facilities	Reduction of losses of winter-run and spring-run Chinook, steelhead, and green sturgeon by reducing exports when large numbers of juvenile Chinook are migrating into the upper Delta and are at risk of entrainment by the export pumps
Action Suite IV.4. Modifications of the Operations and Infrastructure of the CVP and SWP Fish Collection Facilities	1. Achievement of 75% salvage efficiency at both facilities; 2. Increase in efficiency of the fish collection facilities to improve survival of listed anadromous fishes
Action IV.5. Formation of Delta Operations for Salmon and Sturgeon (DOSS) Technical Working Group	Creation of a technical advisory team to provide recommendations to the water operations management team (WOMT) and NMFS regarding measures to reduce adverse effects of SWP/CVP Delta operations on listed anadromous fishes and coordination of other technical teams' work
Action IV.6. South Delta Improvement Program—Phase I (Permanent Operable Gates)	No implementation of DWR's South Delta Improvement Program (replacement of temporary barriers with permanent operable gates)
V. Fish Passage Program	
NF1. Formation of Interagency Fish Passage Steering Committee	To charter, and support through funding agreements, an interagency committee to provide oversight and technical, management, and policy direction for the Fish Passage Program
NF2. Evaluation of Salmonid Spawning and Rearing Habitat Above Dams	Quantification and characterization of the location, amount, suitability, and functionality of existing and/or potential spawning and rearing habitat for listed species above Reclamation-operated dams
NF3. Development of Fish Passage Pilot Plan	Completion of a 3-year plan for the Fish Passage Pilot program
NF4. Implementation of Pilot Reintroduction Program	Implementation of short-term fish passage actions that will inform planning for long-term passage actions
NF5. Comprehensive Fish Passage Report	To evaluate the effectiveness of fish passage alternatives and make recommendations for the development and implementation of long-term passage alternatives and a long-term fish passage program
LF1. Long-term Funding and Support to the Interagency Fish Passage Steering Committee	Continued convening, funding, and staffing of the Fish Passage Steering Committee should the Comprehensive Fish Passage Report indicate that long-term fish passage is feasible and desirable
LF2. Long-Term Fish Passage Plan and Program	Provision of structural and operational modification to allow safe fish passage and access to habitat above and below SWP/CVP Central Valley project dams
Source: ICF 2010:Appendix B	

With regard to operations in the Delta, the main actions included changes in operations to the Delta Cross Channel to reduce the number of salmonids entering the central Delta; maintenance of adequate flows in the Sacramento and San Joaquin rivers to increase survival of migrating salmonids; reduction of the likelihood of entrainment/salvage at the south Delta fish collection facilities; and improved efficiency of the fish collection facilities. The NMFS (2009) BO is similar to the USWFS (2008) BO for delta smelt in that flow-based actions are detailed, including restrictions to Old and Middle River reverse flows, as well as other measures such as minimum flows required at Vernalis (San Joaquin River). In addition, actions to reduce the risk of Sacramento River-origin outmigrating fish entering the central Delta are detailed, as are actions to improve salvage efficiency at the SWP/CVP fish facilities in the south Delta. The following describes the RPA that are applicable to the Delta division.

Action IV.1.1 Monitoring and Alerts to Trigger Changes in Delta Cross Channel Operations

In order to reduce the likelihood of emigrating salmonids entering the central Delta through the DCC, this action continues funding for monitoring programs that provide information used to alert managers as to when juvenile Chinook salmon will be approaching the Delta. The *First Alert* is triggered by one of two conditions and determines when the DCC gates should be closed: either capture of yearling-sized (>70 mm) spring-run Chinook salmon at the mouths of natal tributaries between October and April, or an increase in tributary flow of more than 50% over levels preceding the flow spike from October onward. The *Second Alert* is triggered by Sacramento River flows greater than 7,500 cfs at Wilkins Slough and water temperatures less than 13.5ºC (56.3ºF) at Knights Landing.

Action IV.1.2 DCC Gate Operation

The DCC gates will be operated to reduce mortality of emigrating juvenile salmonids and green sturgeon in November, December, and January (Table F-7).

Table F-7. Decision Tree Related to the Operation of the Delta Cross Channel, as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

Date	Triggers	Actions
October 1–November 30	Water quality criteria per D-1641 are met and either the KLCI or the SCI is greater than three fish per day but less than or equal to five fish per day	Within 24 hours of trigger, DCC gates are closed. Gates will remain closed for 3 days.
	Water quality criteria per D-1641 are met and either the KLCI or SCI is greater than five fish per day	Within 24 hours, close the DCC gates and keep them closed until the catch index is less than three fish per day at both the Knights Landing and Sacramento monitoring sites.
	The KLCI or SCI triggers are met but water quality criteria are not met per D-1641 criteria	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5.
December 1–December 14	Water quality criteria are met per D-1641	DCC gates are closed. If Chinook salmon migration experiments are conducted during this time period (e.g., Delta Action 8 or similar studies), the DCC gates may be opened according to the experimental design, with NMFS's prior approval of the study.
	Water quality criteria are not met but both the KLCI and SCI are less than three fish per day	DCC gates may be opened until the water quality criteria are met. Once water quality criteria are met, the DCC gates will be closed within 24 hours of compliance.
	Water quality criteria are not met but either of the KLCI or SCI is greater than three fish per day	DOSS reviews monitoring data and makes recommendation to NMFS and WOMT per procedures in Action IV.5.
December 15–January 31	December 15–January 31	DCC gates are closed.
	NMFS-approved experiments are being conducted	Agency sponsoring the experiment may request gate opening for up to 5 days; NMFS will determine whether opening is consistent with ESA obligations.
	One-time event between December 15 and January 5, when necessary to maintain Delta water quality in response to the astronomical high tide, coupled with low inflow conditions	Upon concurrence of NMFS, DCC gates may be opened 1 hour after sunrise to 1 hour before sunset, for up to 3 days, then returned to full closure. Reclamation and DWR also will reduce Delta exports down to a health and safety level during the period of this action.
February 1–May 15	D-1641 mandatory gate closure	Gates closed, per WQCP criteria.
May 16–June 15	D-1641 gate operations criteria	DCC gates may be closed for up to 14 days during this period, per 2006 WQCP, if NMFS determines it is necessary.

WQCP = water quality control plan.
NMFS = National Marine Fisheries Service.
KLCI = Knights Landing Catch Index .
SCI = Sacramento Catch Index.
DCC = Delta Cross Channel.
DOSS = Delta Operations for Salmon and Sturgeon.
DWR = California Department of Water Resources.
ESA = Endangered Species Act.
WOMT = Water Operations Management Team

Source: National Marine Fisheries Service 2009: 636–639, cited in ICF 2010:Appendix B

Action Suite IV.2 Delta Flow Management

Action Suite IV.2 describes a number of related actions aimed at maintaining adequate flows within the Delta in order to increase survival of outmigrating salmonids. These actions would occur from January 1 until June 15 each year (Table F-8).

Table F-8. Time Periods of Actions in Relation to Action Suite IV.2 (Delta Flow Management) of the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

Action	Period
IV.2.1 (San Joaquin River inflow to export ratio)	April 1–May 31
IV.2.2 (Acoustic tag studies)	March 1–March 31; April 1–May 31; June 1–15
IV.2.3 (OMR flow management)	January 1–June 15

Source: National Marine Fisheries Service 2009, cited in ICF 2010:Appendix B

For interim operations (2010–2012), Action IV.2.1 restricts exports and requires minimum flows at Vernalis on the San Joaquin River (Tables F-9 and F-10). Minimum long-term flows at Vernalis (Table F-11) would be achieved by Reclamation/DWR seeking supplemental agreement with the San Joaquin River Group Authority.

Table F-9. Minimum Flows Required at Vernalis during the Interim Operations of the SWP/CVP (2010–2011), as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

New Melones Index (taf)[1]	Minimum Flow Required at Vernalis (cfs)
0–999	No new requirements
1,000–1,399	D-1641 requirements or 1,500, whichever is greater
1,400–1,999	D-1641 requirements or 3,000, whichever is greater
2,000–2,499	4,500
2,500 or greater	6,000

Notes: taf = thousand acre-feet; cfs = cubic feet per second
Source: National Marine Fisheries Service 2009: 642, cited in ICF 2010:Appendix B

[1] The New Melones Index is a summation of end of February New Melones Reservoir storage and forecasted inflow using 50% exceedance from March through September.

Table F-10. Maximum Allowed Exports during the Interim Operations of the State Water Project/Central Valley Project (2010–2011), as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

Flows at Vernalis (cfs)	Combined CVP and SWP Export
0–6,000	1,500 cfs
6,000–21,750	4:1 (Vernalis flow:export ratio)
21,750 or greater	Unrestricted until flood recedes below 21,750 cfs

Notes: cfs = cubic feet per second; CVP = Central Valley Project; SWP = State Water Project
Source: National Marine Fisheries Service 2009: 642, cited in ICF 2010:Appendix B

Table F-11. Minimum Long-Term Flows at Vernalis during the Interim Operations of the SWP/CVP (2010–2011), as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

San Joaquin River Index (60-20-20)[2]	Minimum Long-Term Flow at Vernalis (cfs)
Critically dry (≤2.1)	1,500
Dry (>2.1, ≤2.5)	3,000
Below normal (>2.5, ≤3.1)	4,500
Above normal (>3.1, <3.8)	6,000
Wet (≥3.8)	6,000

Note: cfs = cubic feet per second
Source: National Marine Fisheries Service 2009: 643–644, cited in ICF:2010:Appendix B

Beginning in 2012, exports would be restricted to a specified fraction of Vernalis flows (Table F-12). Exceptions would arise during multiple dry years (see NMFS 2009, 644, for definitions) or when exports of at least 1,500 cfs may not be achievable (the minimum requirement for human health and safety).

[2] The San Joaquin River Index (aka the San Joaquin Valley index) is computed according to the following formula:

I_{SJ}=0.6X+0.2Y and 0.2Z

Where:

I_{SJ}=San Joaquin Valley Index

X=Current year's April–July San Joaquin Valley unimpaired runoff (maf)

Y=Current year's October–March San Joaquin Valley unimpaired runoff (maf)

Z=Previous year's index in maf, not to exceed 0.9 maf

San Joaquin Valley unimpaired runoff for the current water year is a forecast of the sum of the following locations: Stanislaus River, total flow to New Melones Reservoir; Tuolumne River, total inflow to Don Pedro Reservoir; Merced River, total flow to Exchequer Reservoir; San Joaquin River, total inflow to Millerton Lake.

Table F-12. Flow: Export Ratio Limitations for the San Joaquin River, as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service (2009) Operations Criteria and Plan Biological Opinion

San Joaquin Valley Classification (San Joaquin River index)	Vernalis Flow (cfs):CVP/SWP Combined Export Ratio
Critically dry (≤ 2.1)	1:1
Dry (> 2.1, ≤ 2.5)	2:1
Below normal (> 2.5, ≤ 3.1)	3:1
Above normal (> 3.1, < 3.8)	4:1
Wet (≥ 3.8)	4:1
Vernalis flow equal to or greater than 21,750 cfs	Unrestricted exports until flood recedes below 21,750 cfs

Notes: cfs = cubic feet per second; CVP = Central Valley Project; SWP = State Water Project
Source: National Marine Fisheries Service 2009, cited in ICF 2010:Appendix B

Action IV.2.2 consists of a 6-year acoustic tag experiment to confirm proportional causes of salmonid mortality attributable to flows, exports, and other SWP/CVP project or non-project adverse effects during outmigration through the Delta.

Whereas the USFWS (2008) delta smelt OCAP BO RPA focuses mostly on managing OMR flows, the NMFS (2009) OCAP BO RPA details measures specific not only to OMR flows but also to SWP/CVP exports themselves (see Action IV.3 below). Action IV.2.3 aims to manage OMR flows between January 1 and June 15 in order to reduce the vulnerability of emigrating listed salmonids within the lower Sacramento and San Joaquin Rivers to entrainment into the channels of the south Delta and at the export pumps. The action consists of three stages of increasingly restrictive measures (Table F-13).

Table F-13. Decision Tree Related to Management of Flows in the Old and Middle Rivers, as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

Date	Triggers	Action
January 1–June 15	January 1–June 15	Exports are managed to a level that produces a 14-day running average of the tidally filtered flow of (minus) -5,000 cfs in Old and Middle River (OMR). A 5-day running average flow will be calculated from the daily tidally filtered values and be no more than 25% more negative than the targeted requirement flow for the 14-day average flow.
January 1–June 15 (first stage trigger)	Daily SWP/CVP older juvenile loss density (fish per taf): (1) is greater than incidental take limit divided by 2,000 (2% WR JPE[3] ÷ 2,000), with a minimum value of 2.5 fish per taf; or (2) daily loss is greater than daily measured fish density divided by 12 taf; or (3) CNFH CWT LFR[4] or LSNFH CWT WR[5] cumulative loss greater than 0.5%; or (4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 12 taf	Reduce exports to achieve an average net OMR flow of (minus) -3,500 cfs for a minimum of 5 consecutive days. The 5-day running average OMR flows will be no more than 25% more negative than the targeted flow level at any time during the 5-day running average period (e.g., -4,375 cfs average over 5 days). Resumption of (minus) -5,000 cfs flows is allowed when average daily fish density is less than trigger density for 3 consecutive days following the 5 consecutive days of export reduction. Reductions are required when any one criterion is met.
January 1–June 15 (second stage trigger)	Daily SWP/CVP older juvenile loss density (fish per taf) is: (1) greater than incidental take limit (2% of WR JPE) divided by 1,000, with a minimum value of 2.5 fish per taf; or (2) daily loss is greater than daily fish density divided by 8 taf ; or (3) CNFH CWT LFR or LSNFH CWT WR cumulative loss greater than 0.5%, or (4) daily loss of wild steelhead (intact adipose fin) is greater than the daily measured fish density divided by 8 taf	Reduce exports to achieve an average net OMR flow of (minus) -2,500 cfs for a minimum of 5 consecutive days. Resumption of (minus) -5,000 cfs flows is allowed when average daily fish density is less than trigger density for 3 consecutive days following the 5 consecutive days of export reduction. Reductions are required when any one criterion is met.
End of triggers	Continue action until June 15 or until average daily water temperature at Mossdale is greater than 72ºF (22ºC) for 7 consecutive days (1 week), whichever is earlier	If trigger for end of OMR regulation is met, the restrictions on OMR are lifted.

Source: National Marine Fisheries Service 2009: 648–650, cited in ICF 2010:Appendix B

[3] WR JPE is the winter-run Chinook salmon Juvenile Production Estimate, which is based on the number of spawning adult females (from carcass surveys), female fecundity, and egg-to-fry survival (Gaines and Poytress 2004).
[4] CNFH CWT LFR is coded wire–tagged late fall–run Chinook salmon from Coleman National Fish Hatchery on Battle Creek.
[5] LSNFH CWT WR is coded wire–tagged winter-run Chinook salmon from Livingston Stone National Fish Hatchery on the Sacramento River.

Action IV.3 Reduce Likelihood of Entrainment or Salvage at the Export Facilities

In order to reduce entrainment from November 1 to December 31, exports may be reduced based on various triggers (Table F-14). Advance warning will be provided by the *Third Alert* (see Action IV.1.2 above for a description of the First and Second Alerts), consisting of catch indices of more than 10 fish captured per day (November 1–February 28) or more than 15 fish captured per day (March 1–April 30) from either the Knights Landing or Sacramento catch indices. Action IV.2.3 will be implemented from January 1 to April 30 to control export levels during this time.

Table F-14. Triggers and Actions Related to Management of SWP/CVP Exports, as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

Date	Triggers	Action
January 1–June 15	Daily SWP/CVP older juvenile loss density greater than 8 fish/thousand acre feet (taf), or daily loss is more than 95 fish per day, or CNFH CWT LFR or LSNFH CWT WR cumulative loss is greater than 0.5%	Reduce exports to a combined 6,000 cfs for 3 days or until CVP/SWP daily density is less than 8 fish/taf. Export reductions are required when any one of the four criteria is met.
	Daily SWP/CVP older juvenile loss density greater than 15 fish/taf, or daily loss is more than 120 fish per day, or CNFH CWT LFR or LSNFH CWT WR cumulative loss greater than 0.5%	Reduce exports to a combined 4,000 cfs for 3 days or until CVP/SWP daily density is less than 8 fish/taf. Export reductions are required when any one of the four criteria is met.

Notes: SWP = State Water Project; CVP = Central Valley Project; CNFH CWT LFR = Coleman National Fish Hatchery, coded wire–tagged, late fall–run Chinook salmon; LSNFH CWT WR = Livingston Stone National Fish Hatchery, coded wire–tagged, winter-run Chinook salmon

Source: National Marine Fisheries Service 2009: 652–653, cited in ICF 2010:Appendix B

Action Suite IV.4 Modifications of the Operations and Infrastructure of the CVP and SWP Fish Collection Facilities

A number of related actions are identified in Action Suite IV.4, each contributing to the overall objective of a 75% performance goal for whole-facility salvage at the SWP and CVP fish collection facilities (Table F-15).

Table F-15. Actions to Achieve a 75% Salvage Efficiency Performance Goal at the SWP/CVP Fish Collection Facilities, as Stated in the Reasonable and Prudent Alternative from the National Marine Fisheries Service Operations Criteria and Plan Biological Opinion

Action	Objective	Components
Action IV.4.1. Tracy Fish Collection Facility (TFCF) Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency	Implement specific measures to reduce pre-screen loss and improve screening efficiency at Federal facilities	1. Improvement of survival of listed fish to >75%; 2. Optimization of simultaneous salvage of juvenile salmonids and delta smelt; 3. Removal of predators in the secondary channel at least once per week, plus installation of equipment to detect predators; 4. Louver bypasses and channel flows operated at at least 75% efficiency; 5. Head differential between Old River and primary channel <1.5 ft at the trash rack; 6. Installation/maintenance of flow meters in the primary and secondary channels to ensure design flow conditions are met; and 7. Change of operations to meet salvage criteria. Detailed records of operating actions provided to NMFS upon request and following major/long-term deviations
Action IV.4.2. Skinner Fish Collection Facility Improvements to Reduce Pre-Screen Loss and Improve Screening Efficiency	Implement specific measures to reduce pre-screen loss and improve screening efficiency at state facilities	1. Improvement of salvage efficiency of listed anadromous fish to minimum 75% from the entrance to the primary channel; 2. Reduction of salmon/steelhead loss to no more than 40% in Clifton Court Forebay; and 3. Removal of secondary channel predators at least once per week.
Action IV.4.3. Tracy Fish Collection Facility and the Skinner Fish Collection Facility Actions to Improve Salvage Monitoring, Reporting, and Release Survival Rates	To improve overall survival of listed species at facilities through accurate, rapid salvage reporting and state-of-the-art salvage release procedures. This reporting is also necessary to provide information needed to trigger OMR Action IV.2.3.	1. Sampling rates no less than 25% of operational time; 2. Creation of websites to make salvage data available within 2 days of collection; 3. Release-site studies to develop methods to reduce losses of fish; 4. Reduction of predation following release by at least 50% from current rate; 5. Reduction of stress in transported fish by treating tanker water with salt and other products; 6. Training of personnel conducting fish counts; 7. Tanker truck runs to be scheduled at least every 12 hours; and 8. Maintenance of suitable environmental conditions during truck transport according to the Bates Table[6].

Source: National Marine Fisheries Service 2009: 653–658, cited in ICF 2010:Appendix B

Action IV.5 Formation of Delta Operations for Salmon and Sturgeon (DOSS) Technical Working Group

Action IV.5 involves formation of a technical working group that will provide recommendations for real-time management of Delta division SWP/CVP operations; annually review project operations and associated monitoring data; track implementation of Delta Actions IV.1–IV.5 and evaluate their

[6] The Bates Table was developed in the 1950s by D. Bates and gives information on maximum recommended fish loadings into tanker trucks of different volumes and water temperatures.

effectiveness; oversee implementation of the San Joaquin acoustic fish tag experiment (Action IV.2.2); coordinate with the Smelt Working Group (SWG) to benefit both USFWS- and NMFS-listed species; and coordinate with other technical teams to ensure consistent PRA implementation.

Action IV.6 South Delta Improvement Program—Phase I (Permanent Operable Gates)

Action IV.6 consists of DWR not implementing Phase I of the South Delta Improvements Program to replace temporary barriers with permanent operable gates. NMFS is of the opinion that installation of permanent operable gates will adversely modify critical habitat.

Delta Wetlands Fishery Resources Effect Assessment

The fishery resources assessment evaluates the Delta conditions that are important for relevant life stages of each fish species being evaluated. Where possible, effects are evaluated as the estimates of the percentage of a whole population that is affected. The baseline conditions are compared with the flow and habitat conditions with the project operating for a range of baseline Delta inflows. The periods used in each analysis differed according to input data and other considerations—these are detailed below. For most analyses, a 1980–2003 baseline period was adopted. This period was used because it is generally representative of the full range of Delta hydrology simulated with the IDSM model (1922–2003) and also corresponds to the period of most reliable fish salvage density data (fish/taf) collected at the SWP and CVP fish facilities (upon which several analyses are based). Potential effects of the project operations on fish habitat and survival, as well as entrainment and predation losses are considered using appropriate fish surveys and export fish salvage data to characterize the existing conditions.

Simulated flows used in the analysis are described in Chapter 2, “Project Description and Alternatives.” The main considerations are that diversions to the reservoir islands were assumed to occur in December–March and discharges for export by SWP and CVP were assumed to occur in July–November.

Losses of Fish Eggs and Larvae by Entrainment

Fish larvae in the Delta are susceptible to entrainment at water diversions. Under the Proposed Action, direct losses to entrainment would occur at the new reservoir and habitat island diversions, but entrainment at agricultural diversions would cease. Indirect losses would occur when project water is released and is exported by the SWP and CVP facilities. The 2001 FEIS and preceding draft documents used a fish transport model called DeltaMOVE to simulate an entrainment index for evaluating the effects of project operations on fish distribution and entrainment loss in the Delta. Models such as DeltaMOVE essentially treat larvae as passive particles (albeit with occasional refinements such as avoidance of particular salinities) and assess their dispersal according to water movements and flow splits between the Delta channels. Kimmerer and Nobriga (2008) simulated movement of fish larvae in the Delta using a particle tracking model (PTM) to determine the fate of particles over a certain period of time. They examined a large number of different export and inflow scenarios and discovered that the proportion of particles lost to entrainment by the SWP and CVP pumps is well predicted by the export to inflow ratio (E/I), i.e., the quantity of water exported from the Delta by the CVP and SWP divided by water flowing in from the various tributaries (particularly the Sacramento River). High exports and low inflows give greater losses of particles (simulated eggs/larvae) over a given time period than lower exports and high inflows. Particles originating in a region quite susceptible to flow alteration by the SWP and CVP pumps (e.g., the Central Delta) will also be lost in greater numbers than particles originating in a region relatively unaffected by the pumps (e.g., the confluence of the Sacramento and San Joaquin rivers). As with the 2001 FEIS and preceding draft documents, an assessment was made of the potential effect of direct and indirect entrainment losses on striped bass eggs and larvae of Delta and longfin smelt.

Methods

For each species, one billion larvae were assumed to originate in fixed regions of the Delta during certain months of each year. The proportion of total eggs or larvae assigned to each region and month generally followed those used in the 2001 FEIS and preceding draft documents (Table F-16), with some slight modifications based on more recent information (Moyle 2002; California Department of Fish and Game 2009a). The E/I ratio was calculated for the baseline period with only simulated SWP and CVP exports for each month from WY 1980 to 2003. (This period was adopted for consistency with the entrainment analysis of juvenile and adult fish described below). The percentage of eggs or larvae that would be lost to entrainment from each region during a 30-day period was based on the sigmoidal relationships plotted by Kimmerer and Nobriga (2008). An equation that appeared to produce similar curves to those plotted by Kimmerer and Nobriga (2008) differed only in a single exponent (A),

$$Loss = \frac{Maximum\ (100\%)}{1 + 100 \times e^{\left(-A \times \frac{E}{I}\right)}}$$

The relationships between percentage of eggs or larvae lost had values of the A exponent ranging from 5 (Confluence of the Sacramento and San Joaquin rivers) to 15 (lower Mokelumne River) (Figure F-1). In the Confluence region, exports of 50% of the inflow (E/I = 0.5) were modeled as giving only 10% entrainment loss of particles (eggs or larvae) in that month, whereas the same E/I ratio gave 95% entrainment loss in the Mokelumne River.

For each species, the total number of particles (eggs or larvae) assumed for the whole year (i.e., one billion) was multiplied by the monthly weights to give the number of particles at the start of each month. The species-specific monthly numbers of particles were then multiplied by the weights for each region. The percentage of particles lost in each region was calculated based on the simulated E/I ratio, first for the baseline condition with SWP/CVP exports alone, then with exports plus Proposed Action Reservoir Island diversions and increased exports of reservoir island discharges, next with baseline exports and existing agricultural discharges, and finally with SWP/CVP exports and Habitat Island diversions. The overall effect of the Proposed Action diversions and discharges for export were characterized in terms of the percentage of the modeled SWP/CVP entrainment loss and also the percentage of the total number of particles per year (i.e., one billion).

The procedure for striped bass was not the same as for the other two species. The monthly weights used for striped bass spawning in the Sacramento River differed from those in the Delta and so, consistent with the 2001 FEIS and preceding draft documents, 55% of particles were assigned to the Sacramento River and 45% were assigned to the Delta (lower San Joaquin River). The monthly weightings were then applied to these two regions and the final results were combined.

As noted in the 2001 FEIS and preceding draft documents, the analysis is sensitive to the locations chosen for particles to originate in; in some years there may be more spawning occurring in the Delta than outside and so greater susceptibility to entrainment, whereas other years may have less spawning in the Delta and greater probability of safe passage downstream. A major assumption of the analysis was that entrainment at the project facilities would be described by the same E/I-loss relationship as used for the SWP/CVP facilities.

Main Assumptions

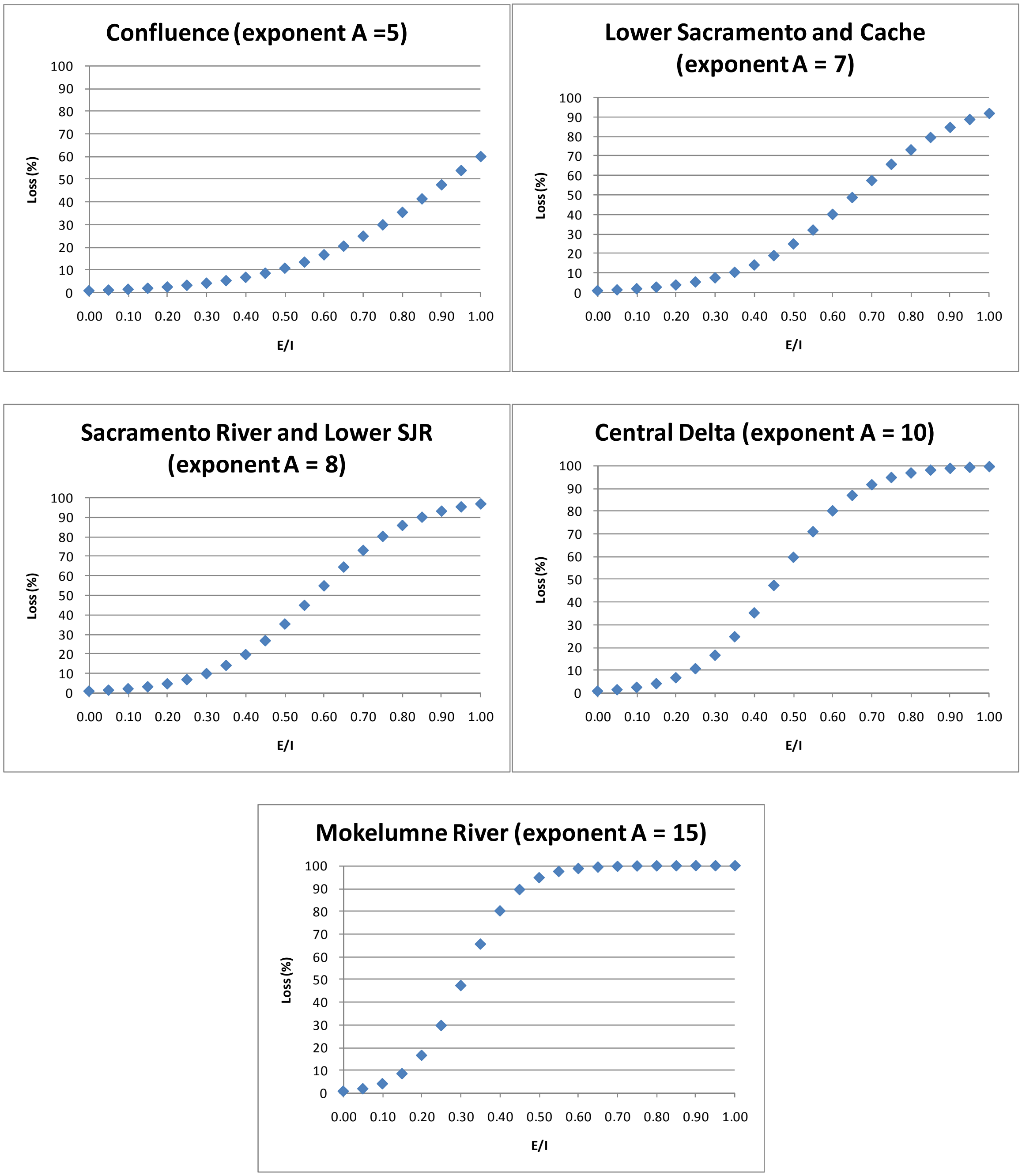
The assumptions of the egg and larval entrainment analysis were as follows:

- diversions to the DW reservoir islands occur in December–March;
- discharges for export occur in July–November;
- each species spawns according to a fixed pattern in each year, both spatially and seasonally, i.e., the species were assumed to spawn in the same places at the same times each year—the results of the analysis are dependent on this assumption;
- entrainment of eggs and larvae to the project islands can be estimated using relationships similar to the E/I curves developed for the SWP/CVP export facilities by Kimmer and Nobriga (2008);
- each month's losses will be completed before month's end (this was the case for most relationships reported by Kimmerer and Nobriga [2008]);
- intake screening offers no protection to eggs and larvae;
- eggs and larvae behave as passive particles and move with water flows;

- diversions to the agricultural and Habitat Islands are the same (quantity and timing) in all years.

Table F-16. Monthly and Location Weights Used in the Analysis of Fish Egg and Larval Entrainment for the Project

	Monthly weights						
	Dec	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**
Delta smelt	0	0	0.1	0.25	0.35	0.25	0.05
Longfin smelt	0.1	0.25	0.35	0.2	0.1	0	0
Striped bass (Delta)	0	0	0	0	0.8	0.2	0
Striped bass (Sacramento River)	0	0	0	0	0	0.8	0.2
	Location weights						
	Confluence	**Cache Slough**	**Lower Sacramento River**	**Sacramento River at Hood**	**Lower San Joaquin River**	**Mokelumne River**	**Central Delta**
Delta smelt	0.167	0.167	0.167	0	0.167	0.167	0.167
Longfin smelt	0.333	0.333	0.333	0	0	0	0
Striped bass (Delta)	0	0	0	0	1	0	0
Striped bass (Sacramento River)	0	0	0	1	0	0	0
Source: ICF 2010:Appendix B							



$$Loss = \frac{Maximum\ (100\%)}{1 + 100 \times e^{(-A \times \frac{E}{I})}}$$

Figure F-1. Sigmoidal Relationships between Export:Inflow Ratio (E/I) and Monthly Percentage of Particles Lost to Entrainment for Various Regions in the Delta

Note: The exponent A of the exponential equation was varied to give the different sigmoidal curves.

Source: ICF 2010: Appendix B

Results

Delta Smelt

The baseline entrainment of Delta smelt by SWP and CVP in the simulation averaged over 76 million larvae per year from 1980 to 2003, or about 8% of the 1 billion larvae (particles) assumed to have been produced each year (Table F-17). The lowest entrainment of 2% occurred in 1983 and the maximum entrainment was 14% in 1981. Entrainment loss of delta smelt larvae estimated for the Proposed Action ranged from 0.0% in several years to 2.4% in 1987, and averaged about 0.3% (Table F-18). Loss of delta smelt larvae due to export of discharged project water did not occur because discharges were limited to the July–September period (Table F-16).

Based on the assumed original locations of delta smelt larvae and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the Proposed Action), it was estimated there would be a net project benefit: approximately 830,000 less delta smelt larvae would be entrained annually (Tables F-19, F-20, and F-21). As a whole, the net effect of the project was estimated to be an average of 0.2% loss of the total number of larvae per year (Table F-21).

Table F-17. Simulated Entrainment Losses of Delta Smelt Larvae under the Baseline Export Pumping by SWP and CVP. (The initial total number of larvae was 1,000,000,000.)

Water Year	Feb	March	Apr	May	Jun	Total	Percent
1980	1,806,320	7,072,270	44,641,531	22,156,222	6,084,116	81,760,459	8%
1981	19,221,175	40,242,587	32,796,386	33,873,036	9,610,588	135,743,772	14%
1982	2,240,672	6,275,880	5,563,242	12,776,283	6,271,507	33,127,585	3%
1983	1,517,258	3,079,121	7,770,641	6,609,050	1,310,782	20,286,851	2%
1984	5,695,948	16,165,248	20,010,108	15,625,061	7,412,294	64,908,659	6%
1985	29,952,373	48,052,942	32,772,141	23,795,996	9,610,586	144,184,038	14%
1986	1,589,819	4,289,803	34,938,295	43,219,576	5,910,158	89,947,651	9%
1987	24,856,172	23,805,002	6,763,662	24,027,996	9,610,588	89,063,420	9%
1988	3,730,997	8,874,899	27,842,552	10,337,617	5,951,100	56,737,165	6%
1989	6,515,306	14,263,847	21,192,901	10,820,055	9,610,587	62,402,696	6%
1990	7,254,303	48,052,934	7,021,173	29,138,217	9,134,564	100,601,191	10%
1991	9,424,584	44,794,304	8,824,678	25,085,952	3,829,659	91,959,177	9%
1992	18,786,234	48,052,932	11,638,776	6,365,461	4,115,481	88,958,884	9%
1993	5,595,591	31,081,039	14,076,311	9,452,438	5,429,485	65,634,863	7%
1994	29,952,375	42,071,251	18,606,432	26,073,452	9,610,586	126,314,096	13%
1995	7,493,611	3,766,018	11,494,447	6,115,021	2,352,230	31,221,327	3%
1996	1,811,958	5,786,323	14,462,619	7,635,296	6,034,767	35,730,963	4%
1997	3,141,077	26,918,691	29,433,425	15,695,342	8,169,747	83,358,282	8%
1998	1,485,244	5,403,910	10,779,468	9,309,545	1,269,348	28,247,515	3%
1999	2,277,397	7,909,411	23,738,926	11,332,253	7,036,965	52,294,953	5%
2000	2,191,761	8,790,112	35,980,121	19,862,759	9,610,588	76,435,341	8%
2001	27,239,154	48,052,937	19,540,238	11,196,899	3,015,600	109,044,829	11%
2002	1,368,856	16,483,488	23,646,953	26,052,102	9,610,587	77,161,986	8%
2003	1,455,149	48,052,937	21,971,404	8,773,346	7,490,651	87,743,487	9%
					Average	**76,369,550**	**8%**

Source: ICF 2010:Appendix B

Table F-18. Simulated Entrainment Losses of Delta Smelt Larvae under the Baseline Export Pumping by SWP and CVP plus Proposed Action Diversions and Discharges for Export. Overall % is SWP/CVP loss plus DW loss; DW% is the loss attributable to the Proposed Action. (The initial total number of larvae was 1,000,000,000.)

Water Year	Feb	Mar	Apr	May	Jun	Total	Overall %	DW %
1980	1,807,553	7,093,581	44,641,531	22,156,222	6,084,116	81,783,003	8%	0.0%
1981	19,221,175	48,052,939	32,796,386	33,873,036	9,610,588	143,554,124	14%	0.8%
1982	2,242,652	6,289,711	5,563,242	12,776,283	6,271,507	33,143,395	3%	0.0%
1983	1,518,056	3,081,256	7,770,641	6,609,050	1,310,782	20,289,784	2%	0.0%
1984	5,708,754	16,242,262	20,010,108	15,625,061	7,412,294	64,998,479	6%	0.0%
1985	29,952,373	48,052,942	32,772,141	23,795,996	9,610,586	144,184,038	14%	0.0%
1986	1,843,140	4,310,679	34,938,295	43,219,576	5,910,158	90,221,848	9%	0.0%
1987	24,856,172	48,052,939	6,763,662	24,027,996	9,610,588	113,311,356	11%	2.4%
1988	3,730,997	8,874,899	27,842,552	10,337,617	5,951,100	56,737,165	6%	0.0%
1989	6,515,306	25,715,475	21,192,901	10,820,055	9,610,587	73,854,323	7%	1.1%
1990	7,254,303	48,052,934	7,021,173	29,138,217	9,134,564	100,601,191	10%	0.0%
1991	9,424,584	48,052,939	8,824,678	25,085,952	3,829,659	95,217,812	10%	0.3%
1992	28,714,760	48,052,935	11,638,776	6,365,461	4,115,481	98,887,414	10%	1.0%
1993	5,605,251	31,218,811	14,076,311	9,452,438	5,429,485	65,782,296	7%	0.0%
1994	29,952,375	42,071,251	18,606,432	26,073,452	9,610,586	126,314,096	13%	0.0%
1995	7,507,855	3,769,222	11,494,447	6,115,021	2,352,230	31,238,776	3%	0.0%
1996	1,813,266	5,800,603	14,462,619	7,635,296	6,034,767	35,746,551	4%	0.0%
1997	3,144,968	27,072,881	29,433,425	15,695,342	8,169,747	83,516,363	8%	0.0%
1998	1,485,863	5,415,230	10,779,468	9,309,545	1,269,348	28,259,454	3%	0.0%
1999	2,279,655	7,933,181	23,738,926	11,332,253	7,036,965	52,320,980	5%	0.0%
2000	2,350,988	8,815,302	35,980,121	19,862,759	9,610,588	76,619,759	8%	0.0%
2001	29,952,374	48,052,937	19,540,238	11,196,899	3,015,600	111,758,048	11%	0.3%
2002	1,368,856	16,483,488	23,646,953	26,052,102	9,610,587	77,161,986	8%	0.0%
2003	1,455,149	48,052,937	21,971,404	8,773,346	7,490,651	87,743,487	9%	0.0%
					Average	**78,885,239**	**8%**	**0.3%**

Source: ICF 2010:Appendix B

Table F-19. Simulated Entrainment Losses of Delta Smelt Larvae under the Baseline Export Pumping by SWP and CVP plus Existing Agricultural Diversions. Overall % is SWP/CVP loss plus agricultural diversion loss; Ag % is the loss attributable to the existing agricultural diversions. (The initial total number of larvae was 1,000,000,000.)

Water Year	Feb	Mar	Apr	May	Jun	Total	Overall %	Ag %
1980	1,811,642	7,072,270	44,641,531	22,549,325	6,525,359	82,600,125	8%	0.08%
1981	19,386,600	40,242,587	32,796,386	34,646,716	10,271,817	137,344,107	14%	0.16%
1982	2,248,924	6,275,880	5,563,242	12,877,942	6,597,173	33,563,161	3%	0.04%
1983	1,520,583	3,079,121	7,770,641	6,639,922	1,342,918	20,353,185	2%	0.01%
1984	5,751,344	16,165,248	20,010,108	15,989,629	7,993,342	65,909,671	7%	0.10%
1985	30,226,435	48,052,942	32,772,141	24,319,698	10,307,237	145,678,454	15%	0.15%
1986	1,592,716	4,289,803	34,938,295	43,698,070	6,409,434	90,928,317	9%	0.10%
1987	25,093,961	23,805,002	6,763,662	24,623,849	10,325,335	90,611,809	9%	0.15%
1988	3,853,135	8,874,899	27,842,552	10,770,986	6,660,372	58,001,944	6%	0.13%
1989	6,798,488	14,263,847	21,192,901	11,111,379	10,352,457	63,719,072	6%	0.13%
1990	7,473,992	48,052,934	7,021,173	30,392,132	10,066,220	103,006,451	10%	0.24%
1991	9,830,059	44,794,304	8,824,678	26,087,856	4,685,680	94,222,576	9%	0.23%
1992	18,938,051	48,052,932	11,638,776	6,634,106	4,719,282	89,983,148	9%	0.10%
1993	5,635,900	31,081,039	14,076,311	9,575,196	5,730,173	66,098,619	7%	0.05%
1994	30,165,153	42,071,251	18,606,432	26,887,968	10,333,121	128,063,926	13%	0.17%
1995	7,553,043	3,766,018	11,494,447	6,140,937	2,445,295	31,399,741	3%	0.02%
1996	1,817,603	5,786,323	14,462,619	7,695,878	6,470,240	36,232,664	4%	0.05%
1997	3,157,307	26,918,691	29,433,425	16,062,354	8,823,601	84,395,378	8%	0.10%
1998	1,487,822	5,403,910	10,779,468	9,370,980	1,299,384	28,341,564	3%	0.01%
1999	2,286,811	7,909,411	23,738,926	11,525,057	7,584,971	53,045,176	5%	0.08%
2000	2,199,493	8,790,112	35,980,121	20,220,074	10,225,452	77,415,252	8%	0.10%
2001	27,421,519	48,052,937	19,540,238	11,572,282	3,520,507	110,107,484	11%	0.11%
2002	1,388,484	16,483,488	23,646,953	26,715,288	10,321,572	78,555,785	8%	0.14%
2003	1,476,432	48,052,937	21,971,404	8,859,960	8,026,124	88,386,857	9%	0.06%
					Average	**77,415,186**	**8%**	**0.10%**

Source: ICF 2010:Appendix B

Table F-20. Simulated Entrainment Losses of Delta Smelt Larvae under the Baseline Export Pumping by SWP and CVP plus Increased Habitat Island Diversions. Overall % is SWP/CVP loss plus Habitat Island diversion loss; Habitat % is the loss attributable to the Habitat Island diversions. (The initial total number of larvae was 1,000,000,000.)

Water Year	Feb	Mar	Apr	May	Jun	total	Overall %	Habitat %
1980	1,808,384	7,072,270	44,641,531	22,214,319	6,181,180	81,917,684	8%	0.02%
1981	19,285,394	40,242,587	32,796,386	33,987,567	9,757,956	136,069,890	14%	0.03%
1982	2,243,872	6,275,880	5,563,242	12,791,341	6,343,440	33,217,775	3%	0.01%
1983	1,518,548	3,079,121	7,770,641	6,613,627	1,317,871	20,299,808	2%	0.00%
1984	5,717,395	16,165,248	20,010,108	15,678,760	7,540,735	65,112,246	7%	0.02%
1985	30,058,734	48,052,942	32,772,141	23,873,326	9,765,853	144,522,996	14%	0.03%
1986	1,590,943	4,289,803	34,938,295	43,290,636	6,019,681	90,129,358	9%	0.02%
1987	24,948,511	23,805,002	6,763,662	24,115,915	9,769,890	89,402,980	9%	0.03%
1988	3,777,926	8,874,899	27,842,552	10,400,870	6,105,833	57,002,080	6%	0.03%
1989	6,623,991	14,263,847	21,192,901	10,862,852	9,775,938	62,719,528	6%	0.03%
1990	7,338,945	48,052,934	7,021,173	29,322,781	9,341,888	101,077,720	10%	0.05%
1991	9,580,610	44,794,304	8,824,678	25,233,236	4,009,048	92,441,876	9%	0.05%
1992	18,845,167	48,052,932	11,638,776	6,404,606	4,244,759	89,186,240	9%	0.02%
1993	5,611,208	31,081,039	14,076,311	9,470,576	5,495,692	65,734,825	7%	0.01%
1994	30,034,959	42,071,251	18,606,432	26,193,508	9,771,625	126,677,775	13%	0.04%
1995	7,516,639	3,766,018	11,494,447	6,118,864	2,372,666	31,268,634	3%	0.00%
1996	1,814,147	5,786,323	14,462,619	7,644,266	6,130,549	35,837,904	4%	0.01%
1997	3,147,367	26,918,691	29,433,425	15,749,401	8,314,731	83,563,616	8%	0.02%
1998	1,486,244	5,403,910	10,779,468	9,318,648	1,275,976	28,264,246	3%	0.00%
1999	2,281,047	7,909,411	23,738,926	11,360,699	7,157,910	52,447,993	5%	0.02%
2000	2,194,759	8,790,112	35,980,121	19,915,539	9,747,618	76,628,150	8%	0.02%
2001	27,309,955	48,052,937	19,540,238	11,251,899	3,122,176	109,277,205	11%	0.02%
2002	1,376,438	16,483,488	23,646,953	26,149,998	9,769,050	77,425,926	8%	0.03%
2003	1,463,369	48,052,937	21,971,404	8,786,161	7,609,130	87,883,000	9%	0.01%
					Average	**76,587,894**	**8%**	**0.02%**

Source: ICF 2010:Appendix B

Table F-21. Summary of Delta Smelt Larval Entrainment Loss Effects of the Proposed Action Compared to Existing/Baseline Conditions

	Simulated Baseline CVP/SWP Entrainment [1]		Project Diversion Entrainment Effect [2]			Project Export Entrainment Effect [3]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions [6]		Net Project Effect	Net Project Effect
Year	**Loss**	**% of All Larvae**	**Loss**	**% of CVP/SWP**	**% of All Larvae**	**Loss**	**% of All Larvae**	**Loss [4]**	**Loss [5]**	**Reduced Loss**	**% of CVP/SWP Loss**	**% of CVP/SWP Loss**	**% of All Larvae**
1980	81,760,459	8.2%	22,544	0.0%	0.0%	0	0	839,667	157,225	682,441	0.8%	-0.8%	-0.1%
1981	135,743,772	13.6%	7,810,352	5.8%	0.8%	0	0	1,600,334	326,118	1,274,217	0.9%	4.8%	0.7%
1982	33,127,585	3.3%	15,810	0.0%	0.0%	0	0	435,576	90,190	345,386	1.0%	-1.0%	0.0%
1983	20,286,851	2.0%	2,933	0.0%	0.0%	0	0	66,334	12,957	53,377	0.3%	-0.2%	0.0%
1984	64,908,659	6.5%	89,821	0.1%	0.0%	0	0	1,001,013	203,587	797,425	1.2%	-1.1%	-0.1%
1985	144,184,038	14.4%	0	0.0%	0.0%	0	0	1,494,416	338,958	1,155,459	0.8%	-0.8%	-0.1%
1986	89,947,651	9.0%	274,197	0.3%	0.0%	0	0	980,666	181,707	798,959	0.9%	-0.6%	-0.1%
1987	89,063,420	8.9%	24,247,936	27.2%	2.4%	0	0	1,548,389	339,560	1,208,829	1.4%	25.9%	2.3%
1988	56,737,165	5.7%	0	0.0%	0.0%	0	0	1,264,779	264,916	999,864	1.8%	-1.8%	-0.1%
1989	62,402,696	6.2%	11,451,628	18.4%	1.1%	0	0	1,316,376	316,833	999,544	1.6%	16.7%	1.0%
1990	100,601,191	10.1%	0	0.0%	0.0%	0	0	2,405,260	476,529	1,928,731	1.9%	-1.9%	-0.2%
1991	91,959,177	9.2%	3,258,635	3.5%	0.3%	0	0	2,263,399	482,699	1,780,700	1.9%	1.6%	0.1%
1992	88,958,884	8.9%	9,928,529	11.2%	1.0%	0	0	1,024,264	227,356	796,908	0.9%	10.3%	0.9%
1993	65,634,863	6.6%	147,432	0.2%	0.0%	0	0	463,755	99,962	363,794	0.6%	-0.3%	0.0%
1994	126,314,096	12.6%	0	0.0%	0.0%	0	0	1,749,830	363,680	1,386,151	1.1%	-1.1%	-0.1%
1995	31,221,327	3.1%	17,449	0.1%	0.0%	0	0	178,414	47,308	131,107	0.4%	-0.4%	0.0%
1996	35,730,963	3.6%	15,588	0.0%	0.0%	0	0	501,701	106,941	394,760	1.1%	-1.1%	0.0%
1997	83,358,282	8.3%	158,081	0.2%	0.0%	0	0	1,037,096	205,334	831,762	1.0%	-0.8%	-0.1%
1998	28,247,515	2.8%	11,939	0.0%	0.0%	0	0	94,049	16,731	77,318	0.3%	-0.2%	0.0%
1999	52,294,953	5.2%	26,027	0.0%	0.0%	0	0	750,223	153,040	597,183	1.1%	-1.1%	-0.1%
2000	76,435,341	7.6%	184,418	0.2%	0.0%	0	0	979,912	192,809	787,103	1.0%	-0.8%	-0.1%
2001	109,044,829	10.9%	2,713,220	2.5%	0.3%	0	0	1,062,655	232,376	830,279	0.8%	1.7%	0.2%
2002	77,161,986	7.7%	0	0.0%	0.0%	0	0	1,393,799	263,940	1,129,859	1.5%	-1.5%	-0.1%
2003	87,743,487	8.8%	0	0.0%	0.0%	0	0	643,370	139,513	503,857	0.6%	-0.6%	-0.1%
Avg	**76,369,550**	**7.6%**	**2,515,689**	**2.9%**	**0.3%**	**0**	**0.0%**	**1,045,637**	**218,344**	**827,292**	**1.0%**	**1.9%**	**0.2%**

Notes:
(1) Assumes 1,000,000,000 larvae were released annually at various locations.
(2) Assumes diversions from December to March.
(3) Assumes discharge for exports by SWP and CVP from July to November.
(4) Assumes similar pattern of agricultural diversions each year.
(5) Assumes similar pattern of habitat diversions each year.
(6) Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.
Source: ICF 2010:Appendix B

Longfin Smelt

The baseline entrainment of longfin smelt by SWP and CVP in the simulation averaged over 60 million larvae per year from 1980 to 2003, or about 6% of the 1 billion larvae (particles) assumed to have been produced each year (Table F-22). The lowest entrainment of 2% occurred in 1983 and the maximum entrainment was 15% in 1994. Entrainment loss of longfin smelt larvae estimated for the Proposed Action ranged from 0.0% in several years to 2.4% in 1987, and averaged about 0.3% (Table F-23). Loss of longfin smelt larvae due to export of discharged project water did not occur because discharges were limited to the July–September period (Table F-16).

Based on the assumed original locations of longfin smelt larvae and the schedule of diversions for agriculture (under the baseline/existing conditions) and for the Habitat Islands (under the Proposed Action), it was estimated there would be a net benefit of the project: approximately 380,000 less longfin smelt larvae would be entrained annually (Tables F-24, F-25, and F-26). As a whole, the net effect of the project was estimated to be an average of 0.4% loss of the total number of larvae per year (Table F-26).

Table F-22. Simulated Entrainment Losses of Longfin Smelt Larvae under the Baseline Export Pumping by SWP and CVP. (The initial total number of larvae was 1,000,000,000.)

Water Year	Dec	Jan	Feb	Mar	Apr	Total	Percent
1980	13,993,111	4,540,223	5,193,515	3,934,503	5,030,865	32,692,217	3%
1981	24,995,485	20,482,362	24,787,671	12,068,028	4,073,584	86,407,130	9%
1982	1,907,607	5,859,753	5,958,462	3,655,226	1,364,982	18,746,030	2%
1983	1,986,812	4,392,738	4,632,697	2,299,963	1,692,608	15,004,818	2%
1984	1,423,882	4,782,166	10,482,453	6,465,316	3,001,672	26,155,489	3%
1985	12,423,839	73,337,782	42,251,529	14,164,385	4,071,631	146,249,166	15%
1986	21,194,120	31,648,767	4,778,076	2,870,403	4,245,782	64,737,147	6%
1987	24,968,914	37,426,775	32,885,231	8,232,588	1,549,798	105,063,306	11%
1988	23,060,927	21,526,285	8,141,623	4,515,429	3,671,084	60,915,347	6%
1989	24,316,916	25,183,192	11,366,378	5,996,017	3,107,024	69,969,528	7%
1990	15,748,262	48,703,267	12,136,084	14,164,382	1,587,270	92,339,266	9%
1991	4,481,335	19,135,510	14,310,992	13,257,022	1,832,568	53,017,428	5%
1992	14,911,672	23,521,925	24,247,761	14,164,382	2,170,504	79,016,244	8%
1993	17,372,882	6,859,914	10,371,406	9,876,614	2,433,099	46,913,915	5%
1994	22,773,843	67,765,961	42,251,534	12,535,752	2,873,827	148,200,917	15%
1995	29,845,576	4,493,996	12,381,078	2,634,669	2,154,196	51,509,515	5%
1996	8,608,398	8,292,707	5,203,995	3,474,827	2,472,782	28,052,708	3%
1997	1,810,739	3,093,698	7,339,023	8,932,924	3,801,333	24,977,717	2%
1998	15,275,785	5,735,339	4,567,483	3,328,586	2,071,946	30,979,139	3%
1999	4,984,575	9,552,461	6,019,613	4,212,075	3,327,794	28,096,519	3%
2000	24,138,959	14,195,028	5,876,241	4,489,425	4,329,428	53,029,081	5%
2001	21,349,925	53,809,127	37,015,854	14,164,383	2,959,241	129,298,530	13%
2002	6,139,420	8,570,265	4,324,474	6,542,164	3,319,942	28,896,265	3%
2003	5,177,981	6,970,991	4,505,555	14,164,383	3,175,332	33,994,241	3%
					Average	**60,594,236**	**6%**

Source: ICF 2010:Appendix B

Table F-23. Simulated Entrainment Losses of Longfin Smelt Larvae under the Baseline Export Pumping by SWP and CVP plus Proposed Action Diversions and Discharges for Export. Overall % is SWP/CVP loss plus DW loss; DW% is the loss attributable to the Proposed Action. (The initial total number of larvae was 1,000,000,000.)

Water Year	Dec	Jan	Feb	Mar	Apr	total	Overall %	DW %
1980	13,993,111	5,368,930	5,195,808	3,941,760	5,030,865	33,530,474	3%	0.1%
1981	24,995,485	31,975,034	24,787,671	14,164,384	4,073,584	99,996,158	10%	1.4%
1982	2,339,194	5,863,475	5,961,770	3,660,220	1,364,982	19,189,641	2%	0.0%
1983	2,453,544	4,394,719	4,634,315	2,301,055	1,692,608	15,476,242	2%	0.0%
1984	1,605,743	4,785,450	10,496,575	6,483,953	3,001,672	26,373,393	3%	0.0%
1985	22,703,143	73,337,782	42,251,529	14,164,385	4,071,631	156,528,470	16%	1.0%
1986	21,194,120	31,648,767	5,261,672	2,879,497	4,245,782	65,229,838	7%	0.0%
1987	24,968,914	37,426,775	32,885,231	14,164,384	1,549,798	110,995,102	11%	0.6%
1988	23,060,927	36,399,834	8,141,623	4,515,429	3,671,084	75,788,896	8%	1.5%
1989	24,316,916	25,183,192	11,366,378	8,662,314	3,107,024	72,635,825	7%	0.3%
1990	15,748,262	48,703,267	12,136,084	14,164,382	1,587,270	92,339,266	9%	0.0%
1991	4,481,335	19,135,510	14,310,992	14,164,384	1,832,568	53,924,790	5%	0.1%
1992	14,911,672	23,521,925	39,794,549	14,164,383	2,170,504	94,563,033	9%	1.6%
1993	17,372,882	9,137,764	10,382,126	9,908,193	2,433,099	49,234,064	5%	0.2%
1994	22,773,843	67,765,961	42,251,534	12,535,752	2,873,827	148,200,917	15%	0.0%
1995	29,845,576	5,341,686	12,395,605	2,636,158	2,154,196	52,373,221	5%	0.1%
1996	8,608,398	12,162,735	5,206,424	3,480,194	2,472,782	31,930,532	3%	0.4%
1997	2,164,375	3,094,234	7,344,538	8,967,635	3,801,333	25,372,114	3%	0.0%
1998	15,275,785	7,465,411	4,568,751	3,332,987	2,071,946	32,714,880	3%	0.2%
1999	8,070,139	9,562,586	6,023,357	4,219,746	3,327,794	31,203,622	3%	0.3%
2000	24,138,959	20,967,781	6,140,697	4,497,163	4,329,428	60,074,028	6%	0.7%
2001	21,349,925	53,809,127	42,251,532	14,164,383	2,959,241	134,534,208	13%	0.5%
2002	8,472,069	9,997,513	4,324,474	6,542,164	3,319,942	32,656,161	3%	0.4%
2003	8,555,908	6,976,565	4,505,555	14,164,383	3,175,332	37,377,742	4%	0.3%
					Average	**64,676,776**	**6%**	**0.4%**

Source: ICF 2010:Appendix B

Table F-24. Simulated Entrainment Losses of Longfin Smelt Larvae under the Baseline Export Pumping by SWP and CVP Plus Existing Agricultural Diversions. Overall % is SWP/CVP loss plus agricultural diversion loss; Ag % is the loss attributable to the existing agricultural diversions. (The initial total number of larvae was 1,000,000,000.)

Water Year	Dec	Jan	Feb	Mar	Apr	total	Overall %	Ag %
1980	14,133,906	4,550,529	5,203,408	3,934,503	5,030,865	32,791,075	3%	0.02%
1981	25,283,420	20,651,748	24,995,796	12,068,028	4,073,584	86,692,550	9%	0.07%
1982	1,912,876	5,879,788	5,972,244	3,655,226	1,364,982	18,756,321	2%	0.00%
1983	1,992,491	4,403,399	4,639,433	2,299,963	1,692,608	15,011,990	2%	0.00%
1984	1,426,198	4,799,845	10,543,462	6,465,316	3,001,672	26,181,932	3%	0.01%
1985	12,545,888	74,103,826	42,810,738	14,164,385	4,071,631	146,601,252	15%	0.14%
1986	21,418,154	31,953,807	4,783,811	2,870,403	4,245,782	64,910,900	6%	0.05%
1987	25,323,052	37,967,948	33,277,537	8,232,588	1,549,798	105,490,324	11%	0.13%
1988	23,306,682	21,711,976	8,300,324	4,515,429	3,671,084	61,154,293	6%	0.06%
1989	24,748,141	25,614,045	11,663,934	5,996,017	3,107,024	70,403,076	7%	0.12%
1990	15,984,654	49,214,122	12,361,060	14,164,382	1,587,270	92,620,302	9%	0.10%
1991	4,626,658	19,810,237	14,710,382	13,257,022	1,832,568	53,315,102	5%	0.12%
1992	15,307,779	24,055,172	24,435,033	14,164,382	2,170,504	79,390,837	8%	0.11%
1993	17,651,584	6,886,616	10,416,091	9,876,614	2,433,099	47,119,669	5%	0.04%
1994	23,062,788	68,613,243	42,685,228	12,535,752	2,873,827	148,622,032	15%	0.16%
1995	30,165,502	4,504,510	12,441,650	2,634,669	2,154,196	51,748,126	5%	0.04%
1996	8,683,533	8,335,967	5,214,473	3,474,827	2,472,782	28,110,140	3%	0.01%
1997	1,815,114	3,096,580	7,362,005	8,932,924	3,801,333	24,989,766	2%	0.00%
1998	15,432,280	5,755,840	4,572,761	3,328,586	2,071,946	31,087,442	3%	0.02%
1999	5,017,617	9,607,016	6,035,209	4,212,075	3,327,794	28,128,545	3%	0.01%
2000	24,464,076	14,296,321	5,889,299	4,489,425	4,329,428	53,259,032	5%	0.04%
2001	21,575,256	54,358,378	37,350,195	14,164,383	2,959,241	129,617,628	13%	0.11%
2002	6,185,791	8,613,395	4,366,133	6,542,164	3,319,942	28,946,488	3%	0.01%
2003	5,213,825	7,001,005	4,549,414	14,164,383	3,175,332	34,037,343	3%	0.01%
					Average	**60,791,090**	**6%**	**0.06%**

Source: ICF 2010:Appendix B

Table F-25. Simulated Entrainment Losses of Longfin Smelt Larvae under the Baseline Export Pumping by SWP and CVP Plus Increased Habitat Island Diversions. Overall % is SWP/CVP loss plus Habitat Island diversion loss; Habitat % is the loss attributable to the Habitat Island diversions. (The initial total number of larvae was 1,000,000,000.)

Water Year	Dec	Jan	Feb	Mar	Apr	Total	Overall %	Habitat %
1980	14,087,404	4,540,949	5,197,353	3,934,503	5,030,865	32,692,217	3%	0.01%
1981	25,188,380	20,494,277	24,868,282	12,068,028	4,073,584	86,407,130	9%	0.03%
1982	1,911,139	5,861,165	5,963,809	3,655,226	1,364,982	18,746,030	2%	0.00%
1983	1,990,618	4,393,490	4,635,311	2,299,963	1,692,608	15,004,818	2%	0.00%
1984	1,425,434	4,783,412	10,506,097	6,465,316	3,001,672	26,155,489	3%	0.00%
1985	12,505,576	73,391,747	42,467,913	14,164,385	4,071,631	146,249,166	15%	0.04%
1986	21,344,193	31,670,222	4,780,301	2,870,403	4,245,782	64,737,147	6%	0.02%
1987	25,206,105	37,464,781	33,037,052	8,232,588	1,549,798	105,063,306	11%	0.04%
1988	23,225,562	21,539,346	8,202,872	4,515,429	3,671,084	60,915,347	6%	0.02%
1989	24,605,637	25,213,398	11,481,000	5,996,017	3,107,024	69,969,528	7%	0.04%
1990	15,906,493	48,739,212	12,222,945	14,164,382	1,587,270	92,339,266	9%	0.03%
1991	4,578,291	19,182,442	14,464,779	13,257,022	1,832,568	53,017,428	5%	0.03%
1992	15,176,421	23,559,222	24,320,308	14,164,382	2,170,504	79,016,244	8%	0.04%
1993	17,559,429	6,861,795	10,388,732	9,876,614	2,433,099	46,913,915	5%	0.02%
1994	22,967,372	67,825,606	42,419,475	12,535,752	2,873,827	148,200,917	15%	0.04%
1995	30,059,964	4,494,737	12,404,560	2,634,669	2,154,196	51,509,515	5%	0.02%
1996	8,658,718	8,295,754	5,208,060	3,474,827	2,472,782	28,052,708	3%	0.01%
1997	1,813,671	3,093,901	7,347,936	8,932,924	3,801,333	24,977,717	2%	0.00%
1998	15,380,595	5,736,783	4,569,531	3,328,586	2,071,946	30,979,139	3%	0.01%
1999	5,006,709	9,556,302	6,025,663	4,212,075	3,327,794	28,096,519	3%	0.00%
2000	24,356,716	14,202,156	5,881,307	4,489,425	4,329,428	53,029,081	5%	0.02%
2001	21,500,868	53,847,785	37,145,351	14,164,383	2,959,241	129,298,530	13%	0.03%
2002	6,170,479	8,573,303	4,340,599	6,542,164	3,319,942	28,896,265	3%	0.01%
2003	5,201,991	6,973,106	4,522,531	14,164,383	3,175,332	33,994,241	3%	0.00%
					Average	**60,594,236**	**6%**	**0.02%**

Source: ICF 2010:Appendix B

Table F-26. Summary of Longfin Smelt Larval Entrainment Loss Effects of the Proposed Action Compared to Existing/Baseline Conditions

	Simulated Baseline CVP/SWP Entrainment [1]		Project Diversion Entrainment Effect [2]			Project Export Entrainment Effect [3]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions [6]		Net Project Effect	Net Project Effect
Year	**Loss**	**% of All Larvae**	**Loss**	**% of CVP/SWP**	**% of All Larvae**	**Loss**	**% of All Larvae**	**Loss [4]**	**Loss [5]**	**Reduced Loss**	**% of CVP/SWP Loss**	**% of CVP/SWP Loss**	**% of All Larvae**
1980	32,692,217	3.3%	838,257	2.6%	0.1%	0	0	160,994	98,858	62,136	0.2%	2.4%	0.1%
1981	86,407,130	8.6%	13,589,028	15.7%	1.4%	0	0	665,446	285,420	380,026	0.4%	15.3%	1.3%
1982	18,746,030	1.9%	443,611	2.4%	0.0%	0	0	39,088	10,291	28,796	0.2%	2.2%	0.0%
1983	15,004,818	1.5%	471,424	3.1%	0.0%	0	0	23,075	7,172	15,903	0.1%	3.0%	0.0%
1984	26,155,489	2.6%	217,904	0.8%	0.0%	0	0	81,004	26,443	54,561	0.2%	0.6%	0.0%
1985	146,249,166	14.6%	10,279,304	7.0%	1.0%	0	0	1,447,302	352,086	1,095,216	0.7%	6.3%	0.9%
1986	64,737,147	6.5%	492,691	0.8%	0.0%	0	0	534,808	173,753	361,056	0.6%	0.2%	0.0%
1987	105,063,306	10.5%	5,931,796	5.6%	0.6%	0	0	1,287,617	427,018	860,599	0.8%	4.8%	0.5%
1988	60,915,347	6.1%	14,873,549	24.4%	1.5%	0	0	590,147	238,946	351,201	0.6%	23.8%	1.5%
1989	69,969,528	7.0%	2,666,297	3.8%	0.3%	0	0	1,159,633	433,548	726,085	1.0%	2.8%	0.2%
1990	92,339,266	9.2%	0	0.0%	0.0%	0	0	972,222	281,036	691,186	0.7%	-0.7%	-0.1%
1991	53,017,428	5.3%	907,362	1.7%	0.1%	0	0	1,219,439	297,674	921,765	1.7%	0.0%	0.0%
1992	79,016,244	7.9%	15,546,789	19.7%	1.6%	0	0	1,116,626	374,593	742,033	0.9%	18.7%	1.5%
1993	46,913,915	4.7%	2,320,149	4.9%	0.2%	0	0	350,089	205,754	144,335	0.3%	4.6%	0.2%
1994	148,200,917	14.8%	0	0.0%	0.0%	0	0	1,569,922	421,115	1,148,807	0.8%	-0.8%	-0.1%
1995	51,509,515	5.2%	863,707	1.7%	0.1%	0	0	391,012	238,611	152,401	0.3%	1.4%	0.1%
1996	28,052,708	2.8%	3,877,824	13.8%	0.4%	0	0	128,874	57,432	71,441	0.3%	13.6%	0.4%
1997	24,977,717	2.5%	394,397	1.6%	0.0%	0	0	30,238	12,049	18,189	0.1%	1.5%	0.0%
1998	30,979,139	3.1%	1,735,741	5.6%	0.2%	0	0	182,275	108,303	73,971	0.2%	5.4%	0.2%
1999	28,096,519	2.8%	3,107,103	11.1%	0.3%	0	0	103,193	32,025	71,167	0.3%	10.8%	0.3%
2000	53,029,081	5.3%	7,044,947	13.3%	0.7%	0	0	439,468	229,951	209,517	0.4%	12.9%	0.7%
2001	129,298,530	12.9%	5,235,678	4.0%	0.5%	0	0	1,108,923	319,098	789,825	0.6%	3.4%	0.4%
2002	28,896,265	2.9%	3,759,896	13.0%	0.4%	0	0	131,160	50,222	80,937	0.3%	12.7%	0.4%
2003	33,994,241	3.4%	3,383,501	10.0%	0.3%	0	0	109,717	43,102	66,616	0.2%	9.8%	0.3%
Avg	**60,594,236**	**6.1%**	**4,082,540**	**6.9%**	**0.4%**	**0**	**0.0%**	**576,761**	**196,854**	**379,907**	**0.5%**	**6.4%**	**0.4%**

Notes:

[1] Assumes 1,000,000,000 larvae were released annually at various locations.

[2] Assumes diversions from December to March.

[3] Assumes discharge for exports by SWP and CVP from July to September.

[4] Assumes similar pattern of agricultural diversions each year.

[5] Assumes similar pattern of habitat diversions each year.

[6] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.

Source: ICF 2010:Appendix B

Striped Bass

Limiting project diversions to December–March and limiting discharge for export to July–September would avoid entrainment effects on striped bass eggs, assuming eggs were vulnerable from April to June (Table F-16). Losses attributable to the baseline SWP/CVP exports ranged from 2% (1983) to 9% (1986) and averaged 5% per year (Table F-27).

Based on the assumed original locations of striped bass spawning and the schedule of diversions for agriculture (under the baseline/existing conditions) and for the Habitat Islands (under the Proposed Action), it was estimated there would be a net project benefit: approximately 870,000 less striped bass eggs would be entrained annually (Tables F-28, F-29, F-30). As a whole, the net benefit of the project was estimated to be an average of 0.1% less eggs lost per year (Table F-30).

Table F-27. Simulated Entrainment Losses of Striped Bass Eggs under the Baseline Export Pumping by SWP and CVP. (The initial total number of eggs was 1,000,000,000.)

Water Year	Apr	May	Jun	Total	Percent
1980	32,838,071	28,990,724	7,397,861	69,226,656	7%
1981	24,894,802	41,135,711	11,423,399	77,453,911	8%
1982	5,603,082	19,249,883	7,588,331	32,441,295	3%
1983	7,558,005	11,795,080	2,384,798	21,737,883	2%
1984	16,552,609	22,308,356	8,790,847	47,651,812	5%
1985	24,879,017	30,647,008	11,423,396	66,949,421	7%
1986	26,294,172	52,038,242	7,222,425	85,554,839	9%
1987	6,687,682	30,881,610	11,423,399	48,992,690	5%
1988	21,682,791	16,484,238	7,263,603	45,430,632	5%
1989	17,340,354	17,045,594	11,423,397	45,809,345	5%
1990	6,913,436	36,106,557	10,808,525	53,828,519	5%
1991	8,436,054	31,953,164	5,172,826	45,562,044	5%
1992	10,648,706	11,459,876	5,454,483	27,563,065	3%
1993	12,448,884	15,432,001	6,743,412	34,624,297	3%
1994	15,607,527	32,956,896	11,423,396	59,987,819	6%
1995	10,539,134	11,110,376	3,646,119	25,295,629	3%
1996	12,726,528	13,161,309	7,347,964	33,235,801	3%
1997	22,712,693	22,382,149	9,642,550	54,737,392	5%
1998	9,990,653	15,259,178	2,328,122	27,577,953	3%
1999	19,015,886	17,633,229	8,385,909	45,035,024	5%
2000	26,978,972	26,670,624	11,423,398	65,072,994	7%
2001	16,237,594	17,478,733	4,352,605	38,068,931	4%
2002	18,955,737	32,935,151	11,423,397	63,314,285	6%
2003	17,855,263	14,602,574	8,876,715	41,334,552	4%
			Average	**48,186,950**	**5%**

Source: ICF 2010:Appendix B

Table F-28. Simulated Entrainment Losses of Striped Bass Eggs under the Baseline Export Pumping by SWP and CVP Plus Existing Agricultural Diversions. Overall % is SWP/CVP loss plus agricultural diversion loss; Ag % is the loss attributable to the existing agricultural diversions. (The initial total number of larvae was 1,000,000,000.)

Water Year	Apr	May	Jun	Total	Overall %	Ag %
1980	32,838,071	29,387,652	7,849,111	70,074,834	7%	0.08%
1981	24,894,802	41,982,807	12,327,143	79,204,753	8%	0.18%
1982	5,603,082	19,361,727	7,923,513	32,888,322	3%	0.04%
1983	7,558,005	11,837,243	2,428,286	21,823,534	2%	0.01%
1984	16,552,609	22,690,444	9,439,671	48,682,724	5%	0.10%
1985	24,879,017	31,176,753	12,377,291	68,433,061	7%	0.15%
1986	26,294,172	52,642,855	7,729,606	86,666,632	9%	0.11%
1987	6,687,682	31,484,723	12,402,985	50,575,389	5%	0.16%
1988	21,682,791	16,988,858	7,989,232	46,660,881	5%	0.12%
1989	17,340,354	17,380,831	12,441,581	47,162,766	5%	0.14%
1990	6,913,436	37,415,729	12,039,626	56,368,791	6%	0.25%
1991	8,436,054	32,971,569	6,012,809	47,420,431	5%	0.19%
1992	10,648,706	11,829,306	6,045,679	28,523,691	3%	0.10%
1993	12,448,884	15,579,783	7,042,161	35,070,829	4%	0.04%
1994	15,607,527	33,788,235	12,414,054	61,809,816	6%	0.18%
1995	10,539,134	11,146,780	3,748,322	25,434,236	3%	0.01%
1996	12,726,528	13,239,845	7,792,201	33,758,574	3%	0.05%
1997	22,712,693	22,766,463	10,421,633	55,900,788	6%	0.12%
1998	9,990,653	15,333,587	2,369,276	27,693,517	3%	0.01%
1999	19,015,886	17,852,356	8,980,722	45,848,964	5%	0.08%
2000	26,978,972	27,032,999	12,261,773	66,273,744	7%	0.12%
2001	16,237,594	17,905,864	4,865,293	39,008,751	4%	0.09%
2002	18,955,737	33,611,693	12,397,638	64,965,069	6%	0.17%
2003	17,855,263	14,709,536	9,477,153	42,041,951	4%	0.07%
			Average	**49,262,169**	**5%**	**0.11%**

Source: ICF 2010:Appendix B

Table F-29. Simulated Entrainment Losses of Striped Bass Eggs under the Baseline Export Pumping by SWP and CVP Plus Increased Habitat Island Diversions. Overall % is SWP/CVP loss plus Habitat Island diversion loss; Habitat % is the loss attributable to the Habitat Island Diversions. (The initial total number of larvae was 1,000,000,000.)

Water Year	Apr	May	Jun	Total	Overall %	Habitat %
1980	32,838,071	29,049,389	7,496,316	69,383,777	7%	0.02%
1981	24,894,802	41,260,598	11,619,636	77,775,036	8%	0.03%
1982	5,603,082	19,266,464	7,661,890	32,531,436	3%	0.01%
1983	7,558,005	11,801,336	2,394,425	21,753,767	2%	0.00%
1984	16,552,609	22,364,745	8,931,853	47,849,207	5%	0.02%
1985	24,879,017	30,725,193	11,630,233	67,234,443	7%	0.03%
1986	26,294,172	52,127,699	7,332,731	85,754,602	9%	0.02%
1987	6,687,682	30,970,545	11,635,654	49,293,881	5%	0.03%
1988	21,682,791	16,558,297	7,419,852	45,660,941	5%	0.02%
1989	17,340,354	17,095,013	11,643,779	46,079,146	5%	0.03%
1990	6,913,436	36,298,387	11,072,845	54,284,669	5%	0.05%
1991	8,436,054	32,102,621	5,349,829	45,888,503	5%	0.03%
1992	10,648,706	11,514,051	5,581,328	27,744,085	3%	0.02%
1993	12,448,884	15,453,876	6,808,963	34,711,723	3%	0.01%
1994	15,607,527	33,079,218	11,637,985	60,324,730	6%	0.03%
1995	10,539,134	11,115,779	3,668,665	25,323,578	3%	0.00%
1996	12,726,528	13,172,951	7,444,906	33,344,385	3%	0.01%
1997	22,712,693	22,438,865	9,811,522	54,963,080	5%	0.02%
1998	9,990,653	15,270,213	2,337,235	27,598,102	3%	0.00%
1999	19,015,886	17,665,627	8,515,286	45,196,799	5%	0.02%
2000	26,978,972	26,724,182	11,605,777	65,308,931	7%	0.02%
2001	16,237,594	17,541,578	4,462,203	38,241,374	4%	0.02%
2002	18,955,737	33,034,879	11,634,526	63,625,142	6%	0.03%
2003	17,855,263	14,618,422	9,007,478	41,481,162	4%	0.01%
			Average	**48,389,687**	**5%**	**0.02%**

Source: ICF 2010:Appendix B

Table F-30. Summary of Striped Bass Entrainment Loss Effects of the Proposed Action Compared to the Baseline Conditions

	Simulated Baseline CVP/SWP Entrainment [1]		Project Diversion Entrainment Effect [2]			Project Export Entrainment Effect [3]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions [6]		Net Project Effect	Net Project Effect
Year	Loss	% of All Eggs	Loss	% of CVP/SWP	% of All Eggs	Loss	% of All Eggs	Loss [4]	Loss [5]	Reduced Loss	% of CVP/SWP Loss	% of CVP/SWP Loss	% of All Eggs
1980	69,226,656	6.9%	0	0.0%	0.0%	0	0	848,178	157,120	691,058	1.0%	-1.0%	-0.1%
1981	77,453,911	7.7%	0	0.0%	0.0%	0	0	1,750,841	321,125	1,429,716	1.8%	-1.8%	-0.1%
1982	32,441,295	3.2%	0	0.0%	0.0%	0	0	447,027	90,141	356,886	1.1%	-1.1%	0.0%
1983	21,737,883	2.2%	0	0.0%	0.0%	0	0	85,651	15,884	69,767	0.3%	-0.3%	0.0%
1984	47,651,812	4.8%	0	0.0%	0.0%	0	0	1,030,912	197,395	833,517	1.7%	-1.7%	-0.1%
1985	66,949,421	6.7%	0	0.0%	0.0%	0	0	1,483,640	285,022	1,198,618	1.8%	-1.8%	-0.1%
1986	85,554,839	8.6%	0	0.0%	0.0%	0	0	1,111,793	199,763	912,031	1.1%	-1.1%	-0.1%
1987	48,992,690	4.9%	0	0.0%	0.0%	0	0	1,582,699	301,191	1,281,508	2.6%	-2.6%	-0.1%
1988	45,430,632	4.5%	0	0.0%	0.0%	0	0	1,230,250	230,309	999,941	2.2%	-2.2%	-0.1%
1989	45,809,345	4.6%	0	0.0%	0.0%	0	0	1,353,421	269,801	1,083,619	2.4%	-2.4%	-0.1%
1990	53,828,519	5.4%	0	0.0%	0.0%	0	0	2,540,272	456,150	2,084,122	3.9%	-3.9%	-0.2%
1991	45,562,044	4.6%	0	0.0%	0.0%	0	0	1,858,387	326,459	1,531,928	3.4%	-3.4%	-0.2%
1992	27,563,065	2.8%	0	0.0%	0.0%	0	0	960,626	181,020	779,606	2.8%	-2.8%	-0.1%
1993	34,624,297	3.5%	0	0.0%	0.0%	0	0	446,531	87,426	359,106	1.0%	-1.0%	0.0%
1994	59,987,819	6.0%	0	0.0%	0.0%	0	0	1,821,997	336,911	1,485,086	2.5%	-2.5%	-0.1%
1995	25,295,629	2.5%	0	0.0%	0.0%	0	0	138,607	27,949	110,658	0.4%	-0.4%	0.0%
1996	33,235,801	3.3%	0	0.0%	0.0%	0	0	522,773	108,584	414,189	1.2%	-1.2%	0.0%
1997	54,737,392	5.5%	0	0.0%	0.0%	0	0	1,163,396	225,688	937,708	1.7%	-1.7%	-0.1%
1998	27,577,953	2.8%	0	0.0%	0.0%	0	0	115,563	20,148	95,415	0.3%	-0.3%	0.0%
1999	45,035,024	4.5%	0	0.0%	0.0%	0	0	813,939	161,775	652,164	1.4%	-1.4%	-0.1%
2000	65,072,994	6.5%	0	0.0%	0.0%	0	0	1,200,750	235,937	964,814	1.5%	-1.5%	-0.1%
2001	38,068,931	3.8%	0	0.0%	0.0%	0	0	939,820	172,443	767,377	2.0%	-2.0%	-0.1%
2002	63,314,285	6.3%	0	0.0%	0.0%	0	0	1,650,783	310,857	1,339,927	2.1%	-2.1%	-0.1%
2003	41,334,552	4.1%	0	0.0%	0.0%	0	0	707,400	146,610	560,789	1.4%	-1.4%	-0.1%
Avg	**48,186,950**	**4.8%**	**0**	**0.0%**	**0.0%**	**0**	**0.0%**	**1,075,219**	**202,738**	**872,481**	**1.7%**	**-1.7%**	**-0.1%**

Notes:

[1] Assumes 1,000,000,000 eggs were released annually at various locations

[2] Assumes diversions from December to March

[3] Assumes discharge for exports by SWP and CVP from July to September

[4] Assumes similar pattern of agricultural diversions each year

[5] Assumes similar pattern of habitat diversions each year

[6] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.

Source: ICF 2010: Appendix B

Entrainment Loss of Juvenile and Adult Fish

A potentially significant effect of the project on fishery resources is through entrainment. Entrainment loss due to project diversions is the total number of fish diverted onto the Reservoir and Habitat Islands. The Proposed Action would greatly reduce entrainment of fish at the unscreened agricultural diversions. All project facilities would be screened but some fish are still likely to be entrained (particularly smaller individuals) and some larger fish may be impinged on the screens. For juvenile and adult fish greater than 20 mm in length, the fish screens are assumed to considerably reduce direct entrainment losses. The screen structures would be in the water only during actual diversions (as assumed in the project description), and predator populations associated with the screens are not likely to increase during the 2- to 4-week diversion period. However, the presence of boat docks, pilings, and other structures associated with the intakes could provide habitat for predatory fish that may increase entrainment losses. Entrainment loss attributable to the project also includes fish lost at the SWP fish facility as a result of discharges of water from the Reservoir Islands. The magnitude of this entrainment loss may be larger than that of entrainment loss caused by project diversions (because of the project screens) but will affect a different fish assemblage due to the marked seasonality of many species.

The assessment of project entrainment effects was made for several listed species and other species of conservation interest: Chinook salmon, steelhead, Delta smelt, longfin smelt, green sturgeon, and Sacramento splittail. Striped bass and American shad were included to document effects on species with economic (and ecological) importance. Threadfin shad and white catfish were also analyzed to demonstrate possible effects on species of high abundance and therefore ecological importance that occupy differing habitats (threadfin shad are pelagic schooling species whereas white catfish are demersal).

Methods

Historical CVP and SWP salvage records (California Department of Fish and Game 2009a) were used to estimate monthly densities of fish in the Delta that are large enough to be screened at the project, i.e., longer than 20 mm. Only data from 1980 onwards were used because taxonomic identification for taxa such as the smelts became more consistent at this time. A summary of many of these data is provided in the Draft EIS for the Delta-Mendota Canal/California Aqueduct Intertie Project (U.S. Bureau of Reclamation 2009). Fish density (fish salvaged/taf exported at SWP and CVP) in each month was examined for each species of interest. The monthly values of fish density in the Delta adopted for the analysis were fixed for each year and were based on estimated numbers of fish collected at the fish salvage facilities multiplied by factors to account for presalvage losses due to predation and passage through the screening louvers (Table F-31). Presalvage losses were accounted for by multiplying the SWP salvage density by 5.3 (reflecting prescreen loss of around 80% due to louver efficiency and predation losses; National Marine Fisheries Service 2009, 352) and by multiplying the CVP salvage density by 2.5 (reflecting prescreen losses of approximately 60%). For green sturgeon, predation loss was assumed to be minimal (5% instead of 75% at SWP and 15% at CVP), with resulting multipliers of 1.4 for SWP data and 2.2 for CVP data based mostly on louver inefficiency.

Chinook salmon were divided into the four different runs found in the Central Valley using a simplified version of the Delta length-at-month key (Table F-32; S. Greene, DWR, unpublished) and assessing the proportions in each run by month for fish length data from the salvage facilities from 1993 to 2008. The proportions were then multiplied by the estimated density for all runs combined to give seasonal density patterns for each species.

Table F-31. Assumed Survival Proportions for Fish During Salvage at the State Water Project (SWP) and Central Valley Project (CVP) Fish Collection Facilities. The data from both facilities were used to calculate density of fish in the Delta. The SWP loss multiplier was used to estimate losses during export from the equation: loss = fish density drawn to the export facilities (fish/taf) × water exported × loss multiplier. CHTR is collection, handling, trucking, and release.

	1. Most fish		2. Smelts		3. Green sturgeon	
	Proportion	Running Proportion	Proportion	Running Proportion	Proportion	Running Proportion
SWP						
Prescreen survival	0.25	0.25	0.25	0.25	0.95	0.95
Louver efficiency	0.75	0.19	0.75	0.19	0.75	0.71
CHTR survival	0.98	0.18	0.00	0.00	0.98	0.70
Postrelease survival	0.90	0.17	0.00	0.00	0.99	0.69
CVP						
Prescreen survival	0.85	0.85	0.85	0.85	0.95	0.95
Louver efficiency	0.47	0.40	0.47	0.40	0.47	0.44
CHTR survival	0.98	0.39	0.00	0.00	0.98	0.44
Postrelease survival	0.90	0.35	0.00	0.00	0.99	0.43
	Loss multiplier (For SWP Export) =	0.83	Loss multiplier (For SWP Export) =	1.00	Loss multiplier (For SWP Export) =	0.31
Source: ICF 2010:Appendix B						

Table F-32. Length-at-Month Key Used to Assign Chinook Salmon to Different Runs. Values are mm of fork length.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Winter-run	66-175	81-225	111-270	136-270	171-270	221-270	0-35	0-50, 246-270	0-60	31-80	41-105	51-135
Spring-run	46-65	56-80	71-110	81-135	101-170	121-220	151-270	181-245	221-270	0-30	0-40	36-50
Fall-run	0-45, 221-270	0-55	0-70	36-80	46-100	56-120	71-150	81-180	101-220	121-270	151-270	0-35, 181-270
Late fall–run	175-220	226-270	–	0-35	0-45	0-55	36-70	51-80	61-100	81-120	106-150	136-180

Source: ICF 2010:Appendix B

The entrainment analyses covered the period from 1980 to 2003. The baseline entrainment due to SWP and CVP operations was calculated by multiplying the assumed monthly density of each species by the quantity of water exported in that month and correcting for presalvage and postsalvage losses with a loss multiplier:

> Baseline entrainment loss by SWP and CVP (number of fish) = Fish density (fish/taf) × water exported (taf) × loss multiplier.

The loss multiplier accounted for all sources of losses, grouped by species (Table F-31). Presalvage loss is described above for the calculation of fish density in the Delta from salvage data. Postsalvage loss was assumed to be 2% during collection, holding, trucking and release and 10% by predation (NMFS 2009, 352); all smelt were assumed to die during salvage (Kimmerer 2008, 11) and pre-/post-salvage predation on green sturgeon was assumed to result in a 1% loss).

The entrainment effect of the project's diversions onto the Reservoir and Habitat Islands was calculated by multiplying the assumed density of fish by the simulated quantity of water diverted, incorporating a screen efficiency of 95% (as assumed in the NMFS 2009 OCAP BO) and a small-intake correction factor (see below):

> Reservoir Island entrainment loss (number of fish) = Fish density (fish/taf) × water exported (taf) × small-intake correction factor (0.50) × screen efficiency multiplier (0.05).

The small-intake correction factor was included to account for the general non-linear relationship between the size of a water intake (or amount of water withdrawn) and the number of fish (or proportion of a fish population) that is entrained (Kimmerer 2008). The SWP and CVP intakes are very large (several thousand cfs each), whereas the Reservoir Island intakes are smaller (each being 1,000-2000 cfs) and the agricultural/habit island intakes are each less than 100 cfs. Moyle and Israel (2005) noted that there is scant information on entrainment of fish in the Central Valley, but that one example from the Yuba River illustrates the concept (also recently highlighted by Kimmerer 2008) that the number of fish entrained increases in a non-linear manner (Figure F-2). An examination of various sources that included predictive entrainment-flow relationships at relatively large intakes was made to determine the ratio of the density of fish entrained at 2,000 cfs (i.e., a similar size to the Reservoir Island intakes) compared to the density of fish entrained at 4,000 cfs (i.e., a similar size to the SWP and CVP intakes). The first five examples presented in Table F-33 are from the NMFS OCAP BO (2009, 370-372) and the other two are examples from power plant cooling-water intakes. The average ratio from all studies combined is 0.49; that is, the average density of fish salvaged or entrained at a 2,000-cfs intake is approximately half that of a 4,000-cfs intake. It was therefore assumed that 0.5 was a reasonable small-intake correction factor for the reservoir-island intakes. The reasons for the nonlinear relationship may be the increase in 'draw' of fish from an adjacent water body with increasing diversion size, as would occur when the proportion of the water volume diverted increases. In the case of the SWP/CVP export facilities, NMFS (2009, 369) suggested that relationship could be attributable to the faster transit time past predators, giving more fish at the salvage facilities and lower prescreen predation losses.

Table F-33. Ratio of Fish Density Salvaged or Entrained at Various Water Intakes of 2,000 cfs and 4,000 cfs

Study	Density (2,000-cfs intake)	Density (4,000-cfs intake)	Ratio
Chinook salmon salvage, older juveniles (SWP) (NMFS 2009)	0.063	0.092	0.251
Chinook salmon salvage, older juveniles (SWP) (NMFS 2009)	0.006	0.024	0.251
Steelhead salvage (unclipped; SWP) (NMFS 2009)	0.022	0.028	0.794
Steelhead salvage (clipped; SWP) (NMFS 2009)	0.007	0.0286	0.260
Steelhead salvage (unclipped; CVP) (NMFS 2009)	0.025	0.044	0.560
Great Lakes power plants (all fish) (Kelso and Milburn 1979)	601.1	1056.9	0.569
Northeast European coastal power plants (all fish) (Greenwood 2008)	1230.3	3580.2	0.344

Notes: cfs = cubic feet per second; SWP = State Water Project; CVP = Central Valley Project; NMFS = National Marine Fisheries Service
Source: ICF 2010:Appendix B

For agricultural intakes of relatively small size (<100 cfs), the small-intake correction factor was 0.1, i.e., 10% of the density of fish drawn to the SWP/CVP intakes. This value was based on a comparison of the density (number of white catfish/taf) diverted at Bacon Island during sampling in the summers of 1993, 1994, and 1995 (Cooke and Buffaloe 1998) to the average density of fish entrained into the SWP and CVP intakes (after correcting for prescreen losses, see below). White catfish (greater than 30 mm long) were the main species for which adequate numbers of fish appeared to have been entrained. The density of white catfish entrained into the agricultural diversion ranged from 25 fish/taf in 1995 to almost 36 fish/taf in 1994. The estimated density of fish entrained into the SWP and CVP intakes ranged from almost 146 fish/taf in 1995 to nearly 1,250 fish in 1993. The average annual ratio of the densities (agricultural intake: SWP/CVP intake) was 0.083, i.e., the density of fish in the agricultural intake was 8.3% that of the density at the SWP/CVP intakes. This suggested that a ratio of 10% would be a reasonable small-intake correction factor for the agricultural and habitat-island intakes in the analysis of project effects. The entrainment loss for the agricultural diversions under existing/baseline conditions was estimated as:

> Existing agricultural entrainment loss (number of fish) = Fish density (fish/taf) × water diverted (taf) × small-intake correction factor (0.1).

These assumptions regarding small-intake correction factors are quite uncertain and so comparative analyses were also conducted using values for the Reservoir

Island intakes of 50% and 100% and for the agricultural/Habitat Island intakes of 10%, 50%, and 100%.

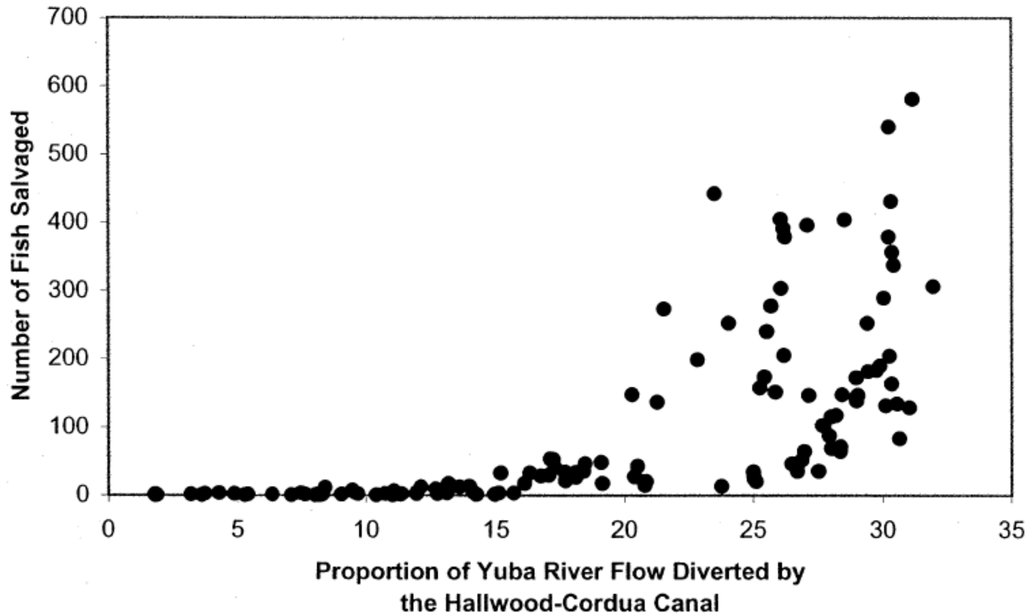


Figure F-2. Relation between the Number of Rainbow Trout Salvaged Daily by DFG at the Hallwood-Cordua Fish Screen between 13 April and 17 August, 2000, and the Proportion of Yuba River Flow Diverted by the Hallwood-Cordua Canal

Source: reproduced from Kozlowski (2004) in ICF 2010:Appendix B

The increased entrainment at the SWP fish facility due to project discharges of reservoir island water was estimated in the same manner as described above for the baseline entrainment:

> Entrainment loss through SWP export of project water (number of fish) = Fish density (fish/taf) × water exported (taf) × loss multiplier.

The effect of the Proposed Action was compared to the baseline entrainment attributable to SWP and CVP water exports. The benefit of the Proposed Action (screening and reduction of agricultural diversions) was weighed against the effects caused by diversions to the Reservoir and Habitat Islands and export of project water by the SWP facility.

Main Assumptions

To summarize, the entrainment analysis of juvenile and adult fish assumed:

- diversions to the Reservoir Islands occur in December–March;
- discharges for export occur in July–November;

- density of fish in the Delta can be estimated from historic SWP and CVP salvage data by applying appropriate corrections for presalvage losses (see above);
- the density of fish is the same in each year and differs by month according to seasonal patterns;
- the volume of water diverted or exported is directly related to the loss of fish, with corrections for pre-/post-salvage losses, screening effectiveness, and size of the intake;
- delta smelt adults occur from December to March and 25% of fish in April salvaged are adults—delta smelt in the remainder of the year are juveniles;
- chinook salmon race (run) can be determined from length in a given month using the key established for the Delta (S. Greene, DWR, unpublished)
- diversions to the agricultural and Habitat Islands are the same (quantity and timing) in all years;
- baseline losses to Delta lowland agricultural diversions are 20 times greater than losses estimated for existing DW agricultural diversions—this assumption is based on the relative size of the irrigated acreages (DW is 5% of the total lowland irrigated acreage) and that other irrigation in the Delta follows the same annual pattern of diversion as the existing DW agriculture.

Results

Fall-Run Chinook Salmon

The baseline entrainment loss of fall-run Chinook salmon by SWP and CVP averaged about 291,000 fish from 1980 to 2003 (Table F-34). The lowest entrainment loss of about 131,000 fish occurred in 1992 and the maximum entrainment was nearly 508,000 fish in 1995. Direct entrainment loss of fall-run Chinook salmon estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to 384 fish in 1986, and averaged 74 fish (Table F-35); this represented an average increased entrainment over baseline conditions of 0–0.2%. Loss of fall-run Chinook salmon due to export of discharged project water averaged 311 fish, ranging from 0 (several years) to almost 1,200 in 1986; this was 0–0.5% of baseline losses (Table F-36).

Based on the assumed monthly density of fall-run Chinook salmon and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 523 less fall-run Chinook salmon would be entrained annually (Table F-37). As a whole, the project was estimated to result in a slight net benefit to fall-run Chinook salmon because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net benefit averaged 138 fish per year, or 0.0% of the baseline entrainment by SWP and CVP (Table F-38).

Table F-34. Baseline Entrainment Loss of Fall-Run Chinook Salmon by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated Loss
	Assumed Density (Fish/thousand acre-feet)												
	9.5	11.8	3.6	9.6	66.7	31.9	126.4	611.2	246.5	4.5	0.4	0.5	
1980	3,449	5,750	1,801	5,419	29,986	11,678	40,750	149,160	76,429	1,881	165	245	326,712
1981	3,967	4,331	1,644	4,988	32,186	13,741	25,479	117,730	70,651	2,190	148	197	277,250
1982	4,141	5,751	1,800	5,110	33,084	14,073	47,791	269,785	106,004	2,266	221	249	490,275
1983	4,676	5,759	1,847	4,793	28,192	9,908	49,719	275,359	106,004	2,266	221	249	488,993
1984	4,676	5,759	1,693	3,614	26,832	12,841	25,235	102,047	68,526	2,069	219	228	253,740
1985	4,648	5,747	1,795	4,751	24,678	8,130	23,105	121,905	67,057	2,254	219	220	264,510
1986	3,650	4,734	1,799	4,918	37,776	14,353	45,235	227,631	65,906	1,608	193	249	408,052
1987	4,279	4,867	1,336	3,401	25,367	11,062	6,175	108,438	65,359	2,122	58	104	232,569
1988	2,556	3,002	1,784	4,875	6,236	2,223	17,214	45,787	47,054	1,747	29	97	132,604
1989	1,791	2,693	1,071	2,606	6,459	14,923	26,882	72,924	62,968	2,184	206	172	194,879
1990	3,292	3,878	1,235	4,833	9,579	6,838	6,175	63,555	48,843	1,506	76	116	149,925
1991	1,834	2,458	354	1,152	7,208	16,001	8,933	68,004	24,785	1,349	70	115	132,263
1992	2,144	1,513	695	1,927	34,636	10,627	10,957	29,868	37,448	766	121	119	130,821
1993	1,696	2,049	1,172	5,306	35,874	15,573	36,708	136,728	99,868	2,254	212	248	337,687
1994	4,568	4,162	1,500	4,019	31,781	8,471	14,867	87,002	64,654	2,261	203	135	223,623
1995	2,939	2,326	1,725	5,169	36,618	15,849	56,014	278,395	106,004	2,266	221	249	507,775
1996	4,676	5,759	1,801	4,688	28,512	11,422	44,116	187,212	76,849	1,581	199	249	367,064
1997	3,298	5,753	1,894	4,856	33,839	12,055	29,499	102,016	65,139	1,266	220	203	260,039
1998	3,355	5,204	1,798	4,767	33,740	12,320	49,769	265,157	106,004	2,266	221	249	484,851
1999	4,676	5,759	1,827	4,773	30,098	13,000	39,706	118,235	69,821	1,900	210	249	290,254
2000	4,330	5,750	1,410	4,883	33,553	14,892	37,653	143,427	75,980	1,537	220	238	323,871
2001	4,092	5,563	1,802	4,984	34,776	14,356	16,307	60,043	29,985	1,771	69	120	173,868
2002	2,403	4,066	1,795	4,989	3,261	6,519	23,400	106,575	65,705	2,220	196	149	221,279
2003	2,366	5,743	1,789	4,873	3,824	12,510	33,906	169,581	74,872	1,633	216	234	311,546
Avg	3,479	4,516	1,557	4,404	25,337	11,807	29,816	137,774	70,080	1,882	172	195	291,019

Source: ICF 2010:Appendix B

Table F-35. Entrainment Loss of Fall-Run Chinook Salmon during Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed Density (Fish/thousand acre-feet)												Estimated	% of
Water Year	**9.5**	**11.8**	**3.6**	**9.6**	**66.7**	**31.9**	**126.4**	**611.2**	**246.5**	**4.5**	**0.4**	**0.5**	**Loss**	**Baseline**
1980	0	0	0	50	1	1	0	0	0	0	0	0	52	0.0%
1981	0	0	0	38	0	42	0	0	0	0	0	0	80	0.0%
1982	0	0	19	0	1	1	0	0	0	0	0	0	21	0.0%
1983	0	0	19	0	1	1	0	0	0	0	0	0	21	0.0%
1984	0	0	19	0	1	1	0	0	0	0	0	0	21	0.0%
1985	0	0	17	0	0	0	0	0	0	0	0	0	17	0.0%
1986	0	0	0	0	380	4	0	0	0	0	0	0	384	0.1%
1987	0	0	0	0	0	144	0	0	0	0	0	0	144	0.1%
1988	0	0	0	43	0	0	0	0	0	0	0	0	43	0.0%
1989	0	0	0	0	0	167	0	0	0	0	0	0	167	0.1%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	19	0	0	0	0	0	0	19	0.0%
1992	0	0	0	0	312	0	0	0	0	0	0	0	312	0.2%
1993	0	0	0	50	1	1	0	0	0	0	0	0	52	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	50	1	1	0	0	0	0	0	0	52	0.0%
1996	0	0	0	50	1	1	0	0	0	0	0	0	52	0.0%
1997	0	0	19	0	1	1	0	0	0	0	0	0	21	0.0%
1998	0	0	0	50	1	1	0	0	0	0	0	0	52	0.0%
1999	0	0	19	0	1	1	0	0	0	0	0	0	21	0.0%
2000	0	0	0	38	94	1	0	0	0	0	0	0	133	0.0%
2001	0	0	0	0	70	0	0	0	0	0	0	0	70	0.0%
2002	0	0	11	21	0	0	0	0	0	0	0	0	32	0.0%
2003	0	0	19	0	0	0	0	0	0	0	0	0	19	0.0%
Average	0	0	6	16	36	16	0	0	0	0	0	0	74	0.0%

Source: ICF 2010:Appendix B

Table F-36. Entrainment Loss of Fall-Run Chinook Salmon during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)												**Estimated**	**% of**
Water year	**9.5**	**11.8**	**3.6**	**9.6**	**66.7**	**31.9**	**126.4**	**611.2**	**246.5**	**4.5**	**0.4**	**0.5**	**loss**	**baseline**
1980	0	0	0	0	0	0	0	0	0	0	46	4	50	0.0%
1981	563	0	0	0	0	0	0	0	0	41	51	22	677	0.2%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	88	0	23	112	0.0%
1985	0	0	0	0	0	0	0	0	0	0	0	18	18	0.0%
1986	701	0	0	0	0	0	0	0	0	447	29	0	1,178	0.3%
1987	60	0	0	0	0	0	0	0	0	0	0	58	118	0.1%
1988	0	0	0	0	0	0	0	0	0	163	58	0	221	0.2%
1989	0	0	0	0	0	0	0	0	0	0	9	43	52	0.0%
1990	153	0	0	0	0	0	0	0	0	0	0	0	153	0.1%
1991	0	0	0	0	0	0	0	0	0	77	0	0	77	0.1%
1992	0	0	0	0	0	0	0	0	0	607	3	0	610	0.5%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	92	829	0	0	0	0	0	0	0	0	0	0	920	0.4%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	421	24	0	444	0.1%
1997	226	0	0	0	0	0	0	0	0	520	0	29	774	0.3%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	369	0	0	369	0.1%
2000	364	0	0	0	0	0	0	0	0	182	0	0	546	0.2%
2001	636	174	0	0	0	0	0	0	0	129	0	0	939	0.5%
2002	0	0	0	0	0	0	0	0	0	0	22	56	78	0.0%
2003	0	0	0	0	0	0	0	0	0	124	0	0	124	0.0%
Average	116	42	0	0	0	0	0	0	0	132	10	11	311	0.1%

Source: ICF 2010:Appendix B

Table F-37. Entrainment Loss of Fall-Run Chinook Salmon during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	9.5	11.8	3.6	9.6	66.7	31.9	126.4	611.2	246.5	4.5	0.4	0.5	
Agricultural diversions	2	0	1	3	19	0	0	165	332	7	1	0	529
Habitat Island diversions	0	0	0	0	0	0	0	1	4	0	0	0	6
Project Benefit	2	0	1	3	19	0	0	163	328	7	1	0	523

Source: ICF 2010:Appendix B

Table F-38. Summary of Fall-Run Chinook Salmon Entrainment Loss Effects of the Project Compared to the Baseline Conditions

Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Project Diversion Effect[3] Loss	Project Diversion Effect[3] % of Baseline SWP/CVP	Project Export Effect[4] Loss	Project Export Effect[4] % of Baseline SWP/CVP	Baseline DW Agricultural Diversion Loss[5]	Project Habitat Diversion Loss[6]	Project Benefit from Reduced and Screened Agricultural Diversions[7] Reduced Loss	Project Benefit from Reduced and Screened Agricultural Diversions[7] % of SWP/CVP	Net Project Effect Loss	Net Project Effect % of SWP/CVP
1980	326,712	10,571	52	0.0%	50	0.0%	529	6	523	0.2%	-421	-0.1%
1981	277,250	10,571	80	0.0%	677	0.2%	529	6	523	0.2%	233	0.1%
1982	490,275	10,571	21	0.0%	0	0.0%	529	6	523	0.1%	-502	-0.1%
1983	488,993	10,571	21	0.0%	0	0.0%	529	6	523	0.1%	-502	-0.1%
1984	253,740	10,571	21	0.0%	112	0.0%	529	6	523	0.2%	-390	-0.2%
1985	264,510	10,571	17	0.0%	18	0.0%	529	6	523	0.2%	-488	-0.2%
1986	408,052	10,571	384	0.1%	1,178	0.3%	529	6	523	0.1%	1,039	0.3%
1987	232,569	10,571	144	0.1%	118	0.1%	529	6	523	0.2%	-261	-0.1%
1988	132,604	10,571	43	0.0%	221	0.2%	529	6	523	0.4%	-259	-0.2%
1989	194,879	10,571	167	0.1%	52	0.0%	529	6	523	0.3%	-304	-0.2%
1990	149,925	10,571	0	0.0%	153	0.1%	529	6	523	0.3%	-370	-0.2%
1991	132,263	10,571	19	0.0%	77	0.1%	529	6	523	0.4%	-427	-0.3%
1992	130,821	10,571	312	0.2%	610	0.5%	529	6	523	0.4%	399	0.3%
1993	337,687	10,571	52	0.0%	0	0.0%	529	6	523	0.2%	-471	-0.1%
1994	223,623	10,571	0	0.0%	920	0.4%	529	6	523	0.2%	397	0.2%
1995	507,775	10,571	52	0.0%	0	0.0%	529	6	523	0.1%	-471	-0.1%
1996	367,064	10,571	52	0.0%	444	0.1%	529	6	523	0.1%	-26	0.0%
1997	260,039	10,571	21	0.0%	774	0.3%	529	6	523	0.2%	273	0.1%
1998	484,851	10,571	52	0.0%	0	0.0%	529	6	523	0.1%	-471	-0.1%
1999	290,254	10,571	21	0.0%	369	0.1%	529	6	523	0.2%	-133	0.0%
2000	323,871	10,571	133	0.0%	546	0.2%	529	6	523	0.2%	156	0.0%
2001	173,868	10,571	70	0.0%	939	0.5%	529	6	523	0.3%	486	0.3%
2002	221,279	10,571	32	0.0%	78	0.0%	529	6	523	0.2%	-413	-0.2%
2003	311,546	10,571	19	0.0%	124	0.0%	529	6	523	0.2%	-380	-0.1%
Avg.	291,019	10,571	74	0.0%	311	0.1%	529	6	523	0.2%	-138	0.0%

Notes.

1 Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

2 Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

3 Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

4 Increased loss of fish assuming SWP export of discharged Project water from July to November.

5 Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

6 Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

7 Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to Project wetland habitat diversions.

Source: ICF 2010:Appendix B

Late-Fall-Run Chinook Salmon

The baseline entrainment loss of late-fall-run Chinook salmon by SWP and CVP averaged just over 20,000 fish from 1980 to 2003 (Table F-39). The lowest entrainment loss of about 6,500 fish occurred in 1991 and the maximum entrainment was over 24,400 fish in 1997. Direct entrainment loss of late-fall-run Chinook salmon estimated for the Proposed Action ranged from 0 fish (several years) to 137 fish (several years), and averaged 52 fish (Table F-40); this represented an average increased entrainment over baseline conditions of 0–0.6%. Loss of late-fall-run Chinook salmon due to export of discharged project water averaged 79 fish, ranging from 0 (several years) to over 900 in 1994; this amounted to 0–4.6% of baseline losses (Table F-41).

Based on the assumed monthly density of late-fall-run Chinook salmon and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 10 less late-fall-run Chinook salmon would be entrained annually (Table F-42). As a whole, the project was estimated to result in a net loss to late-fall-run Chinook salmon because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 121 fish per year, or 0.6% of the baseline entrainment by SWP and CVP (Table F-43).

Table F-39. Baseline Entrainment Loss of Late Fall–Run Chinook Salmon by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												Estimated
Water year	2.7	12.6	26.1	4.7	2.1	0.0	0.0	0.0	0.2	0.0	0.0	0.1	loss
1980	973	6,094	13,130	2,679	946	0	7	0	58	0	8	34	23,929
1981	1,119	4,590	11,984	2,466	1,016	0	4	0	54	0	7	27	21,268
1982	1,168	6,095	13,122	2,526	1,044	0	8	0	81	0	11	35	24,090
1983	1,320	6,103	13,469	2,369	890	0	8	0	81	0	11	35	24,285
1984	1,320	6,103	12,342	1,787	847	0	4	0	52	0	11	32	22,497
1985	1,312	6,091	13,090	2,349	779	0	4	0	51	0	11	31	23,717
1986	1,030	5,017	13,115	2,431	1,192	0	8	0	50	0	9	35	22,887
1987	1,208	5,158	9,741	1,681	800	0	1	0	50	0	3	15	18,657
1988	721	3,182	13,005	2,410	197	0	3	0	36	0	1	14	19,568
1989	505	2,854	7,812	1,288	204	0	5	0	48	0	10	24	12,750
1990	929	4,110	9,007	2,389	302	0	1	0	37	0	4	16	16,795
1991	517	2,605	2,584	569	227	0	2	0	19	0	3	16	6,543
1992	605	1,604	5,066	953	1,093	0	2	0	29	0	6	17	9,373
1993	479	2,171	8,543	2,623	1,132	0	6	0	76	0	10	35	15,075
1994	1,289	4,411	10,933	1,987	1,003	0	3	0	49	0	10	19	19,702
1995	829	2,466	12,579	2,555	1,155	0	9	0	81	0	11	35	19,721
1996	1,320	6,103	13,131	2,318	900	0	7	0	59	0	10	35	23,881
1997	931	6,097	13,812	2,400	1,068	0	5	0	50	0	11	28	24,402
1998	947	5,516	13,109	2,356	1,065	0	8	0	81	0	11	35	23,128
1999	1,320	6,103	13,322	2,359	950	0	7	0	53	0	10	35	24,159
2000	1,222	6,094	10,279	2,414	1,059	0	6	0	58	0	11	33	21,174
2001	1,155	5,895	13,137	2,464	1,097	0	3	0	23	0	3	17	23,794
2002	678	4,309	13,089	2,466	103	0	4	0	50	0	10	21	20,730
2003	668	6,086	13,041	2,409	121	0	6	0	57	0	11	33	22,431
Average	982	4,786	11,352	2,177	799	0	5	0	54	0	8	27	20,190

Source: ICF 2010:Appendix B

Table F-40. Entrainment Loss of Late Fall–Run Chinook Salmon during Project Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	2.7	12.6	26.1	4.7	2.1	0.0	0.0	0.0	0.2	0.0	0.0	0.1	Estimated loss	% of baseline
1980	0	0	0	25	0	0	0	0	0	0	0	0	25	0.1%
1981	0	0	0	19	0	0	0	0	0	0	0	0	19	0.1%
1982	0	0	137	0	0	0	0	0	0	0	0	0	137	0.6%
1983	0	0	137	0	0	0	0	0	0	0	0	0	137	0.6%
1984	0	0	137	0	0	0	0	0	0	0	0	0	137	0.6%
1985	0	0	123	0	0	0	0	0	0	0	0	0	123	0.5%
1986	0	0	0	0	12	0	0	0	0	0	0	0	12	0.1%
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1988	0	0	0	21	0	0	0	0	0	0	0	0	21	0.1%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1992	0	0	0	0	10	0	0	0	0	0	0	0	10	0.1%
1993	0	0	0	25	0	0	0	0	0	0	0	0	25	0.2%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	25	0	0	0	0	0	0	0	0	25	0.1%
1996	0	0	0	25	0	0	0	0	0	0	0	0	25	0.1%
1997	0	0	137	0	0	0	0	0	0	0	0	0	137	0.6%
1998	0	0	0	25	0	0	0	0	0	0	0	0	25	0.1%
1999	0	0	137	0	0	0	0	0	0	0	0	0	137	0.6%
2000	0	0	0	19	3	0	0	0	0	0	0	0	22	0.1%
2001	0	0	0	0	2	0	0	0	0	0	0	0	2	0.0%
2002	0	0	80	10	0	0	0	0	0	0	0	0	90	0.4%
2003	0	0	137	0	0	0	0	0	0	0	0	0	137	0.6%
Average	0	0	43	8	1	0	0	0	0	0	0	0	52	0.3%

Source: ICF 2010:Appendix B

Table F-41. Entrainment Loss of Late Fall–Run Chinook Salmon during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	**2.7**	**12.6**	**26.1**	**4.7**	**2.1**	**0.0**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**0.1**	**Estimated loss**	**% of baseline**
1980	0	0	0	0	0	0	0	0	0	0	2	1	3	0.0%
1981	159	0	0	0	0	0	0	0	0	0	2	3	164	0.8%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	0	0	3	3	0.0%
1985	0	0	0	0	0	0	0	0	0	0	0	3	3	0.0%
1986	198	0	0	0	0	0	0	0	0	0	1	0	199	0.9%
1987	17	0	0	0	0	0	0	0	0	0	0	8	25	0.1%
1988	0	0	0	0	0	0	0	0	0	0	3	0	3	0.0%
1989	0	0	0	0	0	0	0	0	0	0	0	6	6	0.1%
1990	43	0	0	0	0	0	0	0	0	0	0	0	43	0.3%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	26	878	0	0	0	0	0	0	0	0	0	0	904	4.6%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	0	1	0	1	0.0%
1997	64	0	0	0	0	0	0	0	0	0	0	4	68	0.3%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2000	103	0	0	0	0	0	0	0	0	0	0	0	103	0.5%
2001	179	184	0	0	0	0	0	0	0	0	0	0	364	1.5%
2002	0	0	0	0	0	0	0	0	0	0	1	8	9	0.0%
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Average	33	44	0	0	0	0	0	0	0	0	0	1	79	0.4%

Source: ICF 2010:Appendix B

Table F-42. Entrainment Loss of Late Fall–Run Chinook Salmon during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												
	2.7	12.6	26.1	4.7	2.1	0.0	0.0	0.0	0.2	0.0	0.0	0.1	Number of fish
Agricultural diversions	0	0	7	1	1	0	0	0	0	0	0	0	10
Habitat Island diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Benefit	0	0	7	1	1	0	0	0	0	0	0	0	10

Source: ICF 2010:Appendix B

Table F-43. Summary of Late Fall–Run Chinook Salmon Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/ SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/ CVP	Loss	% of Baseline SWP/ CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/ CVP	Loss	% of SWP/ CVP
1980	23,929	202	25	0.1%	3	0.0%	10	0	10	0.0%	18	0.1%
1981	21,268	202	19	0.1%	164	0.8%	10	0	10	0.0%	173	0.8%
1982	24,090	202	137	0.6%	0	0.0%	10	0	10	0.0%	127	0.5%
1983	24,285	202	137	0.6%	0	0.0%	10	0	10	0.0%	127	0.5%
1984	22,497	202	137	0.6%	3	0.0%	10	0	10	0.0%	130	0.6%
1985	23,717	202	123	0.5%	3	0.0%	10	0	10	0.0%	116	0.5%
1986	22,887	202	12	0.1%	199	0.9%	10	0	10	0.0%	202	0.9%
1987	18,657	202	0	0.0%	25	0.1%	10	0	10	0.1%	15	0.1%
1988	19,568	202	21	0.1%	3	0.0%	10	0	10	0.0%	14	0.1%
1989	12,750	202	0	0.0%	6	0.1%	10	0	10	0.1%	-3	0.0%
1990	16,795	202	0	0.0%	43	0.3%	10	0	10	0.1%	34	0.2%
1991	6,543	202	0	0.0%	0	0.0%	10	0	10	0.1%	-10	-0.1%
1992	9,373	202	10	0.1%	0	0.0%	10	0	10	0.1%	0	0.0%
1993	15,075	202	25	0.2%	0	0.0%	10	0	10	0.1%	15	0.1%
1994	19,702	202	0	0.0%	904	4.6%	10	0	10	0.0%	894	4.5%
1995	19,721	202	25	0.1%	0	0.0%	10	0	10	0.0%	15	0.1%
1996	23,881	202	25	0.1%	1	0.0%	10	0	10	0.0%	16	0.1%
1997	24,402	202	137	0.6%	68	0.3%	10	0	10	0.0%	195	0.8%
1998	23,128	202	25	0.1%	0	0.0%	10	0	10	0.0%	15	0.1%
1999	24,159	202	137	0.6%	0	0.0%	10	0	10	0.0%	127	0.5%
2000	21,174	202	22	0.1%	103	0.5%	10	0	10	0.0%	115	0.5%
2001	23,794	202	2	0.0%	364	1.5%	10	0	10	0.0%	356	1.5%
2002	20,730	202	90	0.4%	9	0.0%	10	0	10	0.0%	90	0.4%
2003	22,431	202	137	0.6%	0	0.0%	10	0	10	0.0%	127	0.6%
Average	20,190	202	52	0.2%	79	0.4%	10	0	10	0.1%	121	0.6%

Notes:

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Winter-Run Chinook Salmon

The baseline entrainment loss of winter-run Chinook salmon by SWP and CVP averaged about 60,000 fish from 1980 to 2003 (Table F-44). The lowest entrainment loss of about 31,000 fish occurred in 1991and the maximum entrainment was just over 80,000 fish in 1995. Direct entrainment loss of winter-run Chinook salmon estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to 424 fish in 1986, and averaged 120 fish (Table F-45); this represented an average increased entrainment over baseline conditions of 0–0.2%. Loss of winter-run Chinook salmon due to export of discharged project water did not occur because discharges were assumed to occur in July–November (Table F-46).

Based on the assumed monthly density of winter-run Chinook salmon and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 31 less winter-run Chinook salmon would be entrained annually (Table F-47). As a whole, the Project was estimated to result in a net loss to winter-run Chinook salmon because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 85 fish per year, or 0.1% of the baseline entrainment by SWP and CVP (F-48).

Table F-44. Baseline Entrainment Loss of Winter-Run Chinook Salmon by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												Estimated
Water year	**0.0**	**0.0**	**18.7**	**18.5**	**73.6**	**36.5**	**9.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**loss**
1980	0	0	9,403	10,441	33,076	13,353	2,911	246	0	0	0	0	69,429
1981	0	0	8,582	9,611	35,502	15,711	1,820	194	0	0	0	0	71,421
1982	0	0	9,397	9,847	36,493	16,091	3,414	445	0	0	0	0	75,687
1983	0	0	9,645	9,235	31,097	11,328	3,552	455	0	0	0	0	65,312
1984	0	0	8,838	6,964	29,596	14,683	1,803	168	0	0	0	0	62,053
1985	0	0	9,374	9,155	27,220	9,295	1,650	201	0	0	0	0	56,897
1986	0	0	9,392	9,475	41,668	16,412	3,231	376	0	0	0	0	80,554
1987	0	0	6,976	6,554	27,981	12,648	441	179	0	0	0	0	54,779
1988	0	0	9,313	9,393	6,879	2,542	1,230	76	0	0	0	0	29,432
1989	0	0	5,594	5,021	7,124	17,063	1,920	120	0	0	0	0	36,843
1990	0	0	6,450	9,312	10,566	7,819	441	105	0	0	0	0	34,693
1991	0	0	1,850	2,220	7,950	18,295	638	112	0	0	0	0	31,066
1992	0	0	3,628	3,713	38,205	12,150	783	49	0	0	0	0	58,528
1993	0	0	6,118	10,223	39,571	17,806	2,622	226	0	0	0	0	76,565
1994	0	0	7,829	7,745	35,056	9,686	1,062	144	0	0	0	0	61,521
1995	0	0	9,008	9,959	40,391	18,122	4,001	460	0	0	0	0	81,942
1996	0	0	9,403	9,034	31,450	13,060	3,151	309	0	0	0	0	66,407
1997	0	0	9,891	9,356	37,326	13,784	2,107	168	0	0	0	0	72,632
1998	0	0	9,387	9,185	37,217	14,087	3,555	438	0	0	0	0	73,869
1999	0	0	9,540	9,196	33,199	14,864	2,836	195	0	0	0	0	69,831
2000	0	0	7,361	9,408	37,010	17,028	2,690	237	0	0	0	0	73,733
2001	0	0	9,408	9,603	38,360	16,415	1,165	99	0	0	0	0	75,049
2002	0	0	9,373	9,614	3,598	7,454	1,672	176	0	0	0	0	31,886
2003	0	0	9,339	9,388	4,218	14,303	2,422	280	0	0	0	0	39,951
Average	0	0	8,129	8,485	27,948	13,500	2,130	227	0	0	0	0	60,420

Source: ICF 2010:Appendix B

Table F-45. Entrainment Loss of Winter-Run Chinook Salmon during Project Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	0.0	0.0	18.7	18.5	73.6	36.5	9.0	1.0	0.0	0.0	0.0	0.0	Estimated loss	% of baseline
1980	0	0	0	97	1	1	0	0	0	0	0	0	99	0.1%
1981	0	0	0	73	0	48	0	0	0	0	0	0	121	0.2%
1982	0	0	98	0	1	1	0	0	0	0	0	0	101	0.1%
1983	0	0	98	0	1	1	0	0	0	0	0	0	101	0.2%
1984	0	0	98	0	1	1	0	0	0	0	0	0	101	0.2%
1985	0	0	88	0	0	0	0	0	0	0	0	0	88	0.2%
1986	0	0	0	0	419	5	0	0	0	0	0	0	424	0.5%
1987	0	0	0	0	0	165	0	0	0	0	0	0	165	0.3%
1988	0	0	0	83	0	0	0	0	0	0	0	0	83	0.3%
1989	0	0	0	0	0	191	0	0	0	0	0	0	191	0.5%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	22	0	0	0	0	0	0	22	0.1%
1992	0	0	0	0	344	0	0	0	0	0	0	0	344	0.6%
1993	0	0	0	97	1	1	0	0	0	0	0	0	99	0.1%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	97	1	1	0	0	0	0	0	0	99	0.1%
1996	0	0	0	97	1	1	0	0	0	0	0	0	99	0.1%
1997	0	0	98	0	1	1	0	0	0	0	0	0	101	0.1%
1998	0	0	0	97	1	1	0	0	0	0	0	0	99	0.1%
1999	0	0	98	0	1	1	0	0	0	0	0	0	101	0.1%
2000	0	0	0	73	103	1	0	0	0	0	0	0	177	0.2%
2001	0	0	0	0	77	0	0	0	0	0	0	0	77	0.1%
2002	0	0	57	40	0	0	0	0	0	0	0	0	98	0.3%
2003	0	0	98	0	0	0	0	0	0	0	0	0	98	0.2%
Average	0	0	31	31	40	18	0	0	0	0	0	0	120	0.2%

Source: ICF 2010:Appendix B

Table F-46. Entrainment Loss of Winter-Run Chinook Salmon during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)												**Estimated**	**% of**
Water year	**0.0**	**0.0**	**18.7**	**18.5**	**73.6**	**36.5**	**9.0**	**1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**loss**	**baseline**
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1987	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%

Source: ICF 2010:Appendix B

Table F-47. Entrainment Loss of Winter-Run Chinook Salmon during Existing Agricultural Diversions Compared to Entrainment Loss During Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	0.0	0.0	18.7	18.5	73.6	36.5	9.0	1.0	0.0	0.0	0.0	0.0	
Agricultural diversions	0	0	5	5	21	0	0	0	0	0	0	0	32
Habitat Island diversions	0	0	2	0	3	0	0	0	0	0	0	0	1
Project Benefit	0	0	5	5	20	0	0	0	0	0	0	0	31

Source: ICF 2010:Appendix B

Table F-48. Summary of Winter-Run Chinook Salmon Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Water Year	Baseline CVP/ SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/ CVP	Loss	% of Baseline SWP/ CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/ CVP	Loss	% of SWP/ CVP
1980	69,429	633	99	0.1%	0	0.0%	32	1	31	0.0%	68	0.1%
1981	71,421	633	121	0.2%	0	0.0%	32	1	31	0.0%	90	0.1%
1982	75,687	633	101	0.1%	0	0.0%	32	1	31	0.0%	70	0.1%
1983	65,312	633	101	0.2%	0	0.0%	32	1	31	0.0%	70	0.1%
1984	62,053	633	101	0.2%	0	0.0%	32	1	31	0.1%	70	0.1%
1985	56,897	633	88	0.2%	0	0.0%	32	1	31	0.1%	57	0.1%
1986	80,554	633	424	0.5%	0	0.0%	32	1	31	0.0%	392	0.5%
1987	54,779	633	165	0.3%	0	0.0%	32	1	31	0.1%	133	0.2%
1988	29,432	633	83	0.3%	0	0.0%	32	1	31	0.1%	52	0.2%
1989	36,843	633	191	0.5%	0	0.0%	32	1	31	0.1%	160	0.4%
1990	34,693	633	0	0.0%	0	0.0%	32	1	31	0.1%	-31	-0.1%
1991	31,066	633	22	0.1%	0	0.0%	32	1	31	0.1%	-9	0.0%
1992	58,528	633	344	0.6%	0	0.0%	32	1	31	0.1%	313	0.5%
1993	76,565	633	99	0.1%	0	0.0%	32	1	31	0.0%	68	0.1%
1994	61,521	633	0	0.0%	0	0.0%	32	1	31	0.1%	-31	-0.1%
1995	81,942	633	99	0.1%	0	0.0%	32	1	31	0.0%	68	0.1%
1996	66,407	633	99	0.1%	0	0.0%	32	1	31	0.0%	68	0.1%
1997	72,632	633	101	0.1%	0	0.0%	32	1	31	0.0%	70	0.1%
1998	73,869	633	99	0.1%	0	0.0%	32	1	31	0.0%	68	0.1%
1999	69,831	633	101	0.1%	0	0.0%	32	1	31	0.0%	70	0.1%
2000	73,733	633	177	0.2%	0	0.0%	32	1	31	0.0%	146	0.2%
2001	75,049	633	77	0.1%	0	0.0%	32	1	31	0.0%	46	0.1%
2002	31,886	633	98	0.3%	0	0.0%	32	1	31	0.1%	67	0.2%
2003	39,951	633	98	0.2%	0	0.0%	32	1	31	0.1%	67	0.2%
Avg.	60,420	633	120	0.2%	0	0.0%	32	1	31	0.1%	89	0.1%

Notes.

1 Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

2 Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

3 Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

4 Increased loss of fish assuming SWP export of discharged project water from July to November.

5 Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

6 Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

7 Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Spring-Run Chinook Salmon

The baseline entrainment loss of spring-run Chinook salmon by SWP and CVP averaged almost 131,000 fish from 1980 to 2003 (Table F-49). The lowest entrainment loss of just over 42,000 fish occurred in 1990 and the maximum entrainment was over 240,000 fish in 1995. Direct entrainment loss of spring-run Chinook salmon estimated for the Proposed Action ranged from 0 fish in several years to 245 fish in 1989, and averaged 26 fish (Table F-50); this represented an average increased entrainment over baseline conditions of 0–0.4%. Loss of spring-run Chinook salmon due to export of discharged project water essentially did not occur, with values ranging from 0 (most years) to 1 fish in 1987 and 2002.

Based on the assumed monthly density of spring-run Chinook salmon and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 42 less spring-run Chinook salmon would be entrained annually (Table F-51). As a whole, the project was estimated to result in a slight net benefit to spring-run Chinook salmon because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of DW water from July to November was offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net benefit averaged 16 fish per year, or 0.0% of the baseline entrainment by SWP and CVP (Table F-52).

Table F-49. Baseline Entrainment Loss of Spring-Run Chinook Salmon by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss
	Assumed density (Fish/thousand acre-feet)												
	0.0	0.0	0.1	0.0	3.3	46.9	337.5	141.1	2.7	0.0	0.0	0.0	
1980	0	0	55	25	1,501	17,164	108,844	34,434	833	0	0	2	162,859
1981	0	0	50	23	1,611	20,195	68,055	27,178	770	0	0	2	117,885
1982	0	0	55	24	1,656	20,684	127,653	62,281	1,155	0	0	2	213,509
1983	0	0	56	22	1,411	14,562	132,802	63,568	1,155	0	0	2	213,579
1984	0	0	52	17	1,343	18,873	67,404	23,558	747	0	0	2	111,996
1985	0	0	55	22	1,235	11,948	61,714	28,142	731	0	0	2	103,849
1986	0	0	55	23	1,891	21,096	120,825	52,550	718	0	0	2	197,159
1987	0	0	41	16	1,270	16,258	16,494	25,033	712	0	0	1	59,824
1988	0	0	54	23	312	3,267	45,978	10,570	513	0	0	1	60,718
1989	0	0	33	12	323	21,933	71,804	16,835	686	0	0	2	111,627
1990	0	0	38	22	479	10,050	16,494	14,672	532	0	0	1	42,289
1991	0	0	11	5	361	23,517	23,861	15,699	270	0	0	1	63,725
1992	0	0	21	9	1,734	15,618	29,267	6,895	408	0	0	1	53,954
1993	0	0	36	25	1,795	22,888	98,048	31,564	1,088	0	0	2	155,447
1994	0	0	46	19	1,591	12,451	39,711	20,085	705	0	0	1	74,607
1995	0	0	52	24	1,833	23,295	149,615	64,269	1,155	0	0	2	240,245
1996	0	0	55	22	1,427	16,788	117,836	43,219	837	0	0	2	180,186
1997	0	0	58	23	1,694	17,718	78,795	23,551	710	0	0	2	122,549
1998	0	0	55	22	1,689	18,107	132,936	61,213	1,155	0	0	2	215,178
1999	0	0	56	22	1,506	19,107	106,058	27,295	761	0	0	2	154,807
2000	0	0	43	23	1,679	21,888	100,572	33,111	828	0	0	2	158,146
2001	0	0	55	23	1,741	21,100	43,556	13,861	327	0	0	1	80,664
2002	0	0	55	23	163	9,581	62,503	24,603	716	0	0	1	97,646
2003	0	0	54	23	191	18,386	90,566	39,149	816	0	0	2	149,187
Average	0	0	47	20	1,268	17,353	79,641	31,806	764	0	0	2	130,901

Source: ICF 2010:Appendix B

Table F-50. Entrainment Loss of Spring-Run Chinook Salmon during Diversions onto the Reservoir Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	0.0	0.0	0.1	0.0	3.3	46.9	337.5	141.1	2.7	0.0	0.0	0.0		
1980	0	0	0	0	0	2	0	0	0	0	0	0	2	0.0%
1981	0	0	0	0	0	62	0	0	0	0	0	0	62	0.1%
1982	0	0	1	0	0	2	0	0	0	0	0	0	2	0.0%
1983	0	0	1	0	0	2	0	0	0	0	0	0	2	0.0%
1984	0	0	1	0	0	2	0	0	0	0	0	0	2	0.0%
1985	0	0	1	0	0	0	0	0	0	0	0	0	1	0.0%
1986	0	0	0	0	19	6	0	0	0	0	0	0	25	0.0%
1987	0	0	0	0	0	211	0	0	0	0	0	0	211	0.4%
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1989	0	0	0	0	0	245	0	0	0	0	0	0	245	0.2%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	28	0	0	0	0	0	0	28	0.0%
1992	0	0	0	0	16	0	0	0	0	0	0	0	16	0.0%
1993	0	0	0	0	0	2	0	0	0	0	0	0	2	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	0	0	2	0	0	0	0	0	0	2	0.0%
1996	0	0	0	0	0	2	0	0	0	0	0	0	2	0.0%
1997	0	0	1	0	0	2	0	0	0	0	0	0	2	0.0%
1998	0	0	0	0	0	2	0	0	0	0	0	0	2	0.0%
1999	0	0	1	0	0	2	0	0	0	0	0	0	2	0.0%
2000	0	0	0	0	5	2	0	0	0	0	0	0	6	0.0%
2001	0	0	0	0	4	0	0	0	0	0	0	0	4	0.0%
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2003	0	0	1	0	0	0	0	0	0	0	0	0	1	0.0%
Average	0	0	0	0	2	24	0	0	0	0	0	0	26	0.0%

Source: ICF 2010:Appendix B

Table F-51. Entrainment Loss of Spring-Run Chinook Salmon during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	**0.0**	**0.0**	**0.1**	**0.0**	**3.3**	**46.9**	**337.5**	**141.1**	**2.7**	**0.0**	**0.0**	**0.0**	**Estimated loss**	**% of baseline**
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1981	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1986	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1987	0	0	0	0	0	0	0	0	0	0	0	1	1	0.0%
1988	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1992	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2002	0	0	0	0	0	0	0	0	0	0	0	1	1	0.0%
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
Average	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%

Source: ICF 2010:Appendix B

Table F-52. Entrainment Loss of Spring-Run Chinook Salmon during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	0.0	**0.0**	**0.1**	**0.0**	**3.3**	**46.9**	**337.5**	**141.1**	**2.7**	**0.0**	**0.0**	**0.0**	
Agricultural diversions	0	0	0	0	1	0	0	38	4	0	0	0	43
Habitat Island diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Benefit	0	0	0	0	1	0	0	38	4	0	0	0	43

Source: ICF 2010:Appendix B

Table F-53. Summary of Spring-Run Chinook Salmon Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/CVP	Loss	% of SWP/CVP
1980	162,859	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1981	117,885	852	62	0.1%	0	0.0%	43	0	42	0.0%	20	0.0%
1982	213,509	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1983	213,579	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1984	111,996	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1985	103,849	852	1	0.0%	0	0.0%	43	0	42	0.0%	-42	0.0%
1986	197,159	852	25	0.0%	0	0.0%	43	0	42	0.0%	-17	0.0%
1987	59,824	852	211	0.4%	1	0.0%	43	0	42	0.1%	170	0.3%
1988	60,718	852	0	0.0%	0	0.0%	43	0	42	0.1%	-42	-0.1%
1989	111,627	852	245	0.2%	0	0.0%	43	0	42	0.0%	204	0.2%
1990	42,289	852	0	0.0%	0	0.0%	43	0	42	0.1%	-42	-0.1%
1991	63,725	852	28	0.0%	0	0.0%	43	0	42	0.1%	-14	0.0%
1992	53,954	852	16	0.0%	0	0.0%	43	0	42	0.1%	-27	0.0%
1993	155,447	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1994	74,607	852	0	0.0%	0	0.0%	43	0	42	0.1%	-42	-0.1%
1995	240,245	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1996	180,186	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1997	122,549	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1998	215,178	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
1999	154,807	852	2	0.0%	0	0.0%	43	0	42	0.0%	-40	0.0%
2000	158,146	852	6	0.0%	0	0.0%	43	0	42	0.0%	-36	0.0%
2001	80,664	852	4	0.0%	0	0.0%	43	0	42	0.1%	-39	0.0%
2002	97,646	852	0	0.0%	1	0.0%	43	0	42	0.0%	-41	0.0%
2003	149,187	852	1	0.0%	0	0.0%	43	0	42	0.0%	-42	0.0%
Average	130,901	852	26	0.0%	0	0.0%	43	0	42	0.0%	-16	0.0%

Notes:

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Steelhead

The baseline entrainment loss of steelhead by SWP and CVP averaged over 23,000 fish from 1980 to 2003 (Table F-54). The lowest entrainment loss of nearly 10,000 fish occurred in 1988 and the maximum entrainment was almost 34,000 fish in 1995. Direct entrainment loss of steelhead estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to 105 fish in 1986, and averaged 26 fish (Table F-55); this represented an average increased entrainment over baseline conditions of 0–0.6%. Loss of steelhead due to export of discharged project water averaged 6 fish per year, with values ranging from 0 (several years) to 56 fish in 1994. This was 0–0.3% of baseline SWP/CVP entrainment losses (Table F-56).

Based on the assumed monthly density of steelhead and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 10 less steelhead would be entrained annually (Table F-57). As a whole, the project was estimated to result in a net loss to steelhead because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 28 fish per year, or 0.1% of the baseline entrainment by SWP and CVP (Table F-58).

Table F-54. Baseline Entrainment Loss of Steelhead by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												
Water year	0.1	0.8	1.5	5.6	18.1	19.8	15.4	6.7	0.7	0.1	0.0	0.0	Estimated loss
1980	34	383	772	3,187	8,124	7,245	4,971	1,644	227	31	0	1	26,620
1981	39	289	705	2,934	8,720	8,524	3,108	1,298	210	36	0	1	25,863
1982	40	383	772	3,006	8,963	8,731	5,831	2,974	315	37	0	1	31,053
1983	45	384	792	2,819	7,638	6,146	6,066	3,035	315	37	0	1	27,279
1984	45	384	726	2,126	7,270	7,966	3,079	1,125	203	34	0	1	22,959
1985	45	383	770	2,795	6,686	5,043	2,819	1,344	199	37	0	1	20,122
1986	35	316	771	2,893	10,235	8,904	5,519	2,509	196	26	0	1	31,405
1987	42	325	573	2,001	6,873	6,862	753	1,195	194	35	0	0	18,853
1988	25	200	765	2,868	1,690	1,379	2,100	505	140	29	0	0	9,699
1989	17	180	459	1,533	1,750	9,258	3,280	804	187	36	0	0	17,504
1990	32	259	530	2,843	2,595	4,242	753	701	145	25	0	0	12,124
1991	18	164	152	678	1,953	9,926	1,090	750	74	22	0	0	14,826
1992	21	101	298	1,134	9,384	6,592	1,337	329	111	13	0	0	19,320
1993	16	137	502	3,121	9,720	9,661	4,478	1,507	296	37	0	1	29,477
1994	44	277	643	2,364	8,610	5,255	1,814	959	192	37	0	0	20,198
1995	29	155	740	3,040	9,921	9,832	6,834	3,069	315	37	0	1	33,973
1996	45	384	772	2,758	7,725	7,086	5,382	2,064	228	26	0	1	26,471
1997	32	384	812	2,856	9,168	7,479	3,599	1,125	193	21	0	1	25,669
1998	33	347	771	2,804	9,141	7,643	6,072	2,923	315	37	0	1	30,087
1999	45	384	783	2,808	8,154	8,065	4,844	1,303	207	31	0	1	26,627
2000	42	383	604	2,872	9,091	9,239	4,594	1,581	225	25	0	1	28,658
2001	40	371	772	2,932	9,422	8,906	1,989	662	89	29	0	0	25,213
2002	23	271	770	2,935	884	4,044	2,855	1,175	195	36	0	0	13,189
2003	23	383	767	2,866	1,036	7,761	4,137	1,869	222	27	0	1	19,092
Average	34	301	667	2,591	6,865	7,325	3,638	1,519	208	31	0	1	23,178

Source: ICF 2010:Appendix B

Table F-55. Entrainment Loss of Steelhead during Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	0.1	0.8	1.5	5.6	18.1	19.8	15.4	6.7	0.7	0.1	0.0	0.0	Estimated loss	% of baseline
1980	0	0	0	30	0	1	0	0	0	0	0	0	30	0.1%
1981	0	0	0	22	0	26	0	0	0	0	0	0	48	0.2%
1982	0	0	8	0	0	1	0	0	0	0	0	0	9	0.0%
1983	0	0	8	0	0	1	0	0	0	0	0	0	9	0.0%
1984	0	0	8	0	0	1	0	0	0	0	0	0	9	0.0%
1985	0	0	7	0	0	0	0	0	0	0	0	0	7	0.0%
1986	0	0	0	0	103	3	0	0	0	0	0	0	105	0.3%
1987	0	0	0	0	0	89	0	0	0	0	0	0	89	0.5%
1988	0	0	0	25	0	0	0	0	0	0	0	0	25	0.3%
1989	0	0	0	0	0	104	0	0	0	0	0	0	104	0.6%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	12	0	0	0	0	0	0	12	0.1%
1992	0	0	0	0	84	0	0	0	0	0	0	0	84	0.4%
1993	0	0	0	30	0	1	0	0	0	0	0	0	30	0.1%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	30	0	1	0	0	0	0	0	0	30	0.1%
1996	0	0	0	30	0	1	0	0	0	0	0	0	30	0.1%
1997	0	0	8	0	0	1	0	0	0	0	0	0	9	0.0%
1998	0	0	0	30	0	1	0	0	0	0	0	0	30	0.1%
1999	0	0	8	0	0	1	0	0	0	0	0	0	9	0.0%
2000	0	0	0	22	25	1	0	0	0	0	0	0	48	0.2%
2001	0	0	0	0	19	0	0	0	0	0	0	0	19	0.1%
2002	0	0	5	12	0	0	0	0	0	0	0	0	17	0.1%
2003	0	0	8	0	0	0	0	0	0	0	0	0	8	0.0%
Average	0	0	3	10	10	10	0	0	0	0	0	0	32	0.1%

Source: ICF 2010:Appendix B

Table F-56. Entrainment Loss of Steelhead during Export of Water Discharged from the Project Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	0.1	0.8	1.5	5.6	18.1	19.8	15.4	6.7	0.7	0.1	0.0	0.0		
1980	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1981	5	0	0	0	0	0	0	0	0	1	0	0	6	0.0%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	1	0	0	2	0.0%
1985	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1986	7	0	0	0	0	0	0	0	0	7	0	0	14	0.0%
1987	1	0	0	0	0	0	0	0	0	0	0	0	1	0.0%
1988	0	0	0	0	0	0	0	0	0	3	0	0	3	0.0%
1989	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1990	1	0	0	0	0	0	0	0	0	0	0	0	1	0.0%
1991	0	0	0	0	0	0	0	0	0	1	0	0	1	0.0%
1992	0	0	0	0	0	0	0	0	0	10	0	0	10	0.1%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	1	55	0	0	0	0	0	0	0	0	0	0	56	0.3%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	7	0	0	7	0.0%
1997	2	0	0	0	0	0	0	0	0	9	0	0	11	0.0%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	6	0	0	6	0.0%
2000	4	0	0	0	0	0	0	0	0	3	0	0	7	0.0%
2001	6	12	0	0	0	0	0	0	0	2	0	0	20	0.1%
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
2003	0	0	0	0	0	0	0	0	0	2	0	0	2	0.0%
Average	1	3	0	0	0	0	0	0	0	2	0	0	6	0.0%

Source: ICF 2010:Appendix B

Table F-57. Entrainment Loss of Steelhead during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	0.1	0.8	1.5	5.6	18.1	19.8	15.4	6.7	0.7	0.1	0.0	0.0	
Agricultural diversions	0	0	0	2	5	0	0	2	1	0	0	0	10
Habitat Island diversions	0	0	0	0	0	0	0	0	0	0	0	0	0
Project Benefit	0	0	0	2	5	0	0	2	1	0	0	0	10

Source: ICF 2010:Appendix B

Table F-58. Summary of Steelhead Entrainment Loss Effects of the Project Compared to the Baseline Conditions

Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
			Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/CVP	Loss	% of SWP/CVP
1980	26,620	202	30	0.1%	0	0.0%	10	0	10	0.0%	21	0.1%
1981	25,863	202	48	0.2%	6	0.0%	10	0	10	0.0%	45	0.2%
1982	31,053	202	9	0.0%	0	0.0%	10	0	10	0.0%	-1	0.0%
1983	27,279	202	9	0.0%	0	0.0%	10	0	10	0.0%	-1	0.0%
1984	22,959	202	9	0.0%	2	0.0%	10	0	10	0.0%	1	0.0%
1985	20,122	202	7	0.0%	0	0.0%	10	0	10	0.0%	-3	0.0%
1986	31,405	202	105	0.3%	14	0.0%	10	0	10	0.0%	110	0.3%
1987	18,853	202	89	0.5%	1	0.0%	10	0	10	0.1%	80	0.4%
1988	9,699	202	25	0.3%	3	0.0%	10	0	10	0.1%	18	0.2%
1989	17,504	202	104	0.6%	0	0.0%	10	0	10	0.1%	94	0.5%
1990	12,124	202	0	0.0%	1	0.0%	10	0	10	0.1%	-8	-0.1%
1991	14,826	202	12	0.1%	1	0.0%	10	0	10	0.1%	3	0.0%
1992	19,320	202	84	0.4%	10	0.1%	10	0	10	0.1%	85	0.4%
1993	29,477	202	30	0.1%	0	0.0%	10	0	10	0.0%	21	0.1%
1994	20,198	202	0	0.0%	56	0.3%	10	0	10	0.0%	46	0.2%
1995	33,973	202	30	0.1%	0	0.0%	10	0	10	0.0%	21	0.1%
1996	26,471	202	30	0.1%	7	0.0%	10	0	10	0.0%	27	0.1%
1997	25,669	202	9	0.0%	11	0.0%	10	0	10	0.0%	10	0.0%
1998	30,087	202	30	0.1%	0	0.0%	10	0	10	0.0%	21	0.1%
1999	26,627	202	9	0.0%	6	0.0%	10	0	10	0.0%	5	0.0%
2000	28,658	202	48	0.2%	7	0.0%	10	0	10	0.0%	45	0.2%
2001	25,213	202	19	0.1%	20	0.1%	10	0	10	0.0%	29	0.1%
2002	13,189	202	17	0.1%	0	0.0%	10	0	10	0.1%	7	0.1%
2003	19,092	202	8	0.0%	2	0.0%	10	0	10	0.1%	0	0.0%
Average	23,178	202	32	0.1%	6	0.0%	10	0	10	0.0%	28	0.1%

Notes:

1 Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

2 Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

3 Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

4 Increased loss of fish assuming SWP export of discharged project water from July to November.

5 Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

6 Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

7 Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Striped Bass

The baseline entrainment loss of striped bass by SWP and CVP averaged over 20 million fish from 1980 to 2003 (Table F-59). The lowest entrainment loss of just over 9.7 million fish occurred in 1992 and the maximum entrainment was almost 30 million fish in 1983. Direct entrainment loss of striped bass estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to almost 4,300 fish in several years, and averaged 2,354 fish (Table F-60); this represented an average increased entrainment over baseline conditions of 0.0%. Loss of striped bass due to export of discharged project water averaged almost 470,00 fish per year, with values ranging from 0 (several years) to over 1.9 million fish in 1992. This was 0–19.6% of baseline SWP/CVP entrainment losses (Table F-61).

Based on the assumed monthly density of striped bass and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net benefit of the project: almost 77,000 less striped bass would be entrained annually (Table F-61). As a whole, the project was estimated to result in a net loss to striped bass because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged over 390,000 fish per year, or 2.5% of the baseline entrainment by SWP and CVP (Table F-63).

Table F-59. Baseline Entrainment Loss of Striped Bass by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss
	Assumed density (Fish/thousand acre-feet)												
	427.1	934.1	818.0	434.6	389.2	138.5	66.0	9530.4	37123.7	14169.3	1628.0	315.2	
1980	154,874	453,440	411,105	245,669	174,842	50,711	21,294	2,325,756	11,510,154	5,895,029	608,800	154,042	22,005,718
1981	178,119	341,535	375,233	226,146	187,668	59,666	13,314	1,835,685	10,639,974	6,864,173	547,272	123,458	21,392,243
1982	185,938	453,538	410,853	231,693	192,903	61,109	24,974	4,206,600	15,964,153	7,100,296	813,733	156,432	29,802,223
1983	209,988	454,145	421,699	217,311	164,382	43,021	25,982	4,293,513	15,964,153	7,100,296	813,733	156,432	29,864,654
1984	209,988	454,145	386,419	163,874	156,449	55,759	13,187	1,591,162	10,319,973	6,485,617	808,973	142,934	20,788,481
1985	208,707	453,262	409,863	215,421	143,890	35,300	12,074	1,900,796	10,098,808	7,065,401	809,286	138,030	21,490,837
1986	163,894	373,342	410,628	222,956	220,263	62,326	23,638	3,549,315	9,925,490	5,038,194	713,400	156,013	20,859,457
1987	192,163	383,845	304,998	154,208	147,912	48,032	3,227	1,690,804	9,843,033	6,650,375	213,487	65,490	19,697,574
1988	114,766	236,776	407,174	221,023	36,362	9,652	8,995	713,937	7,086,245	5,474,543	108,486	61,196	14,479,155
1989	80,431	212,352	244,600	118,142	37,660	64,798	14,048	1,137,058	9,483,009	6,845,179	758,771	108,181	19,104,230
1990	147,829	305,797	282,006	219,114	55,852	29,692	3,227	990,975	7,355,684	4,719,312	279,071	72,988	14,461,547
1991	82,334	193,808	80,907	52,226	42,027	69,479	4,668	1,060,352	3,732,563	4,227,775	257,669	72,487	9,876,294
1992	96,266	119,356	158,602	87,366	201,954	46,143	5,726	465,717	5,639,588	2,401,137	445,547	74,937	9,742,339
1993	76,154	161,562	267,472	240,547	209,176	67,620	19,182	2,131,912	15,040,148	7,064,330	781,159	155,968	26,215,230
1994	205,111	328,190	342,303	182,235	185,307	36,785	7,769	1,356,575	9,736,887	7,085,654	748,248	84,690	20,299,755
1995	131,992	183,464	393,857	234,341	213,513	68,822	29,271	4,340,839	15,964,153	7,100,296	813,733	156,432	29,630,712
1996	209,988	454,145	411,129	212,564	166,246	49,598	23,054	2,919,087	11,573,434	4,954,473	733,072	156,182	21,862,972
1997	148,109	453,692	432,450	220,155	197,309	52,346	15,415	1,590,681	9,809,948	3,968,120	809,684	127,294	17,825,202
1998	150,672	410,441	410,437	216,133	196,734	53,496	26,008	4,134,436	15,964,153	7,100,296	813,733	156,432	29,632,969
1999	209,988	454,145	417,115	216,390	175,493	56,449	20,749	1,843,567	10,515,000	5,955,619	774,680	156,041	20,795,237
2000	194,417	453,435	321,821	221,370	195,641	64,666	19,676	2,236,363	11,442,495	4,817,224	810,535	149,160	20,926,803
2001	183,756	438,685	411,314	225,953	202,774	62,338	8,521	936,214	4,515,663	5,549,540	256,280	75,573	12,866,610
2002	107,908	320,657	409,824	226,210	19,017	28,307	12,228	1,661,753	9,895,137	6,958,620	721,423	93,609	20,454,691
2003	106,245	452,890	408,325	220,911	22,297	54,320	17,718	2,644,177	11,275,728	5,116,736	797,829	146,859	21,264,033
Avg.	156,235	356,110	355,422	199,665	147,736	51,268	15,581	2,148,220	10,553,982	5,897,426	634,942	122,536	20,639,124

Source: ICF 2010:Appendix B

Table F-60. Entrainment Loss of Striped Bass during Diversions onto the Reservoir Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	427.1	934.1	818.0	434.6	389.2	138.5	66.0	9530.4	37123.7	14169.3	1628.0	315.2		
1980	0	0	0	2,275	6	5	0	0	0	0	0	0	2,286	0.0%
1981	0	0	0	1,710	0	182	0	0	0	0	0	0	1,892	0.0%
1982	0	0	4,282	6	7	5	0	0	0	0	0	0	4,299	0.0%
1983	0	0	4,282	6	7	5	0	0	0	0	0	0	4,299	0.0%
1984	0	0	4,282	6	6	5	0	0	0	0	0	0	4,298	0.0%
1985	0	0	3,846	0	0	0	0	0	0	0	0	0	3,846	0.0%
1986	0	0	0	0	2,214	18	0	0	0	0	0	0	2,232	0.0%
1987	0	0	0	0	0	625	0	0	0	0	0	0	625	0.0%
1988	0	0	0	1,952	0	0	0	0	0	0	0	0	1,952	0.0%
1989	0	0	0	0	0	725	0	0	0	0	0	0	725	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	83	0	0	0	0	0	0	83	0.0%
1992	0	0	0	0	1,818	0	0	0	0	0	0	0	1,818	0.0%
1993	0	0	0	2,275	7	5	0	0	0	0	0	0	2,286	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	2,275	7	5	0	0	0	0	0	0	2,286	0.0%
1996	0	0	0	2,275	6	5	0	0	0	0	0	0	2,286	0.0%
1997	0	0	4,282	6	7	5	0	0	0	0	0	0	4,299	0.0%
1998	0	0	0	2,275	7	5	0	0	0	0	0	0	2,286	0.0%
1999	0	0	4,282	6	7	5	0	0	0	0	0	0	4,299	0.0%
2000	0	0	0	1,710	547	5	0	0	0	0	0	0	2,261	0.0%
2001	0	0	0	0	409	0	0	0	0	0	0	0	409	0.0%
2002	0	0	2,508	946	0	0	0	0	0	0	0	0	3,454	0.0%
2003	0	0	4,282	6	0	0	0	0	0	0	0	0	4,287	0.0%
Average	0	0	1,335	739	211	70	0	0	0	0	0	0	2,354	0.0%

Source: ICF 2010:Appendix B

Table F-61. Entrainment Loss of Striped Bass during Export of Water Discharged from the Project Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	427.1	934.1	818.0	434.6	389.2	138.5	66.0	9530.4	37123.7	14169.3	1628.0	315.2		
1980	0	0	0	0	0	0	0	0	0	0	168,169	2,482	170,651	0.8%
1981	25,263	0	0	0	0	0	0	0	0	127,984	188,619	13,943	355,808	1.7%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	277,308	0	14,638	291,947	1.4%
1985	0	0	0	0	0	0	0	0	0	0	0	11,514	11,514	0.1%
1986	31,485	0	0	0	0	0	0	0	0	1,402,297	108,262	0	1,542,044	7.4%
1987	2,709	0	0	0	0	0	0	0	0	0	0	36,350	39,059	0.2%
1988	0	0	0	0	0	0	0	0	0	510,986	213,161	0	724,148	5.0%
1989	0	0	0	0	0	0	0	0	0	0	34,207	27,102	61,309	0.3%
1990	6,889	0	0	0	0	0	0	0	0	0	0	0	6,889	0.0%
1991	0	0	0	0	0	0	0	0	0	240,690	0	0	240,690	2.4%
1992	0	0	0	0	0	0	0	0	0	1,902,666	9,477	0	1,912,143	19.6%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	4,112	65,360	0	0	0	0	0	0	0	0	0	0	69,471	0.3%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	1,318,042	87,996	0	1,406,038	6.4%
1997	10,146	0	0	0	0	0	0	0	0	1,629,534	0	17,902	1,657,582	9.3%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	1,156,050	0	0	1,156,050	5.6%
2000	16,360	0	0	0	0	0	0	0	0	570,125	0	0	586,485	2.8%
2001	28,543	13,702	0	0	0	0	0	0	0	404,990	0	0	447,236	3.5%
2002	0	0	0	0	0	0	0	0	0	0	80,999	35,225	116,225	0.6%
2003	0	0	0	0	0	0	0	0	0	389,629	0	0	389,629	1.8%
Average	5,229	3,294	0	0	0	0	0	0	0	413,763	37,120	6,632	466,038	2.3%

Source: ICF 2010:Appendix B

Table F-62. Entrainment Loss of Striped Bass during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	427.1	934.1	818.0	434.6	389.2	138.5	66.0	9530.4	37123.7	14169.3	1628.0	315.2	
Agricultural diversions	73	0	232	123	110	0	0	2,565	49,962	22,683	1,914	174	77,837
Habitat Island diversions	4	8	8	0	2	0	0	19	557	255	21	4	879
Project Benefit	69	-8	224	123	108	0	0	2,546	49,406	22,428	1,893	170	76,958

Source: ICF 2010:Appendix B

Table F-63. Summary of Striped Bass Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/ CVP	Loss	% of SWP/CVP
1980	22,005,718	1,556,731	2,286	0.0%	170,651	0.8%	77,837	879	76,958	0.3%	95,979	0.4%
1981	21,392,243	1,556,731	1,892	0.0%	355,808	1.7%	77,837	879	76,958	0.4%	280,743	1.3%
1982	29,802,223	1,556,731	4,299	0.0%	0	0.0%	77,837	879	76,958	0.3%	-72,659	-0.2%
1983	29,864,654	1,556,731	4,299	0.0%	0	0.0%	77,837	879	76,958	0.3%	-72,659	-0.2%
1984	20,788,481	1,556,731	4,298	0.0%	291,947	1.4%	77,837	879	76,958	0.4%	219,287	1.1%
1985	21,490,837	1,556,731	3,846	0.0%	11,514	0.1%	77,837	879	76,958	0.4%	-61,598	-0.3%
1986	20,859,457	1,556,731	2,232	0.0%	1,542,044	7.4%	77,837	879	76,958	0.4%	1,467,318	7.0%
1987	19,697,574	1,556,731	625	0.0%	39,059	0.2%	77,837	879	76,958	0.4%	-37,274	-0.2%
1988	14,479,155	1,556,731	1,952	0.0%	724,148	5.0%	77,837	879	76,958	0.5%	649,141	4.5%
1989	19,104,230	1,556,731	725	0.0%	61,309	0.3%	77,837	879	76,958	0.4%	-14,924	-0.1%
1990	14,461,547	1,556,731	0	0.0%	6,889	0.0%	77,837	879	76,958	0.5%	-70,069	-0.5%
1991	9,876,294	1,556,731	83	0.0%	240,690	2.4%	77,837	879	76,958	0.8%	163,816	1.7%
1992	9,742,339	1,556,731	1,818	0.0%	1,912,143	19.6%	77,837	879	76,958	0.8%	1,837,003	18.9%
1993	26,215,230	1,556,731	2,286	0.0%	0	0.0%	77,837	879	76,958	0.3%	-74,672	-0.3%
1994	20,299,755	1,556,731	0	0.0%	69,471	0.3%	77,837	879	76,958	0.4%	-7,486	0.0%
1995	29,630,712	1,556,731	2,286	0.0%	0	0.0%	77,837	879	76,958	0.3%	-74,672	-0.3%
1996	21,862,972	1,556,731	2,286	0.0%	1,406,038	6.4%	77,837	879	76,958	0.4%	1,331,366	6.1%
1997	17,825,202	1,556,731	4,299	0.0%	1,657,582	9.3%	77,837	879	76,958	0.4%	1,584,922	8.9%
1998	29,632,969	1,556,731	2,286	0.0%	0	0.0%	77,837	879	76,958	0.3%	-74,672	-0.3%
1999	20,795,237	1,556,731	4,299	0.0%	1,156,050	5.6%	77,837	879	76,958	0.4%	1,083,390	5.2%
2000	20,926,803	1,556,731	2,261	0.0%	586,485	2.8%	77,837	879	76,958	0.4%	511,789	2.4%
2001	12,866,610	1,556,731	409	0.0%	447,236	3.5%	77,837	879	76,958	0.6%	370,687	2.9%
2002	20,454,691	1,556,731	3,454	0.0%	116,225	0.6%	77,837	879	76,958	0.4%	42,721	0.2%
2003	21,264,033	1,556,731	4,287	0.0%	389,629	1.8%	77,837	879	76,958	0.4%	316,959	1.5%
Avg.	20,639,124	1,556,731	2,354	0.0%	466,038	2.9%	77,837	879	76,958	0.4%	391,435	2.5%

Notes:

1 Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

2 Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

3 Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

4 Increased loss of fish assuming SWP export of discharged project water from July to November.

5 Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

6 Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

7 Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

White Catfish

The baseline entrainment loss of white catfish by SWP and CVP averaged over 1.5 million fish from 1980 to 2003 (Table F-64). The lowest entrainment loss of just over 850,000 fish occurred in 1991 and the maximum entrainment was over 2 million fish in 1995. Direct entrainment loss of white catfish estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to over 1,000 fish in 1989, and averaged 585 fish (Table F-65); this represented an average increased entrainment over baseline conditions of 0–0.1%. Loss of white catfish due to export of discharged project water averaged nearly 55,000 fish per year, with values ranging from 0 (several years) to over 160,000 fish in 1986. This was 0–17.2% of baseline SWP/CVP entrainment losses (Table F-66).

Based on the assumed monthly density of white catfish and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: over 3,800 less white catfish would be entrained annually (Table F-67). As a whole, the project was estimated to result in a net loss to white catfish because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged over 50,000 fish per year, or 3.7% of the baseline entrainment by SWP and CVP (Table F-68).

Table F-64. Baseline Entrainment Loss of White Catfish by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss
	Assumed density (Fish/thousand acre-feet)												
	209.1	214.9	135.9	99.5	164.7	206.7	271.5	378.8	786.0	1065.2	614.2	289.0	
1980	75,812	104,334	68,324	56,240	73,979	75,664	87,552	92,446	243,711	443,186	229,688	141,226	1,692,164
1981	87,191	78,585	62,362	51,771	79,406	89,026	54,742	72,966	225,286	516,046	206,475	113,186	1,637,043
1982	91,019	104,356	68,282	53,041	81,622	91,179	102,681	167,208	338,018	533,797	307,005	143,417	2,081,625
1983	102,791	104,496	70,085	49,748	69,554	64,190	106,824	170,662	338,018	533,797	307,005	143,417	2,060,587
1984	102,791	104,496	64,221	37,515	66,197	83,197	54,219	63,247	218,511	487,586	305,209	131,042	1,718,231
1985	102,164	104,292	68,118	49,316	60,883	52,671	49,641	75,555	213,828	531,174	305,327	126,546	1,739,514
1986	80,227	85,904	68,245	51,040	93,198	92,994	97,189	141,081	210,158	378,769	269,151	143,033	1,710,991
1987	94,065	88,320	50,690	35,302	62,585	71,667	13,267	67,208	208,412	499,973	80,544	60,042	1,332,075
1988	56,179	54,481	67,671	50,598	15,386	14,401	36,984	28,378	150,041	411,574	40,930	56,104	982,727
1989	39,372	48,861	40,652	27,046	15,935	96,684	57,757	45,197	200,789	514,618	286,269	99,180	1,472,359
1990	72,363	70,362	46,868	50,161	23,632	44,303	13,267	39,390	155,746	354,796	105,288	66,915	1,043,093
1991	40,303	44,594	13,446	11,956	17,782	103,667	19,193	42,148	79,032	317,842	97,213	66,456	853,634
1992	47,123	27,463	26,359	20,000	85,451	68,849	23,542	18,512	119,410	180,517	168,096	68,702	854,024
1993	37,278	37,174	44,453	55,067	88,507	100,894	78,868	84,741	318,454	531,094	294,715	142,992	1,814,237
1994	100,404	75,514	56,890	41,718	78,407	54,886	31,943	53,922	206,165	532,697	282,299	77,644	1,592,489
1995	64,611	42,214	65,458	53,647	90,342	102,687	120,348	172,543	338,018	533,797	307,005	143,417	2,034,088
1996	102,791	104,496	68,328	48,661	70,342	74,004	94,785	116,030	245,051	372,475	276,573	143,188	1,716,726
1997	72,501	104,391	71,872	50,399	83,486	78,103	63,381	63,228	207,712	298,322	305,477	116,703	1,515,575
1998	73,755	94,440	68,213	49,478	83,242	79,820	106,931	164,339	338,018	533,797	307,005	143,417	2,042,456
1999	102,791	104,496	69,323	49,537	74,255	84,226	85,311	73,280	222,640	447,741	292,271	143,059	1,748,929
2000	95,169	104,332	53,486	50,677	82,780	96,487	80,899	88,893	242,279	362,157	305,798	136,750	1,699,706
2001	89,950	100,938	68,359	51,726	85,798	93,013	35,036	37,213	95,613	417,212	96,689	69,285	1,240,834
2002	52,822	73,781	68,111	51,785	8,046	42,237	50,276	66,053	209,516	523,146	272,178	85,820	1,503,772
2003	52,008	104,207	67,862	50,572	9,434	81,049	72,850	105,103	238,748	384,674	301,004	134,640	1,602,152
Average	76,478	81,939	59,070	45,709	62,510	76,496	64,062	85,389	223,466	443,366	239,551	112,341	1,570,376

Source: ICF 2010:Appendix B

Table F-65. Entrainment Loss of White Catfish during Diversions onto the Reservoir Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	209.1	214.9	135.9	99.5	164.7	206.7	271.5	378.8	786.0	1065.2	614.2	289.0		
1980	0	0	0	521	3	7	0	0	0	0	0	0	530	0.0%
1981	0	0	0	392	0	272	0	0	0	0	0	0	663	0.0%
1982	0	0	712	1	3	7	0	0	0	0	0	0	723	0.0%
1983	0	0	712	1	3	7	0	0	0	0	0	0	723	0.0%
1984	0	0	712	1	3	7	0	0	0	0	0	0	722	0.0%
1985	0	0	639	0	0	0	0	0	0	0	0	0	639	0.0%
1986	0	0	0	0	937	27	0	0	0	0	0	0	963	0.1%
1987	0	0	0	0	0	932	0	0	0	0	0	0	932	0.1%
1988	0	0	0	447	0	0	0	0	0	0	0	0	447	0.0%
1989	0	0	0	0	0	1,082	0	0	0	0	0	0	1,082	0.1%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	125	0	0	0	0	0	0	125	0.0%
1992	0	0	0	0	769	0	0	0	0	0	0	0	769	0.1%
1993	0	0	0	521	3	7	0	0	0	0	0	0	530	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	521	3	7	0	0	0	0	0	0	530	0.0%
1996	0	0	0	521	3	7	0	0	0	0	0	0	530	0.0%
1997	0	0	712	1	3	7	0	0	0	0	0	0	723	0.0%
1998	0	0	0	521	3	7	0	0	0	0	0	0	530	0.0%
1999	0	0	712	1	3	7	0	0	0	0	0	0	723	0.0%
2000	0	0	0	392	231	7	0	0	0	0	0	0	630	0.0%
2001	0	0	0	0	173	0	0	0	0	0	0	0	173	0.0%
2002	0	0	417	217	0	0	0	0	0	0	0	0	633	0.0%
2003	0	0	712	1	0	0	0	0	0	0	0	0	713	0.0%
Average	0	0	222	169	89	105	0	0	0	0	0	0	585	0.0%

Source: ICF 2010:Appendix B

Table F-66. Entrainment Loss of White Catfish during Export of Water Discharged from the Project Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/taf)													
	209.1	214.9	135.9	99.5	164.7	206.7	271.5	378.8	786.0	1065.2	614.2	289.0		
1980	0	0	0	0	0	0	0	0	0	0	63,447	2,276	65,722	3.9%
1981	12,366	0	0	0	0	0	0	0	0	9,622	71,162	12,783	105,933	6.5%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	20,848	0	13,421	34,268	2.0%
1985	0	0	0	0	0	0	0	0	0	0	0	10,556	10,556	0.6%
1986	15,412	0	0	0	0	0	0	0	0	105,424	40,845	0	161,682	9.4%
1987	1,326	0	0	0	0	0	0	0	0	0	0	33,326	34,652	2.6%
1988	0	0	0	0	0	0	0	0	0	38,416	80,421	0	118,837	12.1%
1989	0	0	0	0	0	0	0	0	0	0	12,906	24,847	37,753	2.6%
1990	3,372	0	0	0	0	0	0	0	0	0	0	0	3,372	0.3%
1991	0	0	0	0	0	0	0	0	0	18,095	0	0	18,095	2.1%
1992	0	0	0	0	0	0	0	0	0	143,042	3,575	0	146,617	17.2%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	2,013	15,039	0	0	0	0	0	0	0	0	0	0	17,052	1.1%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	99,090	33,199	0	132,289	7.7%
1997	4,966	0	0	0	0	0	0	0	0	122,508	0	16,413	143,887	9.5%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	86,911	0	0	86,911	5.0%
2000	8,008	0	0	0	0	0	0	0	0	42,862	0	0	50,870	3.0%
2001	13,972	3,153	0	0	0	0	0	0	0	30,447	0	0	47,572	3.8%
2002	0	0	0	0	0	0	0	0	0	0	30,559	32,295	62,854	4.2%
2003	0	0	0	0	0	0	0	0	0	29,292	0	0	29,292	1.8%
Average	2,560	758	0	0	0	0	0	0	0	31,107	14,005	6,080	54,509	3.5%

Source: ICF 2010:Appendix B

Table F-67. Entrainment Loss of White Catfish during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												
	209.1	**214.9**	**135.9**	**99.5**	**164.7**	**206.7**	**271.5**	**378.8**	**786.0**	**1065.2**	**614.2**	**289.0**	**Number of fish**
Agricultural diversions	36	0	39	28	47	0	0	102	1,058	1,705	722	160	3,896
Habitat Island diversions	2	2	1	0	1	0	0	1	12	19	8	4	50
Project Benefit	34	-2	37	28	46	0	0	101	1,046	1,686	714	156	3,846

Source: ICF 2010:Appendix B

Table F-68. Summary of White Catfish Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/CVP	Loss	% of SWP/CVP
1980	1,692,164	77,919	530	0.0%	65,722	3.9%	3,896	50	3,846	0.2%	62,406	3.7%
1981	1,637,043	77,919	663	0.0%	105,933	6.5%	3,896	50	3,846	0.2%	102,750	6.3%
1982	2,081,625	77,919	723	0.0%	0	0.0%	3,896	50	3,846	0.2%	-3,124	-0.2%
1983	2,060,587	77,919	723	0.0%	0	0.0%	3,896	50	3,846	0.2%	-3,124	-0.2%
1984	1,718,231	77,919	722	0.0%	34,268	2.0%	3,896	50	3,846	0.2%	31,145	1.8%
1985	1,739,514	77,919	639	0.0%	10,556	0.6%	3,896	50	3,846	0.2%	7,349	0.4%
1986	1,710,991	77,919	963	0.1%	161,682	9.4%	3,896	50	3,846	0.2%	158,799	9.3%
1987	1,332,075	77,919	932	0.1%	34,652	2.6%	3,896	50	3,846	0.3%	31,738	2.4%
1988	982,727	77,919	447	0.0%	118,837	12.1%	3,896	50	3,846	0.4%	115,438	11.7%
1989	1,472,359	77,919	1,082	0.1%	37,753	2.6%	3,896	50	3,846	0.3%	34,988	2.4%
1990	1,043,093	77,919	0	0.0%	3,372	0.3%	3,896	50	3,846	0.4%	-474	0.0%
1991	853,634	77,919	125	0.0%	18,095	2.1%	3,896	50	3,846	0.5%	14,373	1.7%
1992	854,024	77,919	769	0.1%	146,617	17.2%	3,896	50	3,846	0.5%	143,540	16.8%
1993	1,814,237	77,919	530	0.0%	0	0.0%	3,896	50	3,846	0.2%	-3,316	-0.2%
1994	1,592,489	77,919	0	0.0%	17,052	1.1%	3,896	50	3,846	0.2%	13,205	0.8%
1995	2,034,088	77,919	530	0.0%	0	0.0%	3,896	50	3,846	0.2%	-3,316	-0.2%
1996	1,716,726	77,919	530	0.0%	132,289	7.7%	3,896	50	3,846	0.2%	128,973	7.5%
1997	1,515,575	77,919	723	0.0%	143,887	9.5%	3,896	50	3,846	0.3%	140,763	9.3%
1998	2,042,456	77,919	530	0.0%	0	0.0%	3,896	50	3,846	0.2%	-3,316	-0.2%
1999	1,748,929	77,919	723	0.0%	86,911	5.0%	3,896	50	3,846	0.2%	83,788	4.8%
2000	1,699,706	77,919	630	0.0%	50,870	3.0%	3,896	50	3,846	0.2%	47,653	2.8%
2001	1,240,834	77,919	173	0.0%	47,572	3.8%	3,896	50	3,846	0.3%	43,899	3.5%
2002	1,503,772	77,919	633	0.0%	62,854	4.2%	3,896	50	3,846	0.3%	59,641	4.0%
2003	1,602,152	77,919	713	0.0%	29,292	1.8%	3,896	50	3,846	0.2%	26,159	1.6%
Avg.	1,570,376	77,919	585	0.0%	54,509	4.0%	3,896	50	3,846	0.3%	51,247	3.7%

Notes:

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

American Shad

The baseline entrainment loss of American shad by SWP and CVP averaged almost 3.8 million fish from 1980 to 2003 (Table F-69). The lowest entrainment loss of about 1.8 million fish occurred in 1992 and the maximum entrainment was over 4.7 million fish in 1983. Direct entrainment loss of American shad estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to over 5,100 fish in several years, and averaged over 2,700 fish (Table F-70); this represented an average increased entrainment over baseline conditions of 0–0.1%. Loss of American shad due to export of discharged project water averaged almost 130,000 fish per year, with values ranging from 0 (several years) to almost 385,000 fish in 1986. This was 0–17.4% of baseline SWP/CVP entrainment losses (Table F-71).

Based on the assumed monthly density of American shad and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 7,446 less American shad would be entrained annually (Table F-72). As a whole, the project was estimated to result in a net loss to American shad because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged almost 125,000 fish per year, or 3.7% of the baseline entrainment by SWP and CVP (Table F-73).

Table F-69. Baseline Entrainment Loss of American Shad by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss
	Assumed density (Fish/thousand acre-feet)												
	712.2	**1871.2**	**982.1**	**640.5**	**88.1**	**46.3**	**14.8**	**36.9**	**840.0**	**2330.8**	**1516.9**	**542.7**	
1980	258,237	908,327	493,598	362,085	39,582	16,950	4,763	9,013	260,434	969,691	567,260	265,168	4,155,109
1981	296,994	684,159	450,529	333,310	42,486	19,944	2,978	7,114	240,745	1,129,109	509,930	212,519	3,929,816
1982	310,032	908,524	493,297	341,486	43,671	20,426	5,587	16,302	361,212	1,167,949	758,209	269,281	4,695,975
1983	350,132	909,740	506,318	320,289	37,214	14,380	5,812	16,639	361,212	1,167,949	758,209	269,281	4,717,175
1984	350,132	909,740	463,959	241,529	35,418	18,638	2,950	6,166	233,504	1,066,839	753,773	246,046	4,328,694
1985	347,996	907,969	492,108	317,503	32,575	11,799	2,701	7,366	228,500	1,162,209	754,065	237,604	4,502,395
1986	273,275	747,876	493,026	328,608	49,865	20,833	5,288	13,755	224,579	828,748	664,722	268,560	3,919,133
1987	320,410	768,914	366,200	227,283	33,485	16,055	722	6,553	222,713	1,093,940	198,920	112,735	3,367,930
1988	191,360	474,308	488,879	325,760	8,232	3,226	2,012	2,767	160,337	900,524	101,084	105,342	2,763,830
1989	134,111	425,382	293,682	174,127	8,526	21,659	3,142	4,407	214,567	1,125,984	706,997	186,222	3,298,806
1990	246,488	612,569	338,594	322,946	12,644	9,925	722	3,840	166,433	776,294	260,029	125,641	2,876,125
1991	137,282	388,235	97,142	76,974	9,514	23,224	1,044	4,109	84,455	695,440	240,087	124,779	1,882,284
1992	160,514	239,093	190,427	128,766	45,720	15,424	1,281	1,805	127,604	394,970	415,145	128,996	1,849,745
1993	126,978	323,640	321,144	354,535	47,355	22,602	4,291	8,262	340,305	1,162,033	727,858	268,483	3,707,486
1994	342,001	657,428	410,991	268,591	41,951	12,296	1,738	5,257	220,311	1,165,541	697,192	145,785	3,969,081
1995	220,082	367,514	472,890	345,389	48,336	23,004	6,548	16,823	361,212	1,167,949	758,209	269,281	4,057,237
1996	350,132	909,740	493,628	313,291	37,636	16,579	5,157	11,313	261,866	814,976	683,051	268,851	4,166,220
1997	246,956	908,831	519,227	324,479	44,668	17,497	3,448	6,165	221,964	652,728	754,436	219,123	3,919,523
1998	251,230	822,191	492,796	318,552	44,538	17,881	5,818	16,023	361,212	1,167,949	758,209	269,281	4,525,680
1999	350,132	909,740	500,815	318,930	39,729	18,868	4,641	7,145	237,917	979,658	721,820	268,608	4,358,005
2000	324,169	908,317	386,399	326,271	44,291	21,615	4,401	8,667	258,903	792,400	755,229	256,762	4,087,424
2001	306,393	878,769	493,850	333,025	45,905	20,837	1,906	3,628	102,173	912,861	238,793	130,091	3,468,231
2002	179,925	642,337	492,060	333,404	4,305	9,462	2,735	6,440	223,892	1,144,645	672,197	161,137	3,872,539
2003	177,152	907,225	490,261	325,594	5,048	18,157	3,963	10,247	255,130	841,667	743,390	252,802	4,030,636
Average	260,505	713,357	426,742	294,280	33,446	17,137	3,485	8,325	238,799	970,086	591,617	210,932	3,768,712

Source: ICF 2010:Appendix B

Table F-70. Entrainment Loss of American Shad during Diversions onto the Reservoir Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	712.2	1871.2	982.1	640.5	88.1	46.3	14.8	36.9	840.0	2330.8	1516.9	542.7		
1980	0	0	0	3,353	1	2	0	0	0	0	0	0	3,356	0.1%
1981	0	0	0	2,521	0	61	0	0	0	0	0	0	2,582	0.1%
1982	0	0	5,141	8	1	2	0	0	0	0	0	0	5,152	0.1%
1983	0	0	5,141	8	1	2	0	0	0	0	0	0	5,152	0.1%
1984	0	0	5,141	8	1	2	0	0	0	0	0	0	5,152	0.1%
1985	0	0	4,617	0	0	0	0	0	0	0	0	0	4,617	0.1%
1986	0	0	0	0	501	6	0	0	0	0	0	0	507	0.0%
1987	0	0	0	0	0	209	0	0	0	0	0	0	209	0.0%
1988	0	0	0	2,877	0	0	0	0	0	0	0	0	2,877	0.1%
1989	0	0	0	0	0	242	0	0	0	0	0	0	242	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	28	0	0	0	0	0	0	28	0.0%
1992	0	0	0	0	412	0	0	0	0	0	0	0	412	0.0%
1993	0	0	0	3,353	1	2	0	0	0	0	0	0	3,356	0.1%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	3,353	1	2	0	0	0	0	0	0	3,356	0.1%
1996	0	0	0	3,353	1	2	0	0	0	0	0	0	3,356	0.1%
1997	0	0	5,141	8	1	2	0	0	0	0	0	0	5,152	0.1%
1998	0	0	0	3,353	1	2	0	0	0	0	0	0	3,356	0.1%
1999	0	0	5,141	8	1	2	0	0	0	0	0	0	5,152	0.1%
2000	0	0	0	2,521	124	2	0	0	0	0	0	0	2,646	0.1%
2001	0	0	0	0	93	0	0	0	0	0	0	0	93	0.0%
2002	0	0	3,012	1,394	0	0	0	0	0	0	0	0	4,406	0.1%
2003	0	0	5,141	8	0	0	0	0	0	0	0	0	5,149	0.1%
Average	0	0	1,603	1,089	48	23	0	0	0	0	0	0	2,763	0.1%

Source: ICF 2010:Appendix B

Table F-71. Entrainment Loss of American Shad during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	**712.2**	**1871.2**	**982.1**	**640.5**	**88.1**	**46.3**	**14.8**	**36.9**	**840.0**	**2330.8**	**1516.9**	**542.7**	**Estimated loss**	**% of baseline**
1980	0	0	0	0	0	0	0	0	0	0	156,694	4,273	160,967	3.9%
1981	42,123	0	0	0	0	0	0	0	0	21,052	175,748	24,001	262,925	6.7%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	45,615	0	25,198	70,814	1.6%
1985	0	0	0	0	0	0	0	0	0	0	0	19,820	19,820	0.4%
1986	52,499	0	0	0	0	0	0	0	0	230,668	100,875	0	384,041	9.8%
1987	4,517	0	0	0	0	0	0	0	0	0	0	62,573	67,089	2.0%
1988	0	0	0	0	0	0	0	0	0	84,054	198,616	0	282,670	10.2%
1989	0	0	0	0	0	0	0	0	0	0	31,873	46,653	78,526	2.4%
1990	11,487	0	0	0	0	0	0	0	0	0	0	0	11,487	0.4%
1991	0	0	0	0	0	0	0	0	0	39,592	0	0	39,592	2.1%
1992	0	0	0	0	0	0	0	0	0	312,975	8,830	0	321,805	17.4%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	6,856	130,928	0	0	0	0	0	0	0	0	0	0	137,784	3.5%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	216,809	81,992	0	298,801	7.2%
1997	16,917	0	0	0	0	0	0	0	0	268,047	0	30,817	315,781	8.1%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	190,162	0	0	190,162	4.4%
2000	27,278	0	0	0	0	0	0	0	0	93,782	0	0	121,060	3.0%
2001	47,593	27,448	0	0	0	0	0	0	0	66,618	0	0	141,659	4.1%
2002	0	0	0	0	0	0	0	0	0	0	75,472	60,637	136,109	3.5%
2003	0	0	0	0	0	0	0	0	0	64,091	0	0	64,091	1.6%
Average	8,720	6,599	0	0	0	0	0	0	0	68,061	34,588	11,416	129,383	3.4%

Source: ICF 2010:Appendix B

Table F-72. Entrainment Loss of American Shad during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	712.2	1871.2	982.1	640.5	88.1	46.3	14.8	36.9	840.0	2330.8	1516.9	542.7	
Agricultural diversions	121	0	278	181	25	0	0	10	1,130	3,731	1,784	300	7,561
Habitat Island diversions	7	16	9	1	0	0	0	0	13	42	20	7	115
Project Benefit	114	-16	269	181	24	0	0	10	1,118	3,689	1,764	292	7,446

Source: ICF 2010:Appendix B

Table F-73. Summary of American Shad Entrainment Loss Effects of the Project Compared to the Baseline Conditions

Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Project Diversion Effect[3] Loss	Project Diversion Effect[3] % of Baseline SWP/CVP	Project Export Effect[4] Loss	Project Export Effect[4] % of Baseline SWP/CVP	Baseline DW Agricultural Diversion Loss[5]	Project Habitat Diversion Loss[6]	Project Benefit from Reduced and Screened Agricultural Diversions[7] Reduced Loss	Project Benefit from Reduced and Screened Agricultural Diversions[7] % of SWP/ CVP	Net Project Effect Loss	Net Project Effect % of SWP/CVP
1980	4,155,109	151,216	3,356	0.1%	160,967	3.9%	7,561	115	7,446	0.2%	156,876	3.8%
1981	3,929,816	151,216	2,582	0.1%	262,925	6.7%	7,561	115	7,446	0.2%	258,061	6.6%
1982	4,695,975	151,216	5,152	0.1%	0	0.0%	7,561	115	7,446	0.2%	-2,294	0.0%
1983	4,717,175	151,216	5,152	0.1%	0	0.0%	7,561	115	7,446	0.2%	-2,294	0.0%
1984	4,328,694	151,216	5,152	0.1%	70,814	1.6%	7,561	115	7,446	0.2%	68,520	1.6%
1985	4,502,395	151,216	4,617	0.1%	19,820	0.4%	7,561	115	7,446	0.2%	16,991	0.4%
1986	3,919,133	151,216	507	0.0%	384,041	9.8%	7,561	115	7,446	0.2%	377,103	9.6%
1987	3,367,930	151,216	209	0.0%	67,089	2.0%	7,561	115	7,446	0.2%	59,852	1.8%
1988	2,763,830	151,216	2,877	0.1%	282,670	10.2%	7,561	115	7,446	0.3%	278,101	10.1%
1989	3,298,806	151,216	242	0.0%	78,526	2.4%	7,561	115	7,446	0.2%	71,323	2.2%
1990	2,876,125	151,216	0	0.0%	11,487	0.4%	7,561	115	7,446	0.3%	4,041	0.1%
1991	1,882,284	151,216	28	0.0%	39,592	2.1%	7,561	115	7,446	0.4%	32,174	1.7%
1992	1,849,745	151,216	412	0.0%	321,805	17.4%	7,561	115	7,446	0.4%	314,771	17.0%
1993	3,707,486	151,216	3,356	0.1%	0	0.0%	7,561	115	7,446	0.2%	-4,090	-0.1%
1994	3,969,081	151,216	0	0.0%	137,784	3.5%	7,561	115	7,446	0.2%	130,338	3.3%
1995	4,057,237	151,216	3,356	0.1%	0	0.0%	7,561	115	7,446	0.2%	-4,090	-0.1%
1996	4,166,220	151,216	3,356	0.1%	298,801	7.2%	7,561	115	7,446	0.2%	294,710	7.1%
1997	3,919,523	151,216	5,152	0.1%	315,781	8.1%	7,561	115	7,446	0.2%	313,487	8.0%
1998	4,525,680	151,216	3,356	0.1%	0	0.0%	7,561	115	7,446	0.2%	-4,090	-0.1%
1999	4,358,005	151,216	5,152	0.1%	190,162	4.4%	7,561	115	7,446	0.2%	187,868	4.3%
2000	4,087,424	151,216	2,646	0.1%	121,060	3.0%	7,561	115	7,446	0.2%	116,260	2.8%
2001	3,468,231	151,216	93	0.0%	141,659	4.1%	7,561	115	7,446	0.2%	134,305	3.9%
2002	3,872,539	151,216	4,406	0.1%	136,109	3.5%	7,561	115	7,446	0.2%	133,069	3.4%
2003	4,030,636	151,216	5,149	0.1%	64,091	1.6%	7,561	115	7,446	0.2%	61,794	1.5%
Average	3,768,712	151,216	2,763	0.1%	129,383	3.8%	7,561	115	7,446	0.2%	124,699	3.7%

Notes.
[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.
[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).
[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.
[4]Increased loss of fish assuming SWP export of discharged project water from July to November.
[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction.
[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.
[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.
Source: ICF 2010:Appendix B

Threadfin Shad

The baseline entrainment loss of threadfin shad by SWP and CVP averaged over 9.7 million fish from 1980 to 2003 (Table F-74). The lowest entrainment loss of around 5.1 million fish occurred in 1991 and the maximum entrainment was over 12.2 million fish in 1983. Direct entrainment loss of threadfin shad estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to almost 7,400 fish in several years, and averaged almost 4,800 fish (Table F-75); this represented an average increased entrainment over baseline conditions of 0–0.1%. Loss of threadfin shad due to export of discharged project water averaged over 400,000 fish per year, with values ranging from 0 (several years) to 1.2 million fish in 1986. This was 0–19.3% of baseline SWP/CVP entrainment losses (Table F-76).

Based on the assumed monthly density of threadfin shad and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: over 22,000 less threadfin shad would be entrained annually (Table F-77). As a whole, the project was estimated to result in a net loss to threadfin shad because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged over 385,000 fish per year, or 4.4% of the baseline entrainment by SWP and CVP (Table F-78).

Table F-74. Baseline Entrainment Loss of Threadfin Shad by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss
	Assumed density (Fish/thousand acre-feet)												
	2289.6	**2516.7**	**1404.1**	**1167.0**	**764.5**	**215.4**	**335.4**	**277.0**	**1949.2**	**7250.7**	**4747.1**	**2188.5**	
1980	830,231	1,221,658	705,714	659,716	343,493	78,846	108,173	67,606	604,336	3,016,602	1,775,173	1,069,390	10,480,938
1981	954,838	920,162	644,136	607,288	368,691	92,770	67,636	53,360	558,647	3,512,531	1,595,765	857,065	10,232,889
1982	996,755	1,221,922	705,282	622,184	378,976	95,014	126,866	122,279	838,191	3,633,360	2,372,726	1,085,978	12,199,533
1983	1,125,677	1,223,557	723,900	583,564	322,943	66,890	131,984	124,805	838,191	3,633,360	2,372,726	1,085,978	12,233,575
1984	1,125,677	1,223,557	663,337	440,063	307,359	86,696	66,989	46,252	541,846	3,318,817	2,358,846	992,273	11,171,712
1985	1,118,808	1,221,177	703,582	578,487	282,684	54,886	61,333	55,253	530,233	3,615,504	2,359,759	958,228	11,539,934
1986	878,580	1,005,858	704,895	598,722	432,725	96,905	120,080	103,173	521,133	2,578,142	2,080,170	1,083,071	10,203,455
1987	1,030,121	1,034,154	523,568	414,108	290,586	74,681	16,392	49,149	516,804	3,403,127	622,497	454,647	8,429,833
1988	615,222	637,922	698,966	593,532	71,437	15,007	45,695	20,753	372,060	2,801,431	316,329	424,832	6,613,186
1989	431,167	572,119	419,887	317,257	73,987	100,750	71,361	33,052	497,901	3,502,812	2,212,465	751,013	8,983,770
1990	792,460	823,877	484,099	588,405	109,727	46,166	16,392	28,806	386,207	2,414,964	813,730	506,694	7,011,528
1991	441,363	522,158	138,886	140,245	82,565	108,027	23,714	30,823	195,977	2,163,435	751,325	503,218	5,101,737
1992	516,052	321,569	272,260	234,610	396,757	71,744	29,087	13,538	296,104	1,228,709	1,299,149	520,227	5,199,807
1993	408,235	435,281	459,150	645,959	410,944	105,137	97,444	61,971	789,676	3,614,956	2,277,745	1,082,759	10,389,258
1994	1,099,534	884,210	587,607	489,371	364,052	57,194	39,466	39,433	511,231	3,625,868	2,181,781	587,936	10,467,682
1995	707,564	494,290	676,106	629,296	419,464	107,006	148,693	126,181	838,191	3,633,360	2,372,726	1,085,978	11,238,855
1996	1,125,677	1,223,557	705,756	570,814	326,605	77,117	117,110	84,853	607,658	2,535,301	2,137,529	1,084,246	10,596,223
1997	793,964	1,222,335	742,356	591,199	387,631	81,388	78,309	46,238	515,067	2,030,565	2,360,919	883,699	9,733,670
1998	807,705	1,105,809	704,567	580,399	386,501	83,177	132,116	120,181	838,191	3,633,360	2,372,726	1,085,978	11,850,710
1999	1,125,677	1,223,557	716,032	581,088	344,772	87,768	105,404	53,589	552,085	3,047,606	2,258,853	1,083,266	11,179,698
2000	1,042,203	1,221,644	552,448	594,463	384,354	100,545	99,953	65,007	600,783	2,465,068	2,363,401	1,035,493	10,525,362
2001	985,054	1,181,904	706,073	606,769	398,367	96,925	43,288	27,214	237,093	2,839,808	747,273	524,641	8,394,409
2002	578,458	863,914	703,515	607,459	37,361	44,013	62,117	48,304	519,540	3,560,862	2,103,562	649,848	9,778,953
2003	569,543	1,220,176	700,942	593,229	43,804	84,457	90,008	76,862	592,027	2,618,333	2,326,351	1,019,522	9,935,255
Average	837,524	959,432	610,128	536,176	290,241	79,713	79,150	62,445	554,132	3,017,828	1,851,397	850,666	9,728,832

Source: ICF 2010:Appendix B

Table F-75. Entrainment Loss of Threadfin Shad during Diversions onto the Reservoir Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	2289.6	2516.7	1404.1	1167.0	764.5	215.4	335.4	277.0	1949.2	7250.7	4747.1	2188.5		
1980	0	0	0	6,109	13	7	0	0	0	0	0	0	6,128	0.1%
1981	0	0	0	4,593	0	283	0	0	0	0	0	0	4,876	0.0%
1982	0	0	7,350	15	13	7	0	0	0	0	0	0	7,385	0.1%
1983	0	0	7,350	15	13	7	0	0	0	0	0	0	7,385	0.1%
1984	0	0	7,350	15	13	7	0	0	0	0	0	0	7,385	0.1%
1985	0	0	6,602	0	0	0	0	0	0	0	0	0	6,602	0.1%
1986	0	0	0	0	4,350	28	0	0	0	0	0	0	4,378	0.0%
1987	0	0	0	0	0	971	0	0	0	0	0	0	971	0.0%
1988	0	0	0	5,241	0	0	0	0	0	0	0	0	5,241	0.1%
1989	0	0	0	0	0	1,127	0	0	0	0	0	0	1,127	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	130	0	0	0	0	0	0	130	0.0%
1992	0	0	0	0	3,572	0	0	0	0	0	0	0	3,572	0.1%
1993	0	0	0	6,109	13	7	0	0	0	0	0	0	6,129	0.1%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	6,109	13	7	0	0	0	0	0	0	6,129	0.1%
1996	0	0	0	6,109	13	7	0	0	0	0	0	0	6,128	0.1%
1997	0	0	7,350	15	13	7	0	0	0	0	0	0	7,385	0.1%
1998	0	0	0	6,109	13	7	0	0	0	0	0	0	6,129	0.1%
1999	0	0	7,350	15	13	7	0	0	0	0	0	0	7,385	0.1%
2000	0	0	0	4,593	1,074	7	0	0	0	0	0	0	5,674	0.1%
2001	0	0	0	0	804	0	0	0	0	0	0	0	804	0.0%
2002	0	0	4,306	2,540	0	0	0	0	0	0	0	0	6,846	0.1%
2003	0	0	7,350	15	0	0	0	0	0	0	0	0	7,365	0.1%
Average	0	0	2,292	1,983	414	109	0	0	0	0	0	0	4,798	0.0%

Source: ICF 2010:Appendix B

Table F-76. Entrainment Loss of Threadfin Shad during Export of Water Discharged from the Project Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	2289.6	2516.7	1404.1	1167.0	764.5	215.4	335.4	277.0	1949.2	7250.7	4747.1	2188.5		
1980	0	0	0	0	0	0	0	0	0	0	490,356	17,231	507,587	4.8%
1981	135,425	0	0	0	0	0	0	0	0	65,492	549,984	96,794	847,696	8.3%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	141,904	0	101,623	243,527	2.2%
1985	0	0	0	0	0	0	0	0	0	0	0	79,932	79,932	0.7%
1986	168,783	0	0	0	0	0	0	0	0	717,583	315,676	0	1,202,042	11.8%
1987	14,521	0	0	0	0	0	0	0	0	0	0	252,349	266,870	3.2%
1988	0	0	0	0	0	0	0	0	0	261,482	621,547	0	883,029	13.4%
1989	0	0	0	0	0	0	0	0	0	0	99,743	188,147	287,890	3.2%
1990	36,930	0	0	0	0	0	0	0	0	0	0	0	36,930	0.5%
1991	0	0	0	0	0	0	0	0	0	123,166	0	0	123,166	2.4%
1992	0	0	0	0	0	0	0	0	0	973,631	27,633	0	1,001,264	19.3%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	22,041	176,093	0	0	0	0	0	0	0	0	0	0	198,133	1.9%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	674,468	256,584	0	931,052	8.8%
1997	54,388	0	0	0	0	0	0	0	0	833,864	0	124,281	1,012,534	10.4%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	591,573	0	0	591,573	5.3%
2000	87,699	0	0	0	0	0	0	0	0	291,744	0	0	379,443	3.6%
2001	153,011	36,916	0	0	0	0	0	0	0	207,241	0	0	397,168	4.7%
2002	0	0	0	0	0	0	0	0	0	0	236,182	244,542	480,723	4.9%
2003	0	0	0	0	0	0	0	0	0	199,381	0	0	199,381	2.0%
Average	28,033	8,875	0	0	0	0	0	0	0	211,730	108,238	46,037	402,914	4.1%

Source: ICF 2010:Appendix B

Table F-77. Entrainment Loss of Threadfin Shad during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	2289.6	**2516.7**	**1404.1**	**1167.0**	**764.5**	**215.4**	**335.4**	**277.0**	**1949.2**	**7250.7**	**4747.1**	**2188.5**	
Agricultural diversions	389	0	398	331	217	0	0	75	2,623	11,607	5,582	1,209	22,430
Habitat Island diversions	22	21	13	1	4	0	0	1	29	131	62	30	313
Project Benefit	367	-21	384	329	212	0	0	74	2,594	11,477	5,520	1,180	22,117

Source: ICF 2010:Appendix B

Table F-78. Summary of Threadfin Shad Entrainment Loss Effects of the Project Compared to the Baseline Conditions

Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
			Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/CVP	Loss	% of SWP/CVP
1980	10,480,938	448,606	6,128	0.1%	507,587	4.8%	22,430	313	22,117	0.2%	491,598	4.7%
1981	10,232,889	448,606	4,876	0.0%	847,696	8.3%	22,430	313	22,117	0.2%	830,455	8.1%
1982	12,199,533	448,606	7,385	0.1%	0	0.0%	22,430	313	22,117	0.2%	-14,731	-0.1%
1983	12,233,575	448,606	7,385	0.1%	0	0.0%	22,430	313	22,117	0.2%	-14,731	-0.1%
1984	11,171,712	448,606	7,385	0.1%	243,527	2.2%	22,430	313	22,117	0.2%	228,795	2.0%
1985	11,539,934	448,606	6,602	0.1%	79,932	0.7%	22,430	313	22,117	0.2%	64,417	0.6%
1986	10,203,455	448,606	4,378	0.0%	1,202,042	11.8%	22,430	313	22,117	0.2%	1,184,302	11.6%
1987	8,429,833	448,606	971	0.0%	266,870	3.2%	22,430	313	22,117	0.3%	245,724	2.9%
1988	6,613,186	448,606	5,241	0.1%	883,029	13.4%	22,430	313	22,117	0.3%	866,153	13.1%
1989	8,983,770	448,606	1,127	0.0%	287,890	3.2%	22,430	313	22,117	0.2%	266,901	3.0%
1990	7,011,528	448,606	0	0.0%	36,930	0.5%	22,430	313	22,117	0.3%	14,813	0.2%
1991	5,101,737	448,606	130	0.0%	123,166	2.4%	22,430	313	22,117	0.4%	101,179	2.0%
1992	5,199,807	448,606	3,572	0.1%	1,001,264	19.3%	22,430	313	22,117	0.4%	982,719	18.9%
1993	10,389,258	448,606	6,129	0.1%	0	0.0%	22,430	313	22,117	0.2%	-15,988	-0.2%
1994	10,467,682	448,606	0	0.0%	198,133	1.9%	22,430	313	22,117	0.2%	176,016	1.7%
1995	11,238,855	448,606	6,129	0.1%	0	0.0%	22,430	313	22,117	0.2%	-15,988	-0.1%
1996	10,596,223	448,606	6,128	0.1%	931,052	8.8%	22,430	313	22,117	0.2%	915,063	8.6%
1997	9,733,670	448,606	7,385	0.1%	1,012,534	10.4%	22,430	313	22,117	0.2%	997,802	10.3%
1998	11,850,710	448,606	6,129	0.1%	0	0.0%	22,430	313	22,117	0.2%	-15,988	-0.1%
1999	11,179,698	448,606	7,385	0.1%	591,573	5.3%	22,430	313	22,117	0.2%	576,842	5.2%
2000	10,525,362	448,606	5,674	0.1%	379,443	3.6%	22,430	313	22,117	0.2%	363,000	3.4%
2001	8,394,409	448,606	804	0.0%	397,168	4.7%	22,430	313	22,117	0.3%	375,856	4.5%
2002	9,778,953	448,606	6,846	0.1%	480,723	4.9%	22,430	313	22,117	0.2%	465,452	4.8%
2003	9,935,255	448,606	7,365	0.1%	199,381	2.0%	22,430	313	22,117	0.2%	184,629	1.9%
Average	9,728,832	448,606	4,798	0.0%	402,914	4.6%	22,430	313	22,117	0.2%	385,595	4.4%

Notes.

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Sacramento Splittail

The baseline entrainment loss of Sacramento splittail by SWP and CVP averaged almost 1.7 million fish from 1980 to 2003 (Table F-79). The lowest entrainment loss of around 740,000 fish occurred in 1991 and the maximum entrainment was over 2.6 million fish in 1995. Direct entrainment loss of Sacramento splittail estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to 375 fish in 1986, and averaged 114 fish (Table F-80); this represented an average increased entrainment over baseline conditions of 0.0%. Loss of Sacramento splittail due to export of discharged project water averaged almost 20,000 fish per year, with values ranging from 0 (several years) to almost 85,000 fish in 1992. This was 0–10.4% of baseline SWP/CVP entrainment losses (Table F-81).

Based on the assumed monthly density of Sacramento splittail and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: nearly 6,500 less Sacramento splittail would be entrained annually (Table F-82). As a whole, the project was estimated to result in a net loss to Sacramento splittail because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged almost 13,500 fish per year, or 1.1% of the baseline entrainment by SWP and CVP (Table F-83).

Table F-79. Baseline Entrainment Loss of Sacramento Splittail by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss
	Assumed density (Fish/thousand acre-feet)												
	1.8	1.0	4.2	32.4	65.1	33.2	69.1	1131.7	3820.3	628.3	58.1	6.1	
1980	644	502	2,108	18,344	29,240	12,162	22,284	276,164	1,184,490	261,405	21,734	2,978	1,832,054
1981	740	378	1,924	16,886	31,385	14,310	13,933	217,972	1,094,941	304,381	19,538	2,387	1,718,774
1982	773	502	2,107	17,300	32,260	14,656	26,135	499,498	1,642,843	314,851	29,050	3,024	2,582,999
1983	873	502	2,163	16,226	27,490	10,318	27,189	509,818	1,642,843	314,851	29,050	3,024	2,584,348
1984	873	502	1,982	12,236	26,164	13,373	13,800	188,937	1,062,010	287,594	28,880	2,763	1,639,115
1985	868	501	2,102	16,085	24,063	8,466	12,635	225,703	1,039,251	313,304	28,892	2,668	1,674,538
1986	681	413	2,106	16,648	36,835	14,948	24,737	421,451	1,021,415	223,411	25,468	3,016	1,791,129
1987	799	425	1,564	11,514	24,736	11,520	3,377	200,769	1,012,929	294,900	7,622	1,266	1,571,420
1988	477	262	2,088	16,503	6,081	2,315	9,413	84,774	729,233	242,760	3,873	1,183	1,098,962
1989	334	235	1,254	8,822	6,298	15,541	14,700	135,016	975,880	303,538	27,088	2,091	1,490,798
1990	615	338	1,446	16,361	9,340	7,121	3,377	117,670	756,961	209,270	9,963	1,411	1,133,873
1991	342	214	415	3,900	7,028	16,664	4,885	125,908	384,112	187,474	9,199	1,401	741,541
1992	400	132	813	6,523	33,774	11,067	5,992	55,300	580,360	106,475	15,906	1,449	818,191
1993	317	179	1,372	17,961	34,981	16,218	20,074	253,146	1,547,755	313,256	27,887	3,015	2,236,161
1994	853	363	1,755	13,607	30,990	8,822	8,130	161,082	1,002,006	314,202	26,713	1,637	1,570,160
1995	549	203	2,020	17,498	35,707	16,506	30,631	515,438	1,642,843	314,851	29,050	3,024	2,608,319
1996	873	502	2,108	15,872	27,802	11,896	24,125	346,617	1,191,002	219,698	26,171	3,019	1,869,684
1997	616	502	2,218	16,439	32,997	12,554	16,132	188,880	1,009,524	175,960	28,906	2,461	1,487,188
1998	626	454	2,105	16,138	32,901	12,830	27,216	490,929	1,642,843	314,851	29,050	3,024	2,572,968
1999	873	502	2,139	16,157	29,349	13,539	21,713	218,908	1,082,080	264,092	27,656	3,017	1,680,025
2000	808	502	1,650	16,529	32,718	15,509	20,590	265,549	1,177,527	213,612	28,936	2,883	1,776,815
2001	764	485	2,109	16,872	33,911	14,951	8,917	111,167	464,699	246,085	9,149	1,461	910,571
2002	449	355	2,102	16,891	3,180	6,789	12,796	197,319	1,018,291	308,569	25,755	1,810	1,594,305
2003	442	501	2,094	16,495	3,729	13,028	18,542	313,973	1,160,365	226,893	28,483	2,839	1,787,384
Average	650	394	1,823	14,909	24,707	12,296	16,305	255,083	1,086,092	261,512	22,667	2,369	1,698,805

Source: ICF 2010:Appendix B

Table F-80. Entrainment Loss of Sacramento Splittail during Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)												Estimated	% of
Water year	**1.8**	**1.0**	**4.2**	**32.4**	**65.1**	**33.2**	**69.1**	**1131.7**	**3820.3**	**628.3**	**58.1**	**6.1**	**loss**	**baseline**
1980	0	0	0	170	1	1	0	0	0	0	0	0	172	0.0%
1981	0	0	0	128	0	44	0	0	0	0	0	0	171	0.0%
1982	0	0	22	0	1	1	0	0	0	0	0	0	25	0.0%
1983	0	0	22	0	1	1	0	0	0	0	0	0	25	0.0%
1984	0	0	22	0	1	1	0	0	0	0	0	0	25	0.0%
1985	0	0	20	0	0	0	0	0	0	0	0	0	20	0.0%
1986	0	0	0	0	370	4	0	0	0	0	0	0	375	0.0%
1987	0	0	0	0	0	150	0	0	0	0	0	0	150	0.0%
1988	0	0	0	146	0	0	0	0	0	0	0	0	146	0.0%
1989	0	0	0	0	0	174	0	0	0	0	0	0	174	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	20	0	0	0	0	0	0	20	0.0%
1992	0	0	0	0	304	0	0	0	0	0	0	0	304	0.0%
1993	0	0	0	170	1	1	0	0	0	0	0	0	172	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	170	1	1	0	0	0	0	0	0	172	0.0%
1996	0	0	0	170	1	1	0	0	0	0	0	0	172	0.0%
1997	0	0	22	0	1	1	0	0	0	0	0	0	25	0.0%
1998	0	0	0	170	1	1	0	0	0	0	0	0	172	0.0%
1999	0	0	22	0	1	1	0	0	0	0	0	0	25	0.0%
2000	0	0	0	128	91	1	0	0	0	0	0	0	220	0.0%
2001	0	0	0	0	68	0	0	0	0	0	0	0	68	0.0%
2002	0	0	13	71	0	0	0	0	0	0	0	0	83	0.0%
2003	0	0	22	0	0	0	0	0	0	0	0	0	22	0.0%
Average	0	0	7	55	35	17	0	0	0	0	0	0	114	0.0%

Source: ICF 2010:Appendix B

Table F-81. Entrainment Loss of Sacramento Splittail during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)												Estimated	% of
Water year	1.8	1.0	4.2	32.4	65.1	33.2	69.1	1131.7	3820.3	628.3	58.1	6.1	loss	baseline
1980	0	0	0	0	0	0	0	0	0	0	6,004	48	6,052	0.3%
1981	105	0	0	0	0	0	0	0	0	5,675	6,734	270	12,784	0.7%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	12,297	0	283	12,580	0.8%
1985	0	0	0	0	0	0	0	0	0	0	0	223	223	0.0%
1986	131	0	0	0	0	0	0	0	0	62,183	3,865	0	66,178	3.7%
1987	11	0	0	0	0	0	0	0	0	0	0	703	714	0.0%
1988	0	0	0	0	0	0	0	0	0	22,659	7,610	0	30,269	2.8%
1989	0	0	0	0	0	0	0	0	0	0	1,221	524	1,745	0.1%
1990	29	0	0	0	0	0	0	0	0	0	0	0	29	0.0%
1991	0	0	0	0	0	0	0	0	0	10,673	0	0	10,673	1.4%
1992	0	0	0	0	0	0	0	0	0	84,371	338	0	84,709	10.4%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	17	72	0	0	0	0	0	0	0	0	0	0	89	0.0%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	58,446	3,141	0	61,588	3.3%
1997	42	0	0	0	0	0	0	0	0	72,259	0	346	72,647	4.9%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	51,263	0	0	51,263	3.1%
2000	68	0	0	0	0	0	0	0	0	25,281	0	0	25,349	1.4%
2001	119	15	0	0	0	0	0	0	0	17,959	0	0	18,092	2.0%
2002	0	0	0	0	0	0	0	0	0	0	2,892	681	3,573	0.2%
2003	0	0	0	0	0	0	0	0	0	17,277	0	0	17,277	1.0%
Average	22	4	0	0	0	0	0	0	0	18,348	1,325	128	19,826	1.2%

Source: ICF 2010:Appendix B

Table F-82. Entrainment Loss of Sacramento Splittail during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												
	1.8	**1.0**	**4.2**	**32.4**	**65.1**	**33.2**	**69.1**	**1131.7**	**3820.3**	**628.3**	**58.1**	**6.1**	**Number of fish**
Agricultural diversions	0	0	1	9	18	0	0	305	5,142	1,006	68	3	6,553
Habitat Island diversions	0	0	0	0	0	0	0	2	57	11	1	0	72
Project Benefit	0	0	1	9	18	0	0	302	5,084	995	68	3	6,481

Source: ICF 2010:Appendix B

Table F-83. Summary of Sacramento Splittail Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/ CVP	Loss	% of SWP/ CVP
1980	1,832,054	131,056	172	0.0%	6,052	0.3%	6,553	72	6,481	0.4%	-257	0.0%
1981	1,718,774	131,056	171	0.0%	12,784	0.7%	6,553	72	6,481	0.4%	6,474	0.4%
1982	2,582,999	131,056	25	0.0%	0	0.0%	6,553	72	6,481	0.3%	-6,456	-0.2%
1983	2,584,348	131,056	25	0.0%	0	0.0%	6,553	72	6,481	0.3%	-6,456	-0.2%
1984	1,639,115	131,056	25	0.0%	12,580	0.8%	6,553	72	6,481	0.4%	6,124	0.4%
1985	1,674,538	131,056	20	0.0%	223	0.0%	6,553	72	6,481	0.4%	-6,238	-0.4%
1986	1,791,129	131,056	375	0.0%	66,178	3.7%	6,553	72	6,481	0.4%	60,072	3.4%
1987	1,571,420	131,056	150	0.0%	714	0.0%	6,553	72	6,481	0.4%	-5,617	-0.4%
1988	1,098,962	131,056	146	0.0%	30,269	2.8%	6,553	72	6,481	0.6%	23,934	2.2%
1989	1,490,798	131,056	174	0.0%	1,745	0.1%	6,553	72	6,481	0.4%	-4,562	-0.3%
1990	1,133,873	131,056	0	0.0%	29	0.0%	6,553	72	6,481	0.6%	-6,452	-0.6%
1991	741,541	131,056	20	0.0%	10,673	1.4%	6,553	72	6,481	0.9%	4,212	0.6%
1992	818,191	131,056	304	0.0%	84,709	10.4%	6,553	72	6,481	0.8%	78,532	9.6%
1993	2,236,161	131,056	172	0.0%	0	0.0%	6,553	72	6,481	0.3%	-6,309	-0.3%
1994	1,570,160	131,056	0	0.0%	89	0.0%	6,553	72	6,481	0.4%	-6,391	-0.4%
1995	2,608,319	131,056	172	0.0%	0	0.0%	6,553	72	6,481	0.2%	-6,309	-0.2%
1996	1,869,684	131,056	172	0.0%	61,588	3.3%	6,553	72	6,481	0.3%	55,279	3.0%
1997	1,487,188	131,056	25	0.0%	72,647	4.9%	6,553	72	6,481	0.4%	66,191	4.5%
1998	2,572,968	131,056	172	0.0%	0	0.0%	6,553	72	6,481	0.3%	-6,309	-0.2%
1999	1,680,025	131,056	25	0.0%	51,263	3.1%	6,553	72	6,481	0.4%	44,807	2.7%
2000	1,776,815	131,056	220	0.0%	25,349	1.4%	6,553	72	6,481	0.4%	19,089	1.1%
2001	910,571	131,056	68	0.0%	18,092	2.0%	6,553	72	6,481	0.7%	11,680	1.3%
2002	1,594,305	131,056	83	0.0%	3,573	0.2%	6,553	72	6,481	0.4%	-2,825	-0.2%
2003	1,787,384	131,056	22	0.0%	17,277	1.0%	6,553	72	6,481	0.4%	10,819	0.6%
Average	1,698,805	131,056	114	0.0%	19,826	1.5%	6,553	72	6,481	0.4%	13,460	1.1%

Notes.

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2]Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction..

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Longfin Smelt

The baseline entrainment loss of longfin smelt by SWP and CVP averaged over 130,000 fish from 1980 to 2003 (Table F-84). The lowest entrainment loss of over 43,000 fish occurred in 1992 and the maximum entrainment was over 250,000 fish in 1995. Direct entrainment loss of longfin smelt estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to 17 fish in 1989, and averaged 10 fish (Table F-85); this represented an average increased entrainment over baseline conditions of 0.0%. Loss of longfin smelt due to export of discharged project water averaged 195 fish per year, with values ranging from 0 (several years) to almost 550 fish in 1986. This was 0–1.0% of baseline SWP/CVP entrainment losses (Table F-86).

Based on the assumed monthly density of longfin smelt and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 113 less longfin smelt would be entrained annually (Table F-87). As a whole, the project was estimated to result in a net loss to longfin smelt because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of project water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 92 fish per year, or 0.1% of the baseline entrainment by SWP and CVP (Table F-88).

Table F-84. Baseline Entrainment Loss of Longfin Smelt by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												Estimated
Water year	**0.4**	**0.2**	**2.3**	**2.3**	**0.6**	**3.3**	**141.4**	**224.0**	**32.9**	**2.5**	**2.7**	**1.0**	**loss**
1980	187	101	1,536	1,758	346	1,629	61,484	73,674	13,767	1,402	1,385	684	157,954
1981	216	76	1,402	1,618	372	1,916	38,443	58,150	12,726	1,633	1,245	548	118,345
1982	225	101	1,535	1,658	382	1,963	72,108	133,254	19,094	1,689	1,851	695	234,556
1983	254	101	1,576	1,555	325	1,382	75,017	136,007	19,094	1,689	1,851	695	239,547
1984	254	101	1,444	1,173	310	1,791	38,075	50,404	12,343	1,543	1,840	635	109,913
1985	253	101	1,532	1,542	285	1,134	34,861	60,212	12,079	1,681	1,841	613	116,132
1986	198	83	1,534	1,596	436	2,002	68,251	112,433	11,871	1,199	1,623	693	201,920
1987	233	86	1,140	1,104	293	1,543	9,317	53,560	11,773	1,582	486	291	81,406
1988	139	53	1,522	1,582	72	310	25,972	22,616	8,476	1,302	247	272	62,561
1989	97	47	914	845	75	2,081	40,560	36,019	11,342	1,628	1,726	480	95,816
1990	179	68	1,054	1,568	111	954	9,317	31,391	8,798	1,123	635	324	55,521
1991	100	43	302	374	83	2,231	13,479	33,589	4,464	1,006	586	322	56,580
1992	116	27	593	625	400	1,482	16,532	14,753	6,745	571	1,014	333	43,191
1993	92	36	1,000	1,721	414	2,172	55,385	67,533	17,989	1,681	1,777	692	150,493
1994	248	73	1,279	1,304	367	1,181	22,432	42,973	11,646	1,686	1,702	376	85,267
1995	160	41	1,472	1,677	423	2,210	84,515	137,506	19,094	1,689	1,851	695	251,333
1996	254	101	1,536	1,521	329	1,593	66,563	92,469	13,843	1,179	1,668	693	181,750
1997	179	101	1,616	1,576	391	1,681	44,509	50,389	11,733	944	1,842	565	115,526
1998	182	92	1,534	1,547	390	1,718	75,093	130,968	19,094	1,689	1,851	695	234,852
1999	254	101	1,559	1,549	347	1,813	59,910	58,399	12,577	1,417	1,762	693	140,381
2000	235	101	1,203	1,584	387	2,077	56,811	70,842	13,686	1,146	1,844	662	150,579
2001	222	98	1,537	1,617	402	2,002	24,604	29,657	5,401	1,320	583	336	67,779
2002	131	72	1,531	1,619	38	909	35,306	52,640	11,835	1,655	1,641	416	107,793
2003	129	101	1,526	1,581	44	1,744	51,159	83,761	13,486	1,217	1,815	652	157,215
Average	189	80	1,328	1,429	293	1,646	44,988	68,050	12,623	1,403	1,444	544	134,017

Source: ICF 2010:Appendix B

Table F-85. Entrainment Loss of Longfin Smelt during Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	**0.4**	**0.2**	**2.3**	**2.3**	**0.6**	**3.3**	**141.4**	**224.0**	**32.9**	**2.5**	**2.7**	**1.0**	**Estimated loss**	**% of baseline**
1980	0	0	0	12	0	0	0	0	0	0	0	0	12	0.0%
1981	0	0	0	9	0	4	0	0	0	0	0	0	13	0.0%
1982	0	0	12	0	0	0	0	0	0	0	0	0	12	0.0%
1983	0	0	12	0	0	0	0	0	0	0	0	0	12	0.0%
1984	0	0	12	0	0	0	0	0	0	0	0	0	12	0.0%
1985	0	0	11	0	0	0	0	0	0	0	0	0	11	0.0%
1986	0	0	0	0	3	0	0	0	0	0	0	0	4	0.0%
1987	0	0	0	0	0	15	0	0	0	0	0	0	15	0.0%
1988	0	0	0	10	0	0	0	0	0	0	0	0	10	0.0%
1989	0	0	0	0	0	17	0	0	0	0	0	0	17	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1991	0	0	0	0	0	2	0	0	0	0	0	0	2	0.0%
1992	0	0	0	0	3	0	0	0	0	0	0	0	3	0.0%
1993	0	0	0	12	0	0	0	0	0	0	0	0	12	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1995	0	0	0	12	0	0	0	0	0	0	0	0	12	0.0%
1996	0	0	0	12	0	0	0	0	0	0	0	0	12	0.0%
1997	0	0	12	0	0	0	0	0	0	0	0	0	12	0.0%
1998	0	0	0	12	0	0	0	0	0	0	0	0	12	0.0%
1999	0	0	12	0	0	0	0	0	0	0	0	0	12	0.0%
2000	0	0	0	9	1	0	0	0	0	0	0	0	10	0.0%
2001	0	0	0	0	1	0	0	0	0	0	0	0	1	0.0%
2002	0	0	7	5	0	0	0	0	0	0	0	0	12	0.0%
2003	0	0	12	0	0	0	0	0	0	0	0	0	12	0.0%
Average	0	0	4	4	0	2	0	0	0	0	0	0	10	0.0%

Source: ICF 2010:Appendix B

Table F-86. Entrainment Loss of Longfin Smelt during Export of Water Discharged from the Project Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)													
	0.4	0.2	2.3	2.3	0.6	3.3	141.4	224.0	32.9	2.5	2.7	1.0		
1980	0	0	0	0	0	0	0	0	0	0	340	10	350	0.2%
1981	27	0	0	0	0	0	0	0	0	27	381	55	491	0.4%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	59	0	58	116	0.1%
1985	0	0	0	0	0	0	0	0	0	0	0	45	45	0.0%
1986	34	0	0	0	0	0	0	0	0	297	219	0	549	0.3%
1987	3	0	0	0	0	0	0	0	0	0	0	143	146	0.2%
1988	0	0	0	0	0	0	0	0	0	108	431	0	539	0.9%
1989	0	0	0	0	0	0	0	0	0	0	69	107	176	0.2%
1990	7	0	0	0	0	0	0	0	0	0	0	0	7	0.0%
1991	0	0	0	0	0	0	0	0	0	51	0	0	51	0.1%
1992	0	0	0	0	0	0	0	0	0	402	19	0	422	1.0%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	4	13	0	0	0	0	0	0	0	0	0	0	17	0.0%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	279	178	0	457	0.3%
1997	11	0	0	0	0	0	0	0	0	345	0	71	426	0.4%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	244	0	0	244	0.2%
2000	18	0	0	0	0	0	0	0	0	121	0	0	138	0.1%
2001	31	3	0	0	0	0	0	0	0	86	0	0	119	0.2%
2002	0	0	0	0	0	0	0	0	0	0	164	139	303	0.3%
2003	0	0	0	0	0	0	0	0	0	82	0	0	82	0.1%
Average	6	1	0	0	0	0	0	0	0	87	75	26	195	0.1%

Source: ICF 2010:Appendix B

Table F-87. Entrainment Loss of Longfin Smelt during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	0.4	0.2	2.3	2.3	0.6	3.3	141.4	224.0	32.9	2.5	2.7	1.0	
Agricultural diversions	0	0	1	1	0	0	0	60	44	4	3	1	114
Habitat Island diversions	0	0	0	0	0	0	0	0	0	0	0	0	1
Project Benefit	0	0	1	1	0	0	0	60	44	4	3	1	113

Source: ICF 2010:Appendix B

Table F-88. Summary of Longfin Smelt Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/CVP	Loss	% of SWP/CVP
1980	157,954	2,279	12	0.0%	350	0.2%	114	1	113	0.1%	249	0.2%
1981	118,345	2,279	13	0.0%	491	0.4%	114	1	113	0.1%	391	0.3%
1982	234,556	2,279	12	0.0%	0	0.0%	114	1	113	0.0%	-101	0.0%
1983	239,547	2,279	12	0.0%	0	0.0%	114	1	113	0.0%	-101	0.0%
1984	109,913	2,279	12	0.0%	116	0.1%	114	1	113	0.1%	16	0.0%
1985	116,132	2,279	11	0.0%	45	0.0%	114	1	113	0.1%	-57	0.0%
1986	201,920	2,279	4	0.0%	549	0.3%	114	1	113	0.1%	440	0.2%
1987	81,406	2,279	15	0.0%	146	0.2%	114	1	113	0.1%	48	0.1%
1988	62,561	2,279	10	0.0%	539	0.9%	114	1	113	0.2%	437	0.7%
1989	95,816	2,279	17	0.0%	176	0.2%	114	1	113	0.1%	81	0.1%
1990	55,521	2,279	0	0.0%	7	0.0%	114	1	113	0.2%	-105	-0.2%
1991	56,580	2,279	2	0.0%	51	0.1%	114	1	113	0.2%	-60	-0.1%
1992	43,191	2,279	3	0.0%	422	1.0%	114	1	113	0.3%	311	0.7%
1993	150,493	2,279	12	0.0%	0	0.0%	114	1	113	0.1%	-101	-0.1%
1994	85,267	2,279	0	0.0%	17	0.0%	114	1	113	0.1%	-95	-0.1%
1995	251,333	2,279	12	0.0%	0	0.0%	114	1	113	0.0%	-101	0.0%
1996	181,750	2,279	12	0.0%	457	0.3%	114	1	113	0.1%	356	0.2%
1997	115,526	2,279	12	0.0%	426	0.4%	114	1	113	0.1%	325	0.3%
1998	234,852	2,279	12	0.0%	0	0.0%	114	1	113	0.0%	-101	0.0%
1999	140,381	2,279	12	0.0%	244	0.2%	114	1	113	0.1%	144	0.1%
2000	150,579	2,279	10	0.0%	138	0.1%	114	1	113	0.1%	35	0.0%
2001	67,779	2,279	1	0.0%	119	0.2%				0.2%	7	0.0%
2002	107,793	2,279	12	0.0%	303	0.3%	114	1	113	0.1%	202	0.2%
2003	157,215	2,279	12	0.0%	82	0.1%				0.1%	-19	0.0%
Average	134,017	2,279	10	0.0%	195	0.2%				0.1%	92	0.1%

Notes.

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction.

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Delta Smelt

Adults

The baseline entrainment loss of adult delta smelt by SWP and CVP averaged over 33,500 fish from 1980 to 2003 (Table F-89). The lowest entrainment loss of over 16,000 fish occurred in 1991 and the maximum entrainment was almost 44,000 fish in 1995. Direct entrainment loss of adult delta smelt estimated for the Proposed Action ranged from 0 fish in 1990 and 1994 to 105 fish in 1986, and averaged 62 fish (Table F-90); this represented an average increased entrainment over baseline conditions of 0–0.4%. Loss of adult delta smelt due to export of discharged project water did not occur because the assumed export period did not coincide with the period of susceptibility to export entrainment.

Based on the assumed monthly density of delta smelt adults and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 13 less delta smelt adults would be entrained annually (Table F-92). As a whole, the project was estimated to result in a net loss to delta smelt adults because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 50 fish per year, or 0.1% of the baseline entrainment by SWP and CVP (Table F-93).

Juveniles

The baseline entrainment loss of juvenile delta smelt by SWP and CVP averaged over 260,000 fish from 1980 to 2003 (Table F-89). The lowest entrainment loss of over 100,000 fish occurred in 1992 and the maximum entrainment was almost 444,000 fish in 1983. Direct entrainment loss of juvenile delta smelt estimated for the Proposed Action did not occur because the diversion period did not coincide with the assumed period of susceptibility to entrainment (Table F-90). Loss of juvenile delta smelt due to export of discharged project water averaged over 2,500 fish per year and ranged from 0 fish (several years) to over 9,000 fish (1992) (Table F-91).

Based on the assumed monthly density of delta smelt juveniles and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a net project benefit: 562 less delta smelt juveniles would be entrained annually (Table F-92). As a whole, the project was estimated to result in a net loss to delta smelt juveniles because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and discharge for export (July–November) was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 1,971 fish per year, or 1.1% of the baseline entrainment by SWP and CVP (Table F-93).

Table F-89. Baseline Entrainment Loss of Delta Smelt by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated adult loss	Estimated juvenile loss
	Assumed density (Fish/thousand acre-feet)													
	7.9	4.6	7.3	19.8	18.1	13.5	12.9	363.6	265.9	55.4	14.2	2.6		
1980	3,856	3,012	4,917	15,107	10,970	6,675	5,608	119,606	111,132	31,095	7,140	1,734	39,070	281,781
1981	4,435	2,269	4,488	13,906	11,774	7,853	3,507	94,403	102,731	36,207	6,418	1,390	38,898	250,482
1982	4,629	3,013	4,914	14,247	12,103	8,043	6,578	216,331	154,137	37,453	9,543	1,761	40,951	431,800
1983	5,228	3,017	5,044	13,363	10,313	5,662	6,843	220,801	154,137	37,453	9,543	1,761	36,093	437,071
1984	5,228	3,017	4,622	10,077	9,816	7,339	3,473	81,828	99,641	34,211	9,487	1,609	32,721	237,625
1985	5,196	3,011	4,902	13,247	9,028	4,646	3,180	97,752	97,506	37,269	9,491	1,554	32,617	254,162
1986	4,080	2,480	4,911	13,710	13,819	8,203	6,226	182,529	95,832	26,576	8,366	1,756	42,200	326,289
1987	4,784	2,550	3,648	9,482	9,280	6,322	850	86,952	95,036	35,080	2,504	737	28,945	228,280
1988	2,857	1,573	4,870	13,591	2,281	1,270	2,369	36,715	68,419	28,877	1,272	689	22,605	142,180
1989	2,003	1,411	2,925	7,265	2,363	8,529	3,700	58,475	91,560	36,107	8,898	1,218	22,007	202,446
1990	3,680	2,031	3,373	13,474	3,504	3,908	850	50,962	71,020	24,894	3,273	822	24,471	157,320
1991	2,050	1,287	968	3,211	2,637	9,145	1,229	54,530	36,039	22,301	3,022	816	16,268	120,967
1992	2,397	793	1,897	5,372	12,671	6,073	1,508	23,950	54,451	12,666	5,225	843	26,390	101,456
1993	1,896	1,073	3,199	14,792	13,124	8,900	5,052	109,637	145,215	37,263	9,161	1,756	41,277	309,790
1994	5,107	2,180	4,094	11,206	11,626	4,842	2,046	69,764	94,011	37,376	8,775	953	32,279	219,701
1995	3,286	1,219	4,711	14,410	13,396	9,058	7,709	223,235	154,137	37,453	9,543	1,761	43,502	436,415
1996	5,228	3,017	4,917	13,071	10,430	6,528	6,072	150,119	111,743	26,134	8,597	1,758	36,464	311,150
1997	3,687	3,014	5,172	13,538	12,379	6,890	4,060	81,803	94,717	20,931	9,495	1,433	38,994	218,126
1998	3,751	2,726	4,909	13,290	12,343	7,041	6,850	212,620	154,137	37,453	9,543	1,761	39,296	427,128
1999	5,228	3,017	4,989	13,306	11,010	7,430	5,465	94,808	101,524	31,415	9,085	1,756	38,101	250,932
2000	4,840	3,012	3,849	13,612	12,274	8,511	5,182	115,009	110,479	25,410	9,505	1,679	39,543	273,821
2001	4,575	2,914	4,919	13,894	12,722	8,205	2,244	48,146	43,599	29,273	3,005	851	40,302	134,047
2002	2,687	2,130	4,902	13,910	1,193	3,726	3,221	85,458	95,539	36,706	8,460	1,054	24,536	234,449
2003	2,645	3,008	4,884	13,584	1,399	7,150	4,667	135,981	108,869	26,990	9,356	1,653	28,183	292,003
Average	3,890	2,365	4,251	12,278	9,269	6,748	4,104	110,476	101,900	31,108	7,446	1,379	33,571	261,643

Source: ICF 2010:Appendix B

Table F-90. Entrainment Loss of Delta Smelt during Diversions onto the Reservoir Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated adult loss	% of baseline	Estimated juvenile loss	% of baseline
	Assumed density (Fish/thousand acre-feet)															
	7.9	4.6	7.3	19.8	18.1	13.5	12.9	363.6	265.9	55.4	14.2	2.6				
1980	0	0	0	104	0	0	0	0	0	0	0	0	105	0.3%	0	0.0%
1981	0	0	0	78	0	18	0	0	0	0	0	0	96	0.2%	0	0.0%
1982	0	0	38	0	0	0	0	0	0	0	0	0	39	0.1%	0	0.0%
1983	0	0	38	0	0	0	0	0	0	0	0	0	39	0.1%	0	0.0%
1984	0	0	38	0	0	0	0	0	0	0	0	0	39	0.1%	0	0.0%
1985	0	0	34	0	0	0	0	0	0	0	0	0	34	0.1%	0	0.0%
1986	0	0	0	0	103	2	0	0	0	0	0	0	105	0.2%	0	0.0%
1987	0	0	0	0	0	61	0	0	0	0	0	0	61	0.2%	0	0.0%
1988	0	0	0	89	0	0	0	0	0	0	0	0	89	0.4%	0	0.0%
1989	0	0	0	0	0	71	0	0	0	0	0	0	71	0.3%	0	0.0%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1991	0	0	0	0	0	8	0	0	0	0	0	0	8	0.1%	0	0.0%
1992	0	0	0	0	85	0	0	0	0	0	0	0	85	0.3%	0	0.0%
1993	0	0	0	104	0	0	0	0	0	0	0	0	105	0.3%	0	0.0%
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1995	0	0	0	104	0	0	0	0	0	0	0	0	105	0.2%	0	0.0%
1996	0	0	0	104	0	0	0	0	0	0	0	0	105	0.3%	0	0.0%
1997	0	0	38	0	0	0	0	0	0	0	0	0	39	0.1%	0	0.0%
1998	0	0	0	104	0	0	0	0	0	0	0	0	105	0.3%	0	0.0%
1999	0	0	38	0	0	0	0	0	0	0	0	0	39	0.1%	0	0.0%
2000	0	0	0	78	25	0	0	0	0	0	0	0	104	0.3%	0	0.0%
2001	0	0	0	0	19	0	0	0	0	0	0	0	19	0.0%	0	0.0%
2002	0	0	22	43	0	0	0	0	0	0	0	0	65	0.3%	0	0.0%
2003	0	0	38	0	0	0	0	0	0	0	0	0	38	0.1%	0	0.0%
Average	0	0	12	34	10	7	0	0	0	0	0	0	62	0.2%	0	0.0%

Source: ICF 2010:Appendix B

Table F-91. Entrainment Loss of Delta Smelt during Export of Water Discharged from the Project Islands

Water year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Estimated loss	% of baseline	Estimated loss	% of baseline
	Assumed density (Fish/thousand acre-feet)															
	7.9	4.6	7.3	19.8	18.1	13.5	12.9	363.6	265.9	55.4	14.2	2.6				
1980	0	0	0	0	0	0	0	0	0	0	1,753	25	0	0.0%	1,778	0.6%
1981	559	0	0	0	0	0	0	0	0	600	1,966	139	0	0.0%	3,265	1.3%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1984	0	0	0	0	0	0	0	0	0	1,300	0	146	0	0.0%	1,447	0.6%
1985	0	0	0	0	0	0	0	0	0	0	0	115	0	0.0%	115	0.0%
1986	697	0	0	0	0	0	0	0	0	6,575	1,129	0	0	0.0%	8,400	2.6%
1987	60	0	0	0	0	0	0	0	0	0	0	364	0	0.0%	424	0.2%
1988	0	0	0	0	0	0	0	0	0	2,396	2,222	0	0	0.0%	4,618	3.2%
1989	0	0	0	0	0	0	0	0	0	0	357	271	0	0.0%	628	0.3%
1990	152	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	152	0.1%
1991	0	0	0	0	0	0	0	0	0	1,129	0	0	0	0.0%	1,129	0.9%
1992	0	0	0	0	0	0	0	0	0	8,921	99	0	0	0.0%	9,020	8.9%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1994	91	386	0	0	0	0	0	0	0	0	0	0	0	0.0%	477	0.2%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1996	0	0	0	0	0	0	0	0	0	6,180	917	0	0	0.0%	7,097	2.3%
1997	225	0	0	0	0	0	0	0	0	7,640	0	179	0	0.0%	8,044	3.7%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0	0.0%
1999	0	0	0	0	0	0	0	0	0	5,420	0	0	0	0.0%	5,420	2.2%
2000	362	0	0	0	0	0	0	0	0	2,673	0	0	0	0.0%	3,035	1.1%
2001	632	81	0	0	0	0	0	0	0	1,899	0	0	0	0.0%	2,611	1.9%
2002	0	0	0	0	0	0	0	0	0	0	844	352	0	0.0%	1,197	0.5%
2003	0	0	0	0	0	0	0	0	0	1,827	0	0	0	0.0%	1,827	0.6%
Average	116	19	0	0	0	0	0	0	0	1,940	387	66	0	0.0%	2,528	1.0%

Source: ICF 2010:Appendix B

Table F-92. Entrainment Loss of Delta Smelt during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of adult fish	Number of juvenile fish
	Assumed density (Fish/thousand acre-feet)													
	7.9	4.6	7.3	19.8	18.1	13.5	12.9	363.6	265.9	55.4	14.2	2.6		
Agricultural diversions	1	0	2	6	5	0	0	98	358	89	17	1	13	564
Habitat Island diversions	0	0	0	0	0	0	0	1	4	1	0	0	0	6
Project Benefit	0	0	0	2	5	0	0	2	1	0	0	0	13	558

Source: ICF 2010:Appendix B

Table F-93. Summary of Adult Delta Smelt Entrainment Loss Effects of the Project Compared to the Baseline Conditions

			Project Diversion Effect[3]		Project Export Effect[4]		Baseline DW Agricultural Diversion	Project Habitat Diversion	Project Benefit from Reduced and Screened Agricultural Diversions[7]		Net Project Effect	
Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Loss	% of Baseline SWP/CVP	Loss	% of Baseline SWP/CVP	Loss[5]	Loss[6]	Reduced Loss	% of SWP/CVP	Loss	% of SWP/CVP
1980	39,070	256	105	0.3%	0	0.0%	13	0	13	0.0%	92	0.2%
1981	38,898	256	96	0.2%	0	0.0%	13	0	13	0.0%	83	0.2%
1982	40,951	256	39	0.1%	0	0.0%	13	0	13	0.0%	26	0.1%
1983	36,093	256	39	0.1%	0	0.0%	13	0	13	0.0%	26	0.1%
1984	32,721	256	39	0.1%	0	0.0%	13	0	13	0.0%	26	0.1%
1985	32,617	256	34	0.1%	0	0.0%	13	0	13	0.0%	22	0.1%
1986	42,200	256	105	0.2%	0	0.0%	13	0	13	0.0%	92	0.2%
1987	28,945	256	61	0.2%	0	0.0%	13	0	13	0.0%	48	0.2%
1988	22,605	256	89	0.4%	0	0.0%	13	0	13	0.1%	76	0.3%
1989	22,007	256	71	0.3%	0	0.0%	13	0	13	0.1%	58	0.3%
1990	24,471	256	0	0.0%	0	0.0%	13	0	13	0.1%	-13	-0.1%
1991	16,268	256	8	0.1%	0	0.0%	13	0	13	0.1%	-4	0.0%
1992	26,390	256	85	0.3%	0	0.0%	13	0	13	0.0%	72	0.3%
1993	41,277	256	105	0.3%	0	0.0%	13	0	13	0.0%	92	0.2%
1994	32,279	256	0	0.0%	0	0.0%	13	0	13	0.0%	-13	0.0%
1995	43,502	256	105	0.2%	0	0.0%	13	0	13	0.0%	92	0.2%
1996	36,464	256	105	0.3%	0	0.0%	13	0	13	0.0%	92	0.3%
1997	38,994	256	39	0.1%	0	0.0%	13	0	13	0.0%	26	0.1%
1998	39,296	256	105	0.3%	0	0.0%	13	0	13	0.0%	92	0.2%
1999	38,101	256	39	0.1%	0	0.0%	13	0	13	0.0%	26	0.1%
2000	39,543	256	104	0.3%	0	0.0%	13	0	13	0.0%	91	0.2%
2001	40,302	256	19	0.0%	0	0.0%	13	0	13	0.0%	6	0.0%
2002	24,536	256	65	0.3%	0	0.0%	13	0	13	0.1%	53	0.2%
2003	28,183	256	38	0.1%	0	0.0%	13	0	13	0.0%	26	0.1%
Average	33,571	256	62	0.2%	0	0.0%	13	0	13	0.0%	50	0.1%

Notes.

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction.

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Table F-94. Summary of Juvenile Delta Smelt Entrainment Loss Effects of the Project Compared to the Baseline Conditions

Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Project Diversion Effect[3] Loss	Project Diversion Effect[3] % of Baseline SWP/CVP	Project Export Effect[4] Loss	Project Export Effect[4] % of Baseline SWP/CVP	Baseline DW Agricultural Diversion Loss[5]	Project Habitat Diversion Loss[6]	Project Benefit from Reduced and Screened Agricultural Diversions[7] Reduced Loss	Project Benefit from Reduced and Screened Agricultural Diversions[7] % of SWP/CVP	Net Project Effect Loss	Net Project Effect % of SWP/CVP
1980	281,781	11,279	0	0.0%	1,778	0.6%	564	6	558	0.2%	1,220	0.4%
1981	250,482	11,279	0	0.0%	3,265	1.3%	564	6	558	0.2%	2,707	1.1%
1982	431,800	11,279	0	0.0%	0	0.0%	564	6	558	0.1%	-558	-0.1%
1983	437,071	11,279	0	0.0%	0	0.0%	564	6	558	0.1%	-558	-0.1%
1984	237,625	11,279	0	0.0%	1,447	0.6%	564	6	558	0.2%	889	0.4%
1985	254,162	11,279	0	0.0%	115	0.0%	564	6	558	0.2%	-443	-0.2%
1986	326,289	11,279	0	0.0%	8,400	2.6%	564	6	558	0.2%	7,842	2.4%
1987	228,280	11,279	0	0.0%	424	0.2%	564	6	558	0.2%	-134	-0.1%
1988	142,180	11,279	0	0.0%	4,618	3.2%	564	6	558	0.4%	4,060	2.9%
1989	202,446	11,279	0	0.0%	628	0.3%	564	6	558	0.3%	70	0.0%
1990	157,320	11,279	0	0.0%	152	0.1%	564	6	558	0.4%	-405	-0.3%
1991	120,967	11,279	0	0.0%	1,129	0.9%	564	6	558	0.5%	571	0.5%
1992	101,456	11,279	0	0.0%	9,020	8.9%	564	6	558	0.5%	8,462	8.3%
1993	309,790	11,279	0	0.0%	0	0.0%	564	6	558	0.2%	-558	-0.2%
1994	219,701	11,279	0	0.0%	477	0.2%	564	6	558	0.3%	-81	0.0%
1995	436,415	11,279	0	0.0%	0	0.0%	564	6	558	0.1%	-558	-0.1%
1996	311,150	11,279	0	0.0%	7,097	2.3%	564	6	558	0.2%	6,539	2.1%
1997	218,126	11,279	0	0.0%	8,044	3.7%	564	6	558	0.3%	7,486	3.4%
1998	427,128	11,279	0	0.0%	0	0.0%	564	6	558	0.1%	-558	-0.1%
1999	250,932	11,279	0	0.0%	5,420	2.2%	564	6	558	0.2%	4,862	1.9%
2000	273,821	11,279	0	0.0%	3,035	1.1%	564	6	558	0.2%	2,477	0.9%
2001	134,047	11,279	0	0.0%	2,611	1.9%	564	6	558	0.4%	2,054	1.5%
2002	234,449	11,279	0	0.0%	1,197	0.5%	564	6	558	0.2%	639	0.3%
2003	292,003	11,279	0	0.0%	1,827	0.6%	564	6	558	0.2%	1,269	0.4%
Average	261,643	11,279	0	0.0%	2,528	1.3%	564	6	558	0.2%	1,971	1.1%

Notes.

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction.

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Green Sturgeon

The baseline entrainment loss of green sturgeon by SWP and CVP averaged over 240 fish from 1980 to 2003 (Table F-95). The lowest entrainment loss of over 120 fish occurred in 1988 and the maximum entrainment was almost 310 fish in 1982. Direct entrainment loss of green sturgeon estimated for the Proposed Action was zero, or more accurately less than 0.1% fish per year (Table F-96); this represented an average increased entrainment over baseline conditions of 0–0.2%. Loss of green sturgeon due to export of discharged project water averaged 6 fish per year, with values ranging from 0 (several years) to 20 fish in 1988. This was 0–16.3% of baseline SWP/CVP losses (Table F-97).

Based on the assumed monthly density of green sturgeon and the schedule of diversions for agriculture (under the existing/baseline conditions) and for the Habitat Islands (under the project), it was estimated there would be a very small net benefit of the project: one less green sturgeon would be entrained annually (Table F-98). As a whole, the project was estimated to result in a net loss to green sturgeon because the potential increase in entrainment caused by project diversions (to the Reservoir and Habitat Islands) from December to March and the export of DW water from July to November was not offset by the decrease in entrainment attributable to the reduction and screening of the agricultural diversions. This net loss averaged 5 fish per year, or 2.6% of the baseline entrainment by SWP and CVP (Table F-99).

Table F-95. Baseline Entrainment Loss of Green Sturgeon by SWP and CVP Export Facilities Assumed in the Analysis of Small Juvenile and Adult Fish

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	
	Assumed density (Fish/thousand acre-feet)												Estimated
Water year	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.4	0.1	loss
1980	10	19	18	2	19	15	15	5	1	46	79	30	259
1981	12	15	16	2	21	17	9	4	1	53	71	24	245
1982	12	19	18	2	21	18	17	8	2	55	105	30	308
1983	14	19	18	2	18	12	18	8	2	55	105	30	303
1984	14	19	17	2	17	16	9	3	1	50	105	28	281
1985	14	19	18	2	16	10	8	4	1	55	105	27	278
1986	11	16	18	2	24	18	16	7	1	39	92	30	275
1987	13	16	13	1	16	14	2	3	1	51	28	13	172
1988	8	10	18	2	4	3	6	1	1	42	14	12	121
1989	5	9	11	1	4	19	10	2	1	53	98	21	234
1990	10	13	12	2	6	9	2	2	1	36	36	14	144
1991	5	8	4	1	5	20	3	2	0	33	33	14	128
1992	6	5	7	1	22	13	4	1	1	19	58	15	151
1993	5	7	12	2	23	20	13	4	2	55	101	30	274
1994	13	14	15	2	20	11	5	3	1	55	97	16	252
1995	9	8	17	2	24	20	20	9	2	55	105	30	300
1996	14	19	18	2	18	14	16	6	1	38	95	30	272
1997	10	19	19	2	22	15	11	3	1	31	105	25	262
1998	10	18	18	2	22	15	18	8	2	55	105	30	303
1999	14	19	18	2	19	16	14	4	1	46	100	30	285
2000	13	19	14	2	22	19	14	4	1	37	105	29	279
2001	12	19	18	2	22	18	6	2	1	43	33	15	190
2002	7	14	18	2	2	8	8	3	1	54	93	18	229
2003	7	19	18	2	2	16	12	5	1	40	103	29	254
Average	10	15	15	2	16	15	11	4	1	46	82	24	242

Source: ICF 2010:Appendix B

Table F-96. Entrainment Loss of Green Sturgeon during Diversions onto the Reservoir Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)												Estimated	% of
Water year	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.4	0.1	loss	baseline
1980	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1981	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0%
1982	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
1983	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
1984	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
1985	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
1986	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2%
1987	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2%
1988	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1989	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.2%
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1992	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.2%
1993	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1994	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1996	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1997	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
1998	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0%
1999	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
2000	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0%
2001	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0%
2002	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1%
2003	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.1%
Average	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1%

Source: ICF 2010:Appendix B

Table F-97. Entrainment Loss of Green Sturgeon during Export of Water Discharged from the Project Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep		
	Assumed density (Fish/thousand acre-feet)													
Water year	0.0	0.1	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.2	0.4	0.1	Estimated loss	% of baseline
1980	0	0	0	0	0	0	0	0	0	0	14	0	14	5.4%
1981	1	0	0	0	0	0	0	0	0	1	15	2	19	7.6%
1982	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1983	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1984	0	0	0	0	0	0	0	0	0	1	0	2	3	1.1%
1985	0	0	0	0	0	0	0	0	0	0	0	1	1	0.5%
1986	1	0	0	0	0	0	0	0	0	7	9	0	17	6.1%
1987	0	0	0	0	0	0	0	0	0	0	0	4	5	2.6%
1988	0	0	0	0	0	0	0	0	0	2	17	0	20	16.3%
1989	0	0	0	0	0	0	0	0	0	0	3	3	6	2.6%
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2%
1991	0	0	0	0	0	0	0	0	0	1	0	0	1	0.9%
1992	0	0	0	0	0	0	0	0	0	9	1	0	10	6.6%
1993	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1994	0	2	0	0	0	0	0	0	0	0	0	0	2	0.8%
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1996	0	0	0	0	0	0	0	0	0	6	7	0	13	5.0%
1997	0	0	0	0	0	0	0	0	0	8	0	2	10	4.0%
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%
1999	0	0	0	0	0	0	0	0	0	6	0	0	6	2.0%
2000	1	0	0	0	0	0	0	0	0	3	0	0	3	1.2%
2001	1	0	0	0	0	0	0	0	0	2	0	0	3	1.8%
2002	0	0	0	0	0	0	0	0	0	0	7	4	11	4.7%
2003	0	0	0	0	0	0	0	0	0	2	0	0	2	0.7%
Average	0	0	0	0	0	0	0	0	0	2	3	1	6	2.5%

Source: ICF 2010:Appendix B

Table F-98. Entrainment Loss of Green Sturgeon during Existing Agricultural Diversions Compared to Entrainment Loss during Project Diversions to the Habitat Islands

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Number of fish
	Assumed density (Fish/thousand acre-feet)												
	0.0	**0.1**	**0.1**	**0.0**	**0.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.2**	**0.4**	**0.1**	
Agricultural diversions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.1	1
Habitat Island diversions	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Project Benefit	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.1	1

Source: ICF 2010:Appendix B

Table F-99. Summary of Green Sturgeon Entrainment Loss Effects of the Project Compared to the Baseline Conditions

Year	Baseline CVP/SWP Loss[1]	Baseline Delta Lowland Agriculture Loss[2]	Project Diversion Effect[3] Loss	Project Diversion Effect[3] % of Baseline SWP/CVP	Project Export Effect[4] Loss	Project Export Effect[4] % of Baseline SWP/CVP	Baseline DW Agricultural Diversion Loss[5]	Project Habitat Diversion Loss[6]	Project Benefit from Reduced and Screened Agricultural Diversions[7] Reduced Loss	Project Benefit from Reduced and Screened Agricultural Diversions[7] % of SWP/CVP	Net Project Effect Loss	Net Project Effect % of SWP/CVP
1980	259	17	0	0.0%	14	5.4%	1	0	1	0.3%	13	5.1%
1981	245	17	0	0.0%	19	7.6%	1	0	1	0.3%	18	7.3%
1982	308	17	0	0.1%	0	0.0%	1	0	1	0.3%	-1	-0.2%
1983	303	17	0	0.1%	0	0.0%	1	0	1	0.3%	-1	-0.2%
1984	281	17	0	0.1%	3	1.1%	1	0	1	0.3%	3	0.9%
1985	278	17	0	0.1%	1	0.5%	1	0	1	0.3%	1	0.3%
1986	275	17	0	0.2%	17	6.1%	1	0	1	0.3%	16	6.0%
1987	172	17	0	0.2%	5	2.6%	1	0	1	0.5%	4	2.3%
1988	121	17	0	0.0%	20	16.3%	1	0	1	0.7%	19	15.7%
1989	234	17	0	0.2%	6	2.6%	1	0	1	0.4%	6	2.4%
1990	144	17	0	0.0%	0	0.2%	1	0	1	0.6%	-1	-0.4%
1991	128	17	0	0.0%	1	0.9%	1	0	1	0.6%	0	0.3%
1992	151	17	0	0.2%	10	6.6%	1	0	1	0.5%	9	6.3%
1993	274	17	0	0.0%	0	0.0%	1	0	1	0.3%	-1	-0.3%
1994	252	17	0	0.0%	2	0.8%	1	0	1	0.3%	1	0.4%
1995	300	17	0	0.0%	0	0.0%	1	0	1	0.3%	-1	-0.3%
1996	272	17	0	0.0%	13	5.0%	1	0	1	0.3%	13	4.7%
1997	262	17	0	0.1%	10	4.0%	1	0	1	0.3%	10	3.8%
1998	303	17	0	0.0%	0	0.0%	1	0	1	0.3%	-1	-0.3%
1999	285	17	0	0.1%	6	2.0%	1	0	1	0.3%	5	1.8%
2000	279	17	0	0.0%	3	1.2%	1	0	1	0.3%	3	1.0%
2001	190	17	0	0.0%	3	1.8%	1	0	1	0.4%	3	1.4%
2002	229	17	0	0.1%	11	4.7%	1	0	1	0.4%	10	4.5%
2003	254	17	0	0.1%	2	0.7%	1	0	1	0.3%	1	0.5%
Average	242	17	0	0.1%	6	2.9%	1	0	1	0.4%	5	2.6%

Notes.

[1]Based on average of monthly fish densities at salvage (fish/taf) extrapolated to account for pre- and postsalvage losses and multiplied by export flows.

[2] Assumes baseline loss is 20 times that of the DW Agricultural diversion loss (based on DW being 5% of irrigated Delta acreage).

[3]Assumes diversions from December to March, 50% small-intake correction, and 95% screening efficiency.

[4]Increased loss of fish assuming SWP export of discharged project water from July to November.

[5]Assumes similar pattern of agricultural diversions each year, and10% small-intake correction.

[6]Assumes 95% screening efficiency, 10% small-intake correction, and similar pattern of habitat diversions each year.

[7] Calculated as entrainment loss to existing DW agricultural diversions minus entrainment loss to project wetland habitat diversions.

Source: ICF 2010:Appendix B

Effects of Old and Middle River Flows on Delta Smelt Loss

The USWFS (2008a) OCAP BO for delta smelt examined a number of potential hydrodynamic variables that could quantitatively predict losses of adult and juvenile delta smelt. For adults, a predictive equation was developed (USFWS 2008a, 212) that described percentage loss in terms of Old and Middle River (OMR) flows:

> Adult entrainment loss (Annual % of whole population) = 6.243 – 0.000957*OMR flows (average, December–March).

The estimates of percentage loss were from Kimmerer's (2008, 21) estimates based on FMWT data from 1995 to 2006. The equation suggested that as OMR flows decrease, entrainment loss of adult delta smelt increases. The equation explained a modest proportion of the variability in the data (Adjusted $R^2 = 0.36$). USFWS (2008a, 212) noted that the unexplained variability is because "adult salvage and entrainment is not solely explained by OMR flows" and that "there is wide, apparently random variation in the use of the Central and South Delta by spawning delta smelt." However, USFWS (2008a, 212) suggested that the approach remained useful because "it provides expected salvage and entrainment losses given an OMR flow."

Losses of larval-juvenile delta smelt (as estimated by Kimmerer [2008, 23] for 1995–2006) were also described in terms of OMR flows, but with the addition of a second predictor, X2. Two predictive equations were described by USFWS (2008a, 220):

> Larval-juvenile loss (March–June % of whole population) = (0.00933*March–June X2) – (0.000207*March–June OMR) – 0.556 (Adjusted $R^2 = 0.90$);

> Larval-juvenile loss (April–May % of whole population) = (0.00839*April–May X2) – (0.000029*April–May OMR) – 0.487 (Adjusted $R^2 = 0.87$).

The two equations were developed "to demonstrate that the conclusions are robust with regard to the choice of averaging period" (USFWS 2008a, 220). Estimates for 1995 and 1998 were excluded during model formulation because "the relationship between [OMR, X2, and entrainment loss] is linear when only years that had entrainment higher than 0 were modeled" (USFWS 2008a, 220). The equations suggested that the percentage loss of larval-juvenile delta smelt would increase as OMR flows decrease and as X2 increases (i.e., moves upstream).

There is a potential for the project to influence OMR flows during the assumed diversion period (December–March). Measured OMR flows will not be affected because the OMR flow measurement gauges are upstream of the Reservoir

Islands diversions on Webb Tract and Bacon Island. Although the project intakes will be screened and therefore will probably exclude 95% of fish large enough to be screened, diversions may make delta smelt more susceptible to entrainment by the SWP/CVP export facilities. This possibility was examined by assuming project diversions would decrease OMR flows and therefore increase entrainment loss of delta smelt at the export facilities. It is probable that this analysis represents a worse-case scenario because project diversions are unlikely to cause the same population-level losses as SWP/CVP exports of Delta water.

Methods

For analyses of both adult and larval-juvenile delta smelt, losses were calculated for baseline conditions and for project conditions using the equations calculated by USFWS (2008a; 212, 22) described above. The values of OMR flows and X2 that were used in the predictive equations were averages of monthly averages from the IDSM/CALSIM outputs calculated for each period (adults: December–March; larvae/juveniles: March–June). The March–June averaging period was used for larvae/juveniles because the April–May period would not overlap the assumed project diversion period (December–March). Kimmerer's (2008) estimates of % loss were not provided by USFWS (2008a), so the equations were applied without any attempt to adjust for possible differences in the OMR and X2 input values between this analysis of project effects and that of USFWS (2008a). Calculations of average X2 for March–June used data from February to June because the flows simulated for the project operations provided end-of-month values. The equations predict negative losses in some years; following USFWS (2008a), negative values were changed to zeros before calculating average loss over the baseline period.

Main Assumptions

The main assumptions of this analysis were:

- Diversions to the Reservoir Islands occur in December–March;
- Project diversions to the Reservoir Islands on Webb Tract and Bacon Island decrease OMR flows by the same amount of flow that is diverted and therefore increase the percentage of adult and juvenile delta smelt that is lost due to entrainment at the SWP/CVP export facilities;
- Loss of adult delta smelt to entrainment at the SWP/CVP export facilities is influenced by OMR flows from December to March and can be estimated from an equation in the USFWS (2008a) OCAP BO;
- Loss of larval-juvenile delta smelt to entrainment at the SWP/CVP export facilities is influenced by OMR flows from March to June and can be estimated from an equation in the USFWS (2008a) OCAP BO.

Results

Adult Delta Smelt

Baseline December–March losses of delta smelt adults due to entrainment at the SWP/CVP export facilities from 1980 to 2003 averaged 10.7% of the population and ranged from 0% in 1983 to 14.8% in 2001 (Table F-100). Additional losses due to project diversions decreasing OMR flows averaged 0.70% of the population and ranged from 0% in 1989 and 1994 to 0.94% in 1986 (Table F-100).

Table F-100. Predicted Percentage Losses of Adult Delta Smelt in December–March 1980–2003 Due to Entrainment by the SWP/CVP Export Facilities Under Baseline and Project Conditions

Year	Baseline	Project
1980	8.97%	0.84%
1981	14.42%	0.84%
1982	11.17%	0.85%
1983	0.00%	0.85%
1984	7.50%	0.85%
1985	13.08%	0.75%
1986	9.40%	0.93%
1987	12.35%	0.72%
1988	11.25%	0.72%
1989	11.14%	0.84%
1990	11.57%	0.00%
1991	9.67%	0.10%
1992	11.56%	0.75%
1993	13.63%	0.84%
1994	13.22%	0.00%
1995	12.43%	0.84%
1996	11.42%	0.84%
1997	0.37%	0.85%
1998	9.40%	0.84%
1999	12.31%	0.85%
2000	12.81%	0.86%
2001	14.77%	0.17%
2002	11.39%	0.84%
2003	12.53%	0.84%

Source: ICF 2010:Appendix B

Larval-Juvenile Delta Smelt

Baseline March–June losses of delta smelt larvae/juveniles due to entrainment at the SWP/CVP export facilities from 1980 to 2003 averaged 17.4% of the population and ranged from 0% in 1983 to 27.0% in 1991 (Table F-101). Additional losses due to project diversions decreasing OMR flows averaged 0.24% of the population and ranged from 0% in 1994 to almost 2% in 1989 (Table F-101).

Table F-101. Predicted Percentage Losses of Larval-Juvenile Delta Smelt in March-June 1980–2003 Due to Entrainment by the SWP/CVP Export Facilities Under Baseline and Project Conditions

Year	Baseline	Project
1980	10.81%	0.04%
1981	25.30%	0.64%
1982	6.58%	0.02%
1983	0.00%	0.02%
1984	17.12%	0.02%
1985	26.43%	0.06%
1986	6.90%	0.08%
1987	24.01%	1.85%
1988	23.41%	0.11%
1989	25.40%	1.99%
1990	25.96%	0.00%
1991	26.98%	0.25%
1992	22.82%	0.30%
1993	17.77%	0.05%
1994	26.02%	0.00%
1995	6.20%	0.03%
1996	10.03%	0.03%
1997	16.04%	0.02%
1998	3.31%	0.05%
1999	14.43%	0.03%
2000	17.37%	0.08%
2001	23.19%	0.08%
2002	20.69%	0.04%
2003	21.10%	0.03%

Source: ICF 2010:Appendix B

Through-Delta Migration of Salmonids Originating in the Sacramento River Watershed and the Mokelumne River

Outmigrating Central Valley salmonid smolts must pass through the Delta. Endangered Sacramento River winter-run Chinook salmon and threatened Central Valley spring-run Chinook salmon currently spawn only within the Sacramento River watershed (Moyle et al. 2008); threatened Central Valley steelhead originate mostly from the Sacramento River watershed because the San Joaquin watershed populations are diminished to very low abundance (McEwan 2001). Fish entering the Delta from the Sacramento River may migrate through the river's mainstem or through smaller tributaries to the west (Sutter and Steamboat sloughs). Other fish may enter the central Delta through two main routes, the Delta Cross Channel (DCC) and Georgiana Slough. The proportion of fish entering the central Delta depends on the position of the DCC gates (open or closed) and the amount of flow in the Sacramento River. NMFS (2009, 631) describes an average of about 45% of Sacramento River flow being diverted into the central Delta through the DCC and Georgiana Slough, with 25% being diverted in November and December. Smolts entering the central Delta have reduced probability of surviving passage through the Delta compared to smolts remaining in the mainstem or entering Steamboat and Sutter sloughs. Brandes and McLain (2001) summarized coded-wire-tag studies that showed survival to Chipps Island (just downstream of the Delta) for fish passing through the central Delta (having been released in Georgiana Slough) was around half that of fish released on the mainstem Sacramento River (at Ryde) at low export levels, declining to around 15% of at high export levels (~10,000 cfs). Lower survival may have been a result of the greater distance to travel (37%; White 1998, as cited by Brandes and McLain 2001) but could also have been due to greater residence time caused by lower river flows and high levels of export. A greater residence time in the central Delta may expose fish to an increased threat of predation or poorer water quality compared to the mainstem Sacramento River (NMFS 2009).

Methods

The previous analysis included in the 2001 FEIS and preceding draft documents included a model by Kjelson et al. (1989) to assess the possible effects of the Proposed Action on outmigrating salmonids. A similar approach was adopted in this analysis based on more recent information. An assessment was made of the potential effects of the Proposed Action on mortality of salmonid smolts migrating through the Delta from the Sacramento River. For each salmonid species (i.e., steelhead and winter-run, spring-run, fall-run, and late-fall-run Chinook salmon), the percentage of the total number of smolts entering the Delta in each month was assumed to be the same as the values used in the analysis of fish entrainment (Table F-102), which corresponded to observed migration patterns deduced from salvage data. Baseline mortality (percentage of all smolts entering the Delta) was calculated for the SWP/CVP exports over 1980-2003.

The additional mortality increment attributable to the Proposed Action was then calculated and compared to the baseline value.

Main Assumptions

The main assumptions of the analysis were:

- Brandes and McLain's (2001) findings can be applied to steelhead and winter-run and spring-run Chinook salmon (their observations were for fall-run and late-fall-run Chinook salmon);
- The DCC gates are closed from January to June;
- If the DCC gates are closed, the flow of water into the Central Delta is represented by 0.133(Sacramento River flow at Hood, cfs) + 829;
- If the DCC gates are open, the flow of water into the Central Delta is represented by 0.293(Sacramento River flow at Hood, cfs) + 2090;
- The percentage of smolts leaving the Sacramento River and entering the central Delta is equivalent to the percentage of Sacramento River flow entering the central Delta;
- 90% of smolts entering the Delta and remaining in the Sacramento River (or passing through Steamboat and Sutter Sloughs) would survive to Chipps Island (i.e., 10% mortality)—this mortality rate is at the high end of recent estimates based on acoustic tagging (e.g., Perry and Skalski 2008, as cited by NMFS 2009);
- 45% of smolts entering the Delta and subsequently moving into the central Delta through the DCC or Georgiana Slough would survive to Chipps Island at zero exports (i.e., a minimum of 55% mortality would always occur for smolts);
- Additional mortality of smolts passing through the central Delta would be proportional to the amount of exports, up to a maximum of 100% mortality (at exports of 15,000 cfs), in addition to the 20% baseline central Delta mortality (i.e., a total minimum survival of 0% or maximum mortality of 100% for fish entering the central Delta);
- Project diversions to storage can be treated similarly to increased levels of export, except that the associated mortality is reduced by 50% (due to the intakes being smaller and screened, but acknowledging the potential for the diversions to cause salmonids to follow false migration cues such as reversed flows, resulting in greater probability of predation within the Delta channels or entrainment by the SWP/CVP export facilities);
- Project discharges to export are equivalent to increased levels of export (however, no exports were simulated as occurring during the salmonids' outmigration periods, so there was no effect of this aspect of the Proposed Action in this analysis);
- Diversions for agriculture under the baseline conditions or to the Habitat Islands under the Proposed Action gave negligible effects on mortality

(always <0.01% total-population mortality, with the project beneficial effect of removing the unscreened agricultural diversions always being greater than the negative effects of the habitat island diversions)—these effects were therefore excluded from the analysis for simplicity.

- The percentage mortality due to the project of fall-run Chinook salmon and steelhead originating in the Mokelumne River can be estimated from the percentage of Sacramento River fish that entered the central Delta and the total mortality attributable to the project of these fish: % mortality of Mokelumne fish = % mortality of Sacramento fish × (100/% of Sacramento fish entering the central Delta). This assumes that the path of Sacramento-origin fish through the central Delta is similar to those from the Mokelumne River.

The mortality index should not be construed as the actual level of mortality that would occur because simulated monthly conditions cannot accurately characterize the complex conditions and variable time periods that affect survival during migration through the Delta. The mortality index provides a basis for comparing the effects of the Proposed Action operations on outmigrating salmonid smolts that could result from changes in diversions and Delta flows.

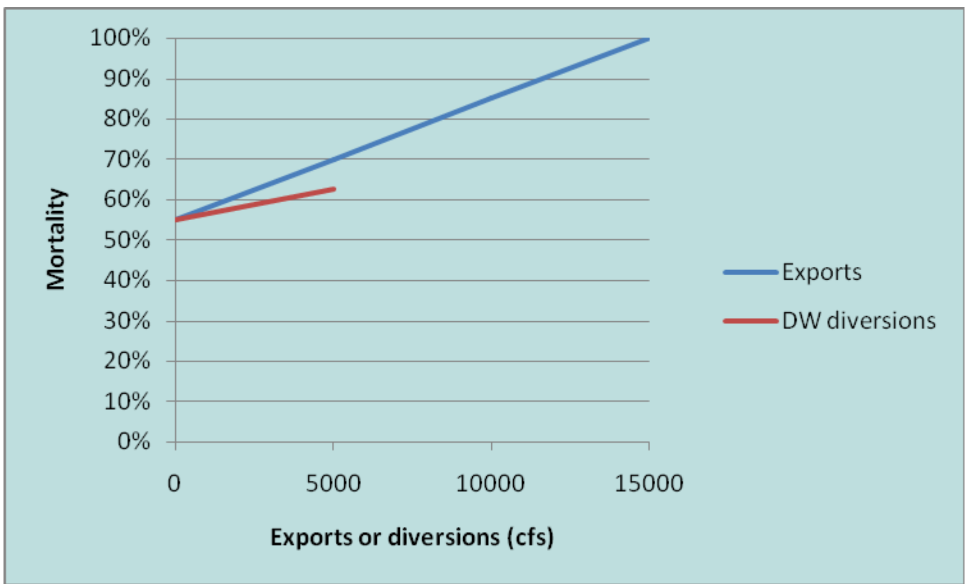


Figure F-3. Assumed Increases in Salmonid Through-Delta Mortality with Increases in SWP/CVP Exports and Proposed Action Diversions. A baseline 55% mortality is assumed to occur for all salmonids entering the central Delta through the Delta Cross Channel or Georgiana Slough.

Source: ICF 2010:Appendix B

Table F-102. Monthly Percentages of Juvenile Salmonids Entering the Delta that were used in the Analysis of Through-Delta Migration Mortality

Salmonid	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fall-run Chinook	0.9%	5.9%	2.8%	11.3%	54.4%	22.0%	0.4%	0.0%	0.0%	0.8%	1.1%	0.3%
Late-fall-run Chinook	9.8%	4.3%	0.0%	0.0%	0.0%	0.4%	0.0%	0.0%	0.1%	5.5%	25.9%	53.9%
Winter-run Chinook	0.0%	0.6%	8.8%	63.5%	26.5%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Spring-run Chinook	11.7%	46.8%	23.2%	5.7%	0.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	11.9%
Steelhead	8.2%	26.2%	28.7%	22.4%	9.8%	1.1%	0.1%	0.0%	0.0%	0.1%	1.1%	2.2%

Source: ICF 2010:Appendix B

Results

Fall-Run Chinook Salmon

Total mortality of fall-run Chinook salmon juveniles between the Sacramento River entrance to the Delta and Chipps Island averaged 23.9% from 1980 to 2003 and ranged from 22.5% in 2003 to 26.1% in 1986 (Table F-103). The proportion of juveniles entering the central Delta averaged 19.3% (range: 15.1% [1983] to 24.2% [1990]). Baseline mortality through the central delta due to SWP/CVP exports plus predation and reduced water quality averaged 13.9% and ranged from 12.5% (2003) to 16.1% (1986). Mortality attributable to the Proposed Action diversions averaged 0.02% (range: 0% [several years] to 0.08% [1986]) (Table F-103).

Table F-103. Annual Mortality of Fall-Run Chinook Salmon Juveniles Originating in the Sacramento River Watershed during Through-Delta Migration under Simulated Baseline and Proposed Action Conditions. Values represent losses of fish entering the Delta on the Sacramento River.

Year	Total mortality	Sacramento River mortality (assumed)	% entering central Delta	Baseline % mortality (CVP/SWP + predation/water quality losses in central Delta)	Proposed Action % mortality
1980	24.6%	10.0%	19.6%	14.6%	0.01%
1981	24.8%	10.0%	20.6%	14.8%	0.03%
1982	23.8%	10.0%	16.3%	13.8%	0.00%
1983	22.8%	10.0%	15.1%	12.8%	0.00%
1984	23.7%	10.0%	19.5%	13.7%	0.01%
1985	23.9%	10.0%	19.5%	13.9%	0.01%
1986	26.1%	10.0%	20.2%	16.1%	0.08%
1987	23.9%	10.0%	20.0%	13.9%	0.02%
1988	24.2%	10.0%	22.4%	14.1%	0.01%
1989	23.3%	10.0%	19.9%	13.2%	0.02%
1990	25.5%	10.0%	24.2%	15.5%	0.00%
1991	25.0%	10.0%	23.8%	15.0%	0.00%
1992	23.8%	10.0%	21.9%	13.7%	0.06%
1993	22.8%	10.0%	17.1%	12.8%	0.01%
1994	24.4%	10.0%	21.0%	14.4%	0.02%
1995	23.4%	10.0%	15.7%	13.4%	0.01%
1996	22.8%	10.0%	16.6%	12.8%	0.02%
1997	24.0%	10.0%	19.8%	14.0%	0.02%
1998	23.3%	10.0%	15.8%	13.3%	0.01%
1999	22.9%	10.0%	17.8%	12.9%	0.01%
2000	24.0%	10.0%	18.7%	13.9%	0.03%
2001	24.3%	10.0%	21.7%	14.2%	0.03%
2002	23.7%	10.0%	20.0%	13.7%	0.01%
2003	22.5%	10.0%	16.9%	12.5%	0.01%
Average	23.9%	10.0%	19.3%	13.9%	0.02%

Notes: CVP = Central Valley Project; SWP = State Water Project

Source: ICF 2010:Appendix B

Late-Fall-Run Chinook Salmon

Total mortality of late-fall-run Chinook salmon juveniles between the Sacramento River entrance to the Delta and Chipps Island averaged 38.7% from 1980 to 2003 and ranged from 24.3% in 1984 to 45.5% in 1987 (Table F-104). The proportion of juveniles entering the central Delta averaged 35.2% (range: 16.1% [1984] to 54.3% [1991]). Baseline mortality through the central Delta due to SWP/CVP exports plus predation and reduced water quality averaged 28.5% and ranged from 13.9% (1984) to 35.5% (1987). Mortality attributable to the Proposed Action diversions averaged 0.23% (range: 0.00% [1989 and 1991] to 0.99% [1985]) (Table F-104).

Table F-104. Annual Mortality of Late-Fall-Run Chinook Salmon Juveniles Originating in the Sacramento River Watershed during Through-Delta Migration under Simulated Baseline and Proposed Action Conditions. Values represent losses of fish entering the Delta on the Sacramento River.

Year	Total mortality	Sacramento River mortality (assumed)	% entering central Delta	Baseline % mortality (CVP/SWP + predation/water quality losses in central Delta)	Proposed Action % mortality
1980	43.1%	10.0%	37.5%	33.0%	0.08%
1981	45.0%	10.0%	41.4%	34.8%	0.16%
1982	25.0%	10.0%	16.5%	14.6%	0.41%
1983	24.8%	10.0%	16.2%	14.4%	0.41%
1984	24.3%	10.0%	16.1%	13.9%	0.41%
1985	37.9%	10.0%	30.5%	27.0%	0.99%
1986	44.6%	10.0%	39.9%	34.4%	0.15%
1987	45.5%	10.0%	43.7%	35.5%	0.02%
1988	43.9%	10.0%	41.5%	33.8%	0.07%
1989	44.7%	10.0%	47.5%	34.7%	0.00%
1990	42.7%	10.0%	41.9%	32.7%	0.03%
1991	44.9%	10.0%	54.3%	34.9%	0.00%
1992	45.1%	10.0%	52.2%	35.1%	0.03%
1993	43.5%	10.0%	45.4%	33.4%	0.08%
1994	44.8%	10.0%	41.7%	34.2%	0.54%
1995	43.9%	10.0%	41.9%	33.9%	0.07%
1996	32.6%	10.0%	25.5%	22.5%	0.08%
1997	31.5%	10.0%	24.0%	21.0%	0.45%
1998	43.3%	10.0%	38.3%	33.2%	0.08%
1999	25.7%	10.0%	17.3%	15.3%	0.44%
2000	44.7%	10.0%	41.2%	34.6%	0.13%
2001	44.8%	10.0%	39.3%	34.6%	0.22%
2002	31.9%	10.0%	26.7%	21.6%	0.30%
2003	31.1%	10.0%	24.2%	20.7%	0.45%
Average	38.7%	10.0%	35.2%	28.5%	0.23%

Notes: CVP = Central Valley Project; SWP = State Water Project
Source: ICF 2010:Appendix B

Winter-Run Chinook Salmon

Total mortality of winter-run Chinook salmon juveniles between the Sacramento River entrance to the Delta and Chipps Island averaged 25.3% from 1980 to 2003 and ranged from 21.6% in 2002 to 27.8% in 2001 (Table F-105). The proportion of juveniles entering the central Delta averaged 19.0% (range: 14.4% [1983] to 26.6% [1991]). Baseline mortality through the central Delta due to SWP/CVP exports plus predation and reduced water quality averaged 15.2% and ranged from 11.5% (2002) to 17.7% (2001). Mortality attributable to the Proposed Action diversions averaged 0.12% (range: 0% [1990 and 1994] to 0.39% [1986]) (Table F-105).

Table F-105. Annual Mortality of Winter-Run Chinook Salmon Juveniles Originating in the Sacramento River Watershed during Through-Delta Migration under Simulated Baseline and Proposed Action Conditions. Values represent losses of fish entering the Delta on the Sacramento River.

Year	Total mortality	Sacramento River mortality (assumed)	% entering central Delta	Baseline % mortality (CVP/SWP + predation/water quality losses in central Delta)	Proposed Action % mortality
1980	25.3%	10.0%	17.8%	15.2%	0.09%
1981	27.1%	10.0%	19.8%	17.0%	0.13%
1982	22.8%	10.0%	14.5%	12.7%	0.09%
1983	22.1%	10.0%	14.4%	12.0%	0.09%
1984	22.9%	10.0%	15.7%	12.8%	0.09%
1985	27.6%	10.0%	21.6%	17.3%	0.22%
1986	26.6%	10.0%	18.2%	16.2%	0.39%
1987	27.0%	10.0%	21.4%	16.8%	0.17%
1988	26.1%	10.0%	23.0%	16.0%	0.09%
1989	27.0%	10.0%	23.9%	16.8%	0.18%
1990	26.1%	10.0%	22.8%	16.1%	0.00%
1991	27.5%	10.0%	26.6%	17.5%	0.02%
1992	27.6%	10.0%	22.4%	17.3%	0.36%
1993	26.3%	10.0%	18.9%	16.2%	0.09%
1994	27.3%	10.0%	21.2%	17.3%	0.00%
1995	26.4%	10.0%	18.2%	16.3%	0.09%
1996	22.5%	10.0%	14.9%	12.5%	0.10%
1997	23.4%	10.0%	15.5%	13.3%	0.09%
1998	25.4%	10.0%	17.6%	15.3%	0.09%
1999	22.8%	10.0%	14.9%	12.7%	0.10%
2000	26.1%	10.0%	18.6%	15.9%	0.17%
2001	27.8%	10.0%	20.3%	17.7%	0.08%
2002	21.6%	10.0%	16.8%	11.5%	0.10%
2003	21.9%	10.0%	16.4%	11.8%	0.10%
Average	25.3%	10.0%	19.0%	15.2%	0.12%

Notes: CVP = Central Valley Project; SWP = State Water Project

Source: ICF 2010:Appendix B

Spring-Run Chinook Salmon

Total mortality of spring-run Chinook salmon juveniles between the Sacramento River entrance to the Delta and Chipps Island averaged 22.9% from 1980 to 2003 and ranged from 21.8% in 1993 to 24.5% in 1986 (Table F-106). The proportion of juveniles entering the central Delta averaged 18.2% (range: 14.7% [1983] to 22.0% [1990]). Baseline mortality through the central Delta due to SWP/CVP exports plus predation and reduced water quality averaged 12.9% and ranged from 11.8% (1993) to 14.5% (1986). Mortality attributable to the Proposed Action diversions averaged 0.01% (range: 0.00% [many years] to 0.07% [1987 and 1989]) (Table F-106).

Table F-106. Annual Mortality of Spring-Run Chinook Salmon Juveniles Originating in the Sacramento River Watershed during Through-Delta Migration under Simulated Baseline and Proposed Action Conditions. Values represent losses of fish entering the Delta on the Sacramento River.

Year	Total mortality	Sacramento River mortality (assumed)	% entering central Delta	Baseline % mortality (CVP/SWP + predation/water quality losses in central Delta)	Proposed Action % mortality
1980	23.8%	10.0%	18.3%	13.8%	0.00%
1981	23.8%	10.0%	19.7%	13.8%	0.02%
1982	22.2%	10.0%	14.8%	12.2%	0.00%
1983	22.1%	10.0%	14.7%	12.1%	0.00%
1984	23.0%	10.0%	18.8%	13.0%	0.00%
1985	23.5%	10.0%	19.8%	13.5%	0.00%
1986	24.5%	10.0%	18.2%	14.5%	0.01%
1987	22.5%	10.0%	20.0%	12.5%	0.07%
1988	23.5%	10.0%	21.5%	13.5%	0.00%
1989	22.2%	10.0%	17.6%	12.1%	0.07%
1990	23.3%	10.0%	22.0%	13.3%	0.00%
1991	23.0%	10.0%	20.7%	13.0%	0.01%
1992	22.6%	10.0%	20.4%	12.6%	0.00%
1993	21.8%	10.0%	15.8%	11.8%	0.00%
1994	23.1%	10.0%	20.3%	13.1%	0.00%
1995	22.7%	10.0%	14.8%	12.7%	0.00%
1996	22.1%	10.0%	15.6%	12.1%	0.00%
1997	23.2%	10.0%	18.8%	13.2%	0.00%
1998	22.4%	10.0%	15.1%	12.4%	0.00%
1999	22.6%	10.0%	17.0%	12.6%	0.00%
2000	23.2%	10.0%	17.6%	13.2%	0.00%
2001	23.5%	10.0%	20.8%	13.5%	0.00%
2002	22.7%	10.0%	18.9%	12.7%	0.00%
2003	22.1%	10.0%	16.4%	12.1%	0.00%
Average	22.9%	10.0%	18.2%	12.9%	0.01%

Notes: CVP = Central Valley Project; SWP = State Water Project

Source: ICF 2010:Appendix B

Steelhead

Total mortality of steelhead juveniles between the Sacramento River entrance to the Delta and Chipps Island averaged 23.8% from 1980 to 2003 and ranged from 22.0% in 1983 to 25.4% in 2001 (Table F-107). The proportion of juveniles entering the central Delta averaged 18.0% (range: 14.6% [1983] to 22.3% [1991]). Baseline mortality through the central delta due to SWP/CVP exports plus predation and reduced water quality averaged 13.8% and ranged from 11.9% (1983) to 15.3% (2001). Mortality attributable to the project averaged 0.07% (range: 0.00% [1990] to 0.23% [1986 and 1989]) (Table F-107). The average percentage loss for steelhead originating in the Mokelumne River was 0.41% (range: 0.00% [1990] to 1.32% [1986]).

Table F-107. Annual Mortality of Steelhead Juveniles Originating in the Sacramento River Watershed during Through-Delta Migration under Simulated Baseline and Proposed Action Conditions. Values represent losses of fish entering the Delta on the Sacramento River.

Year	Total mortality	Sacramento River mortality (assumed)	% entering central Delta	Baseline % mortality (CVP/SWP + predation/water quality losses in central Delta)	Proposed Action % mortality
1980	23.8%	10.0%	17.0%	13.8%	0.06%
1981	25.0%	10.0%	18.6%	14.9%	0.12%
1982	22.6%	10.0%	14.7%	12.6%	0.02%
1983	22.0%	10.0%	14.6%	11.9%	0.02%
1984	22.9%	10.0%	16.8%	12.9%	0.02%
1985	25.0%	10.0%	19.9%	14.9%	0.04%
1986	24.8%	10.0%	17.1%	14.6%	0.23%
1987	24.5%	10.0%	19.4%	14.3%	0.21%
1988	24.3%	10.0%	22.0%	14.2%	0.06%
1989	24.3%	10.0%	19.8%	14.0%	0.23%
1990	24.4%	10.0%	21.5%	14.4%	0.00%
1991	25.1%	10.0%	22.3%	15.1%	0.03%
1992	24.7%	10.0%	20.1%	14.5%	0.20%
1993	24.0%	10.0%	16.8%	13.9%	0.07%
1994	24.9%	10.0%	19.9%	14.9%	0.02%
1995	24.0%	10.0%	15.9%	13.9%	0.06%
1996	22.6%	10.0%	15.5%	12.5%	0.07%
1997	23.7%	10.0%	17.2%	13.7%	0.02%
1998	23.4%	10.0%	15.7%	13.3%	0.07%
1999	22.6%	10.0%	15.6%	12.6%	0.02%
2000	24.1%	10.0%	16.9%	14.0%	0.11%
2001	25.4%	10.0%	19.4%	15.3%	0.05%
2002	22.3%	10.0%	18.0%	12.3%	0.04%
2003	22.5%	10.0%	16.8%	12.4%	0.02%

Average	23.9%	10.0%	18.0%	13.8%	0.07%

Notes: CVP = Central Valley Project; SWP = State Water Project
Source: ICF 2010:Appendix B

Changes in Estuarine Habitat Area

Changes in estuarine habitat area between baseline and project conditions were assessed using the same methods as those described in the 2001 FEIS and preceding draft documents. Salinity is an important habitat factor, and estuarine habitat is often defined in terms of a salinity range (Hieb and Baxter 1993). All estuarine species are assumed to have optimal salinity ranges, and different life stages within a species often vary in their salinity preferences. Species year-class production may be determined partly by the amount of rearing habitat available within the optimal salinity range (Unger 1994), although this is still under investigation (Kimmerer et al. 2009).

Methods

Rearing habitat area, based on the estimated optimal salinity range, was calculated for striped bass and delta and longfin smelt. The optimal salinity range was based on the locations of 10^{th} and 90^{th} percentiles of abundance from survey data: 0.1–2.5 ppt for striped bass larvae (5–9 mm), 0.3–1.8 ppt for delta smelt larvae and early juveniles, and 1.1–18.5 ppt for longfin smelt larvae and early juveniles (< 50 mm).

The Bay-Delta estuary has a complex shape, and the area of optimal salinity habitat varies greatly with its location. The geographical location of the upstream and downstream limits of the optimal salinity habitat was computed from monthly average Delta outflow and the optimal salinity range of the species. The surface area at 1-km segments from the Golden Gate to 100 km upstream was based on estimates made from nautical charts for the 2001 FEIS and preceding draft documents (Table F-108; Figure F-4). It was assumed that there was no functional habitat above km 100.

The project's operations effects on X2 were determined from the changes in Delta outflow, according to the monthly X2 equation developed from historical data (Kimmerer and Monismith 1992) as:

X2 (km) = 122.2 + 0.3278 (previous month X2) -17.65 x log [Outflow (cfs)]

The upstream and downstream limits of the optimal salinity range were calculated using the following equation (Unger 1994):

$$X2 \times [\frac{\ln \frac{31-S}{0.1\,0.07 \times S}}{-7} - 1.5]$$

where X2 is the end-of-month X2 position and S is either the upstream or downstream limit of the optimal salinity range.

Total area of optimal salinity habitat was computed for each month through addition of all areas contained between the upstream and downstream limits of the optimal salinity range.

Table F-108. Habitat Area (km^2) per km Upstream from the Golden Gate Bridge

km	area	km	area	km	area	km	area
0	1.5	26	11.8	52	1.8	78	1.5
1	9.2	27	13.0	53	1.9	79	1.8
2	6.6	28	13.2	54	2.0	80	1.5
3	7.1	29	17.8	55	1.8	81	2.8
4	6.6	30	17.1	56	1.5	82	3.8
5	5.6	31	15.5	57	2.0	83	2.0
6	17.1	32	16.2	58	3.1	84	2.0
7	15.5	33	15.8	59	3.6	85	2.5
8	15.5	34	16.0	60	3.8	86	2.3
9	15.8	35	16.2	61	4.3	87	2.3
10	15.0	36	16.3	62	6.9	88	2.3
11	13.5	37	12.2	63	8.4	89	2.3
12	12.0	38	12.2	64	6.6	90	3.1
13	9.9	39	10.7	65	7.4	91	2.3
14	6.1	40	9.4	66	5.9	92	1.8
15	5.9	41	3.6	67	3.2	93	1.8
16	7.0	42	3.1	68	3.6	94	3.1
17	14.0	43	2.0	69	3.2	95	4.6
18	10.3	44	2.3	70	3.1	96	3.6
19	8.9	45	1.8	71	3.2	97	2.3
20	7.6	46	0.8	72	3.9	98	1.8
21	6.1	47	1.0	73	3.9	99	1.3
22	6.6	48	0.8	74	3.6	100	1.8
23	4.8	49	2.0	75	1.0		
24	5.5	50	1.5	76	1.3		
25	9.2	51	1.5	77	1.3		

Source: 1995 DEIR/EIS, Appendix A, Figure 9; cited in ICF 2010:Appendix B

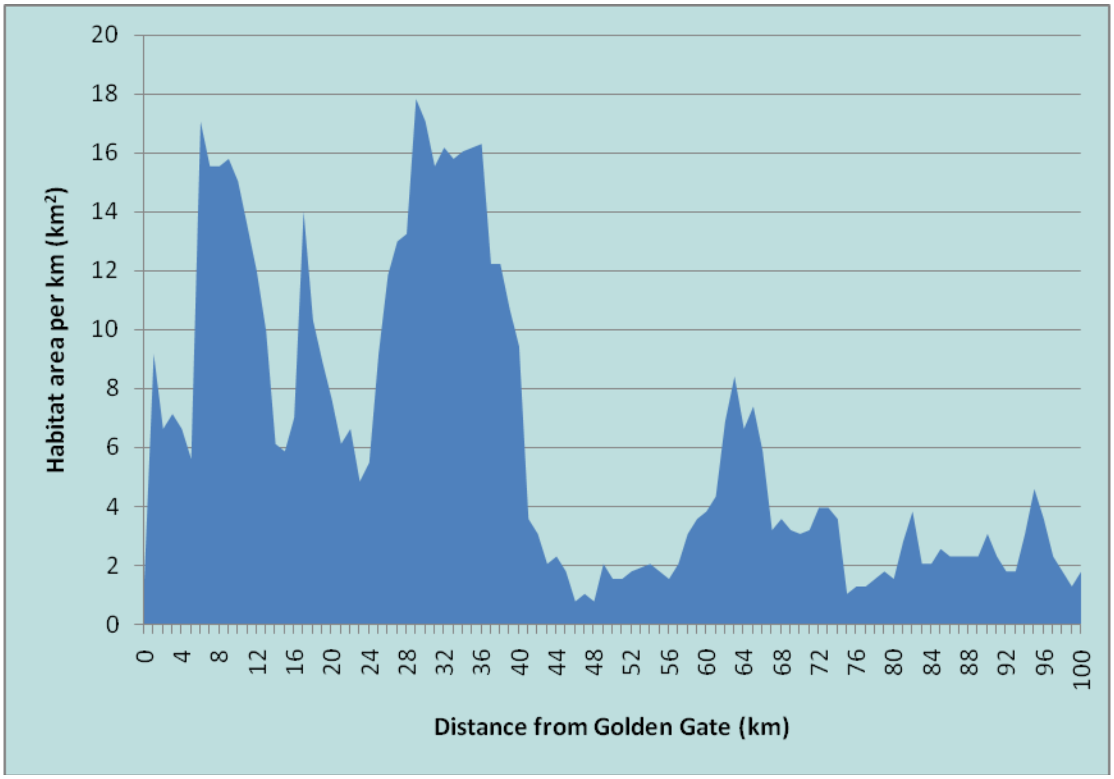


Figure F-4. Habitat Area (km^2) per km Upstream from the Golden Gate Bridge

Source: 1995 DEIR/EIS, Appendix A, Figure 9; cited in ICF 2010:Appendix B.

The annual optimal salinity habitat area (by water year, from 1980 to 2003) was the weighted sum of all months. Weighting was by month and was based on the monthly mean relative abundance of larvae and early juveniles (Table F-109; Unger 1994). Thus, if larvae are present only in April and May, if the area of optimal salinity habitat in April and May is 50 km^2 and 100 km^2, respectively, and if the proportion of larvae present in April and May is 30% and 70%, respectively, the weighted area would be (50 × 0.3) + (100 × 0.7) = 15 + 70 = 85 km^2. Weightings applied to longfin smelt were altered somewhat compared to the values used by Unger (1994) because more recent larval survey data (California Department of Fish and Game 2009a) suggested that a greater proportion of larvae were present in January.

Table F-109. Monthly Weights Applied in the Analysis of Change in Optimal Salinity Area due to Project Operations

Species	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Delta smelt (larvae/early juveniles)	0	0	0	0	0.05	0.1	0.2	0.3	0.2	0.1	0.05	0
Longfin smelt (larvae/early juveniles)	0	0	0.1	0.15	0.4	0.25	0.09	0.01	0	0	0	0
Striped bass (larvae)	0	0	0	0	0	0	0.12	0.52	0.34	0.02	0	0

Source: ICF 2010:Appendix B

Main Assumptions

The assumptions of this analysis were:

- diversions to the Reservoir Islands occur in December–March;
- discharges for export occur in July–November;
- there is no functional habitat for delta smelt, longfin smelt, or striped bass above km 100 of the Sacramento River;
- the monthly weightings of relative abundance of the larval fish remain the same in all years;
- monthly minimum and maximum isohaline positions can be reasonably predicted from X2 position.

Results

Delta Smelt

Optimal salinity habitat for larval/early-juvenile Delta smelt averaged 51.0 km^2 under baseline conditions (range: 43.2–64.6 km^2). Under the Proposed Action, the average, minimum, and maximum area of optimal salinity habitat remained essentially the same. The average change in optimal salinity habitat area attributable to the Proposed Action was actually an increase of 0.09% (0.04 km^2), ranging from a gain of 1.90% (0.9 km^2) in 1987 to a loss of 1.6% (0.79 km^2) in 1981 (Figure F-5).

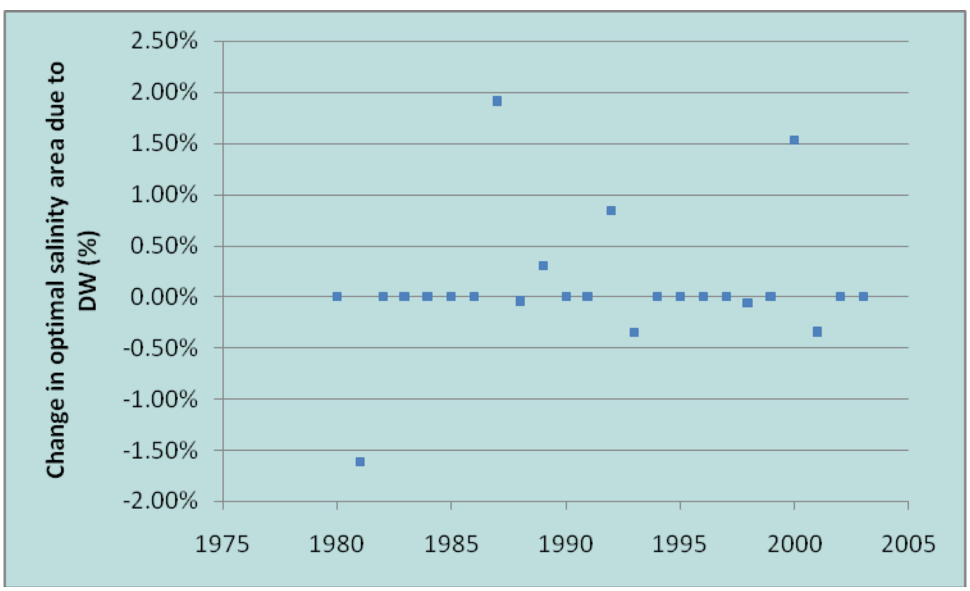


Figure F-5. Change in Larval/Early-Juvenile Delta Smelt Optimal Salinity Habitat Area Attributable to the Proposed Action (in relation to baseline conditions from 1980 to 2003)

Source: ICF 2010:Appendix B

Longfin Smelt

Optimal salinity habitat for larval/early-juvenile longfin smelt averaged 159.9 km^2 under baseline conditions (range: 121.1–226.1 km^2). Under the Proposed Action, the average area of the optimal salinity habitat was reduced to 159.6 km^2 (range: 120.3–226.1 km^2). The average decrease in optimal salinity habitat area attributable to the Proposed Action was 0.17% (0.26 km^2), ranging from a gain of 1.2% (2.34 km^2) in 1995 to a loss of 3.1% (5.74 km^2) in 1996 (Figure F-6).

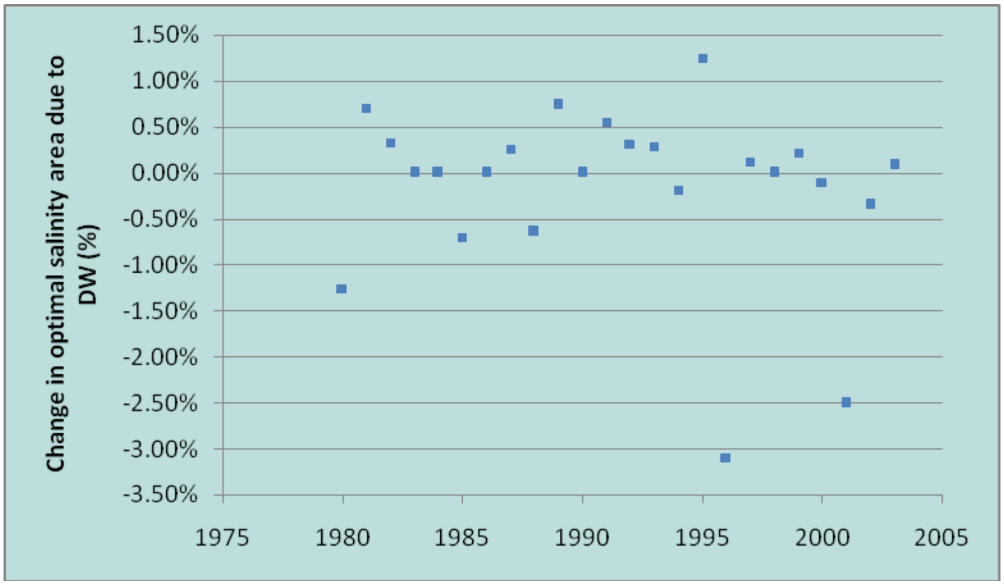


Figure F-6. Change in Larval/Early-Juvenile Longfin Smelt Optimal Salinity Habitat Area Attributable to the Proposed Action (in relation to baseline conditions from 1980 to 2003)

Source: ICF 2010:Appendix B

Striped Bass

Optimal salinity habitat for larval striped bass averaged 75.6 km^2 under baseline conditions (range: 51.9–100.7 km^2). Under the Proposed Action, the average area of the optimal salinity habitat was marginally reduced to 75.5 km^2 (range: 51.9–100.7 km^2). The average decrease in optimal salinity habitat area attributable to the Proposed Action was 0.16% (0.11 km^2), ranging from 0% (0 km^2) in nearly all years to a loss of 2.4% (1.65 km^2) in 2002 (Figure F-7). The relatively few years with change in area are likely to be a result of the coarseness of the analysis inputs (1-km segments of estuarine area were considered, whereas change probably would have occurred at a finer scale).

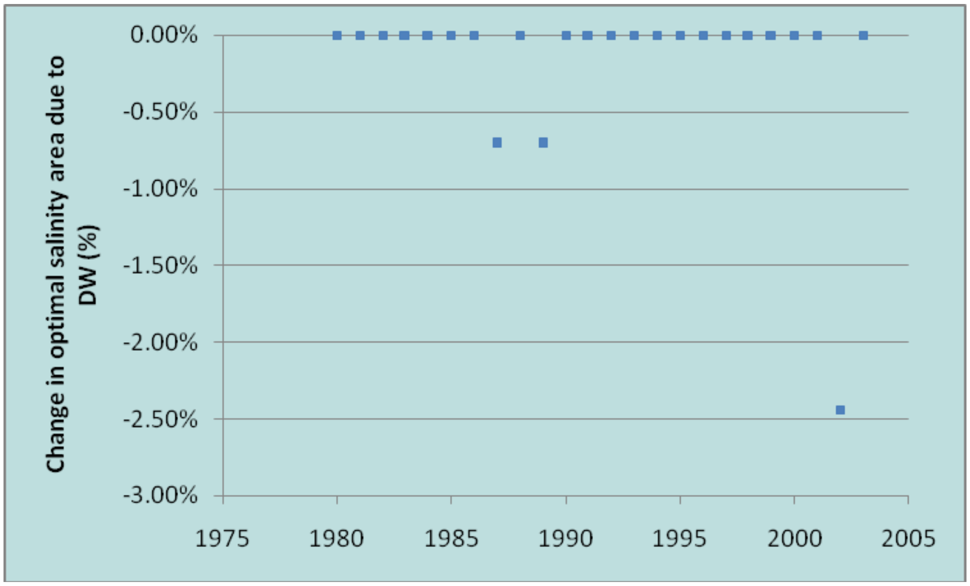


Figure F-7. Change in Larval Striped Bass Optimal Salinity Habitat Area Attributable to the Proposed Action (in relation to baseline conditions from 1980 to 2003)

Source: ICF 2010:Appendix B

Changes in Fish Population Abundance and Survival Caused by Shifts in X2

Beginning two decades ago, increasing concern over declines in estuarine species populations in the Bay-Delta spurred research into indicators of habitat quality or quantity (see Jassby et al. [1995] for a succinct summary). Use of the salinity field as an indicator was of interest "because it is well-defined and measurable, has ecological significance, integrates a number of important estuarine properties and processes, and is meaningful to a large number of constituencies" (Jassby et al. 1995, 274). The longitudinal location of the 2 ppt isohaline (X2) was chosen as a suitable indicator because knowledge of X2 allows the entire mean salt field to be calculated (i.e., where other salinity isohalines would be predicted to be) and also because its location is close to the entrapment zone and the estuarine turbidity maximum, regions of high zooplankton abundance with corresponding importance for juvenile fish (Jassby et al. 1995). Regressions of aquatic animal abundance or survival versus X2 have suggested the importance of X2 as a predictor in several studies (Jassby et al. 1995, Kimmerer 2002). In most cases, movement upstream of X2 is correlated with a decrease in abundance or survival. The mechanisms underlying the link between X2 and fish abundance or survival are not clear: X2 may indicate quantity of habitat available or perhaps likelihood of retention within the entrapment zone (Kimmerer et al. 2009). Regardless, a number of significant X2-abundance relationships have been documented, most recently by Kimmerer et al. (2009). Some of the species for which relationships have been noted include those of conservation interest (longfin smelt) and recreational fishing importance (striped bass and American shad).

Delta smelt is a species for which a simple relationship between abundance and X2 does not exist, at least in recent years as the population has declined (Kimmerer 2009). As noted in the USFWS (2008, 236) OCAP delta smelt BO, indices of juvenile Delta smelt abundance from summer townet surveys are positively related to fall midwater trawl indices in the previous year, from 1987 onwards. Prediction of juvenile abundance from adult abundance is greatly improved when the average X2 location from September to December is included in the regression as a habitat indicator during the juvenile/subadult phase of the life cycle. The USFWS (2008) analysis built on the relationship noted by Feyrer et al. (2007), which used mean conductivity as the covariate rather than X2. In any case, a straightforward stock-recruitment relationship is suggested, wherein higher abundance of subadults in the fall presumably leads to higher abundance of spawning adults and thence to higher abundance of juveniles the following summer. Survival or growth of subadults in the fall may be enhanced by variables correlated with lower salinity or X2 being located further downstream.

The possible effects of the Proposed Action on the abundance or survival of several estuarine species due to X2 position alteration were assessed. It should be borne in mind that the regression relationships used in the analyses are based on data with an appreciable degree of variability, so that differences between baseline/existing conditions and the Proposed Action are typically much closer to each other than to the actual observed values. Assuming the abundance and survival indices are representative of the whole populations involved, then this analysis offers the advantage of placing the effects of the project into the context of a whole population. This contrasts with the entrainment analyses based on salvage, which generally only examine the relative change in entrainment and do not indicate the population as a whole (unless an independent measure of population size can be obtained by other means; see section on "Population-Level Entrainment Estimates" below).

Methods

Kimmerer et al. (2009, 382) provided equations for significant relationships between X2 and survival or abundance of several species. Of these, striped bass survival from egg to first summer (Kimmerer 2002), American shad abundance, and longfin smelt abundance were chosen as representative examples of estuarine species that could be affected by the project (Table F-110). The basic equation was:

> Log_{10} (Predicted abundance or survival) = intercept + (slope × mean X2 position) + (step change × year dummy

The year dummy variable equaled zero before the step change and one after the step change. The mean X2 position was calculated for periods in each year corresponding to the early life stages of each species.

End-of-month X2 location was calculated for the simulated baseline condition. Predicted abundance indices of longfin smelt and American shad (from fall midwater trawl surveys) and survival indices of striped bass (from summer townet surveys) were calculated for the average baseline X2 location during several months of each year from 1967 to 2003. It was assumed that end-of-month X2 averaged for the period of interest for each species (Table F-110) was similar to the X2 averaging used by Kimmerer et al. (2009). The process was repeated for the X2 position under simulated project conditions in order to assess the predicted change in abundance or survival indices from baseline attributable to the project.

Table F-110. Regression Statistics from the Analysis of X2-Abundance/Survival. The equations were used to analyze the effects of the Proposed Action.

Species	Source	N	*P*	Intercept	Slope (± confidence limits)	Step change (± confidence limits)	Comment
American shad (abundance index)	FMWT[a]	38	0.004	4.0	-0.013 (± 0.009)	0.21 (± 0.20)	1967–2007[b]; step change in 1987–1988; Feb–May X2 averaging period
Longfin smelt (abundance index)	FMWT[a]	38	<0.0001	7.0	-0.05 (± 0.01)	-0.81 (± 0.28)	1967–2007[b]; step change in 1987–1988; Jan–Jun X2 averaging period
Striped bass (survival from egg to first summer; Kimmerer 2002)	TNS[c]	32	<0.0001	4.6	-0.025 (± 0.011)	-0.79 (± 0.30)	1978–2007; step change in 1995–1996; Apr–Jun X2 averaging period

Notes:
[a] FMWT – fall midwater trawl survey.
[b] No data for 1974 and 1979.

[c] TNS – summer townet survey.
Source: Kimmerer et al. 2009, 382; cited in ICF 2010:Appendix B

For delta smelt, a procedure was developed that was similar to that adopted by the USFWS (2008) in the OCAP BO. A regression equation was calculated that predicted the juvenile delta smelt summer townet indices from 1988 to 2007 (California Department of Fish and Game 2009b) from the fall midwater trawl indices from 1987 to 2006 (California Department of Fish and Game 2008) and mean end-of-month X2 location for an August to December averaging period. The derived equation was:

> Summer Townet Index = 26.67 + 0.00759 × (Fall Midwater Trawl index in previous year) – 0.304 × (mean end-of-month X2 in previous August–December), r^2 = 64.2%

This compares quite closely to the equation derived for a slightly shorter time period by USFWS (2008, 268):

> Summer Townet Index = 29.12 + 0.00708 × (Fall Midwater Trawl index in previous year) – 0.328 × (mean X2 in previous September–December), r^2 = 60.6%

The predicted summer townet indices from 1987 to 2003 were calculated under baseline conditions and then for the Proposed Action, first using the actual fall midwater trawl indices and modeled mean X2 values, then with the FMWT index held constant at a) the median value of 280 used by USFWS (2008), b) the recent low value of 23 observed in 2008, and c) a high value of around 1,000 that was observed in 1993.

Main Assumptions

The main assumptions of this analysis were:

- Diversions to the Reservoir Islands occur in December–March;
- Discharges for export occur in July–November;
- Occasional releases of project water for Delta outflow occur in September–November;
- The average position of X2 for a period in a species' early life determines abundance or survival later in life;
- Relationships between X2 and abundance index or survival developed by Kimmerer et al. (2009) are valid for use with average end-of-month X2 values during the early life stages of a species;
- For delta smelt, the abundance index of juveniles in the summer townet survey can be predicted from the previous year's fall midwater trawl abundance index and average fall X2 position;
- Changes in abundance index are representative of changes in the overall population's absolute abundance.

Results

American Shad

The predicted FMWT index of American shad under the Proposed Action was on average 0.25% lower than the baseline (Table F-111). The greatest percentage reduction attributable to the Proposed Action was in 1992 (1.18%) and there were also increases in several years, the largest of which was 0.13% in 1994 (Table F-111). Differences in predicted FMWT indices between the modeled baseline and project conditions were considerably less than differences between either baseline or project conditions and the actual FMWT indices.

Table F-111. Results of the Analysis Comparing Predicted Fall Midwater Trawl Indices of American Shad from Average End-Of-Month X2 Location (February–May) for Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change	Actual
1967	1,720	1,718	-0.13%	3,422
1968	1,313	1,309	-0.28%	758
1969	1,971	1,969	-0.09%	3,688
1970	1,519	1,521	0.08%	856
1971	1,415	1,414	-0.07%	1,459
1972	1,106	1,095	-0.97%	335
1973	1,547	1,544	-0.19%	1,085
1975	1,556	1,550	-0.38%	2,491
1977	839	839	0.00%	636
1978	1,622	1,619	-0.17%	2,364
1980	1,640	1,639	-0.10%	3,916
1981	1,137	1,129	-0.71%	1,434
1982	2,087	2,086	-0.04%	5,389
1983	2,417	2,416	-0.02%	2,931
1984	1,411	1,411	-0.02%	817
1985	1,006	1,004	-0.22%	1,598
1986	1,766	1,764	-0.12%	1,860
1987	1,078	1,065	-1.14%	899
1988	1,568	1,561	-0.46%	1,550
1989	1,844	1,831	-0.70%	1,878
1990	1,529	1,529	0.01%	4,316
1991	1,575	1,572	-0.15%	2,988
1992	1,708	1,688	-1.18%	2,010
1993	2,463	2,459	-0.17%	5,157
1994	1,614	1,616	0.13%	1,334
1995	3,246	3,243	-0.09%	6,812
1996	2,997	2,994	-0.08%	4,286
1997	2,388	2,388	-0.03%	2,594
1998	3,352	3,347	-0.15%	4,140
1999	2,655	2,653	-0.08%	715
2000	2,524	2,517	-0.28%	764

Year	Baseline	Project	% change	Actual
2001	1,760	1,754	-0.31%	765
2002	1,976	1,973	-0.17%	1,919
2003	2,213	2,210	-0.12%	9,360
Average	1,840	1,836	-0.25%	2,545
Source: ICF 2010:Appendix B				

Longfin Smelt

The predicted FMWT index of longfin smelt under the Proposed Action was on average 1.02% lower than the baseline (Table F-112). The greatest percentage reduction attributable to the Proposed Action was in 1981 (3.69%) and there were also increases in several years, the largest of which was 1.07% in 1994 (Table F-112). Differences in predicted FMWT indices between the modeled baseline and project conditions were considerably less than differences between either baseline or project conditions and the actual FMWT indices.

Table F-112. Results of the Analysis Comparing Predicted Fall Midwater Trawl Indices of Longfin Smelt from Average End-Of-Month X2 Location (January–June) for Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change	Actual
1967	10,359	10,255	-1.00%	81,737
1968	3,092	3,026	-2.13%	3,279
1969	16,081	15,971	-0.68%	59,350
1970	7,194	7,245	0.70%	6,515
1971	5,044	5,019	-0.48%	15,903
1972	1,686	1,655	-1.82%	760
1973	6,408	6,316	-1.43%	5,896
1975	4,998	4,992	-0.11%	2,819
1977	653	653	0.00%	210
1978	7,031	6,941	-1.28%	6,619
1980	7,852	7,795	-0.73%	31,184
1981	1,991	1,917	-3.69%	2,202
1982	17,714	17,660	-0.31%	62,905
1983	34,389	34,347	-0.12%	11,864
1984	5,480	5,475	-0.08%	7,408
1985	1,301	1,278	-1.75%	992
1986	6,770	6,760	-0.14%	6,160
1987	1,493	1,449	-2.96%	1,520
1988	200	193	-3.54%	791
1989	267	262	-1.82%	456
1990	153	153	0.09%	243
1991	147	146	-0.39%	134
1992	205	199	-3.01%	76
1993	977	964	-1.27%	798
1994	178	180	1.07%	545
1995	2,552	2,534	-0.72%	8,205

Year	Baseline	Project	% change	Actual
1996	1,564	1,555	-0.59%	1,346
1997	1,073	1,071	-0.19%	690
1998	2,849	2,815	-1.16%	6,654
1999	1,079	1,072	-0.61%	5,243
2000	764	751	-1.80%	3,437
2001	242	240	-0.55%	245
2002	448	442	-1.35%	707
2003	710	703	-0.91%	467
Average	4,498	4,472	-1.02%	9,922
Source: ICF 2010: Appendix B				

Striped Bass

The predicted egg-to-juvenile survival index of striped bass under the Proposed Action was on average 0.13% lower than the baseline (Table F-113). The greatest percentage reduction attributable to the Proposed Action was in 1987 (0.96%) and there were also slight increases in several years, the largest of which was 0.04% in 1994 (Table F-113).

Table F-113. Results of the Analysis Comparing Predicted Egg-To-Juvenile Survival Indices of Striped Bass from Average End-Of-Month X2 Location (January–June) for Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change
1978	927	926	-0.05%
1979	647	646	-0.24%
1980	735	735	-0.03%
1981	479	478	-0.40%
1982	1,525	1,524	-0.01%
1983	2,041	2,041	0.00%
1984	624	624	-0.01%
1985	458	457	-0.06%
1986	792	792	-0.04%
1987	471	466	-0.96%
1988	395	394	-0.12%
1989	548	545	-0.59%
1990	354	354	0.00%
1991	387	386	-0.13%
1992	425	423	-0.32%
1993	932	932	-0.05%
1994	419	419	0.04%
1995	1,701	1,700	-0.03%
1996	178	178	-0.02%
1997	95	95	-0.01%
1998	266	266	-0.04%
1999	129	129	-0.02%

Year	Baseline	Project	% change
2000	111	110	-0.08%
2001	73	73	-0.08%
2002	84	84	-0.05%
2003	127	127	-0.03%
Average	574	573	-0.13%
Source: ICF 2010:Appendix B			

Delta Smelt

For the analysis using observed FMWT indices, the predicted summer townet index of delta smelt under the Proposed Action was on average 1.16% greater than the baseline (Table F-114). The greatest percentage increase attributable to the Proposed Action was in 1989 (6.03%) whereas 2001 had the greatest decrease (0.71%). Differences in predicted summer townet indices between the modeled baseline and Project conditions were generally noticeably less than differences between either baseline or Project conditions and the actual summer townet indices.

The analyses using fixed values of the FMWT indices also gave average increases in predicted summer townet indices: as the fixed FWMT index decreased, so the average relative increase in predicted summer townet index went up (Tables B-115, B-116, and B-117). Thus the average change in predicted summer townet index was an increase of 6.06% for an FMWT index of 23, 2.02% for an FMWT index of 280, and 0.75% for an FMWT index of 1,000. The ranges of change also got correspondingly wider: for an FMWT index of 23 the range was from a decrease of 3.25% to an increase of 29.49%; for an FMWT index of 280 the range was from a decrease of 1.25% to an increase of 8.48%; and for an FMWT index of 1,000 the range was from a decrease of 0.46% to an increase of 3.19% (Tables B-115, B-116, and B-117).

Overall, the average predicted increase in summer townet index of juvenile delta smelt was attributable to the modeled Proposed Action scenario of beneficial water releases in October and November of some years. These releases moved X2 downstream and resulted in increased abundance because of the inverse relationship between X2 and summer townet index described in the regression equation above.

Table F-114. Results of the Analysis Comparing Predicted Summer Townet Indices of Delta Smelt from the Previous Year's Fall Midwater Trawl Index and Average End-Of-Month X2 Location (August–December) For Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change	Actual
1987	2.6	2.7	5.21%	1.2
1988	1.3	1.3	0.00%	2.2
1989	3.3	3.5	6.03%	2.2
1990	2.7	2.7	0.00%	2.0
1991	5.2	5.2	0.00%	2.6
1992	1.3	1.3	-0.01%	8.2
1993	9.0	9.3	2.79%	13.0
1994	1.3	1.3	0.00%	3.2
1995	10.1	10.4	3.43%	11.1
1996	4.0	3.9	-0.42%	4.0
1997	3.2	3.2	0.00%	3.3
1998	8.4	8.5	0.42%	11.9
1999	7.6	7.7	1.53%	8.0
2000	6.7	6.8	2.07%	3.5
2001	5.6	5.6	-0.71%	4.7
2002	2.8	2.7	-0.59%	1.6
2003	2.8	2.8	0.00%	2.9
Average	4.6	4.6	1.16%	5.0
Source: ICF 2010:Appendix B				

Table F-115. Results of the Analysis Comparing Predicted Summer Townet Indices of Delta Smelt from a Fixed Fall Midwater Trawl Index of 280 and Average End-Of-Month X2 Location (August–December) for Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change
1987	2.6	2.7	5.21%
1988	2.1	2.1	0.00%
1989	2.6	2.8	7.53%
1990	2.0	2.0	0.00%
1991	2.1	2.1	0.00%
1992	2.2	2.2	-0.01%
1993	3.0	3.2	8.48%
1994	2.6	2.6	0.00%
1995	5.4	5.7	6.43%
1996	5.1	5.1	-0.32%
1997	3.0	3.0	0.00%
1998	7.4	7.4	0.48%
1999	3.2	3.3	3.65%
2000	3.1	3.2	4.50%
2001	3.2	3.1	-1.25%
2002	3.8	3.8	-0.42%
2003	3.4	3.4	0.00%

Year	Baseline	Project	% change
Average	3.3	3.4	2.02%
Source: ICF 2010:Appendix B			

Table F-116. Results of the Analysis Comparing Predicted Summer Townet Indices of Delta Smelt from A Fixed Fall Midwater Trawl Index of 23 and Average End-Of-Month X2 Location (August–December) for Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change
1987	0.6	0.8	21.02%
1988	0.2	0.2	-0.03%
1989	0.7	0.9	29.49%
1990	0.1	0.1	0.00%
1991	0.1	0.1	-0.04%
1992	0.3	0.3	-0.04%
1993	1.0	1.3	24.77%
1994	0.7	0.7	0.00%
1995	3.4	3.8	10.09%
1996	3.2	3.1	-0.52%
1997	1.0	1.0	0.00%
1998	5.4	5.5	0.66%
1999	1.2	1.4	9.38%
2000	1.1	1.3	12.37%
2001	1.2	1.2	-3.25%
2002	1.9	1.9	-0.87%
2003	1.4	1.4	0.00%
Average	1.4	1.5	6.06%
Source: ICF 2010:Appendix B			

Table F-117. Results of the Analysis Comparing Predicted Summer Townet Indices of Delta Smelt from a Fixed Fall Midwater Trawl Index of 1,000 and Average End-Of-Month X2 Location (August–December) for Modeled Baseline and Proposed Action Conditions

Year	Baseline	Project	% change
1987	8.1	8.2	1.68%
1988	7.6	7.6	0.00%
1989	8.1	8.3	2.44%
1990	7.5	7.5	0.00%
1991	7.5	7.5	0.00%
1992	7.7	7.7	0.00%
1993	8.4	8.7	2.98%
1994	8.1	8.1	0.00%
1995	10.8	11.2	3.19%
1996	10.6	10.6	-0.16%
1997	8.4	8.4	0.00%
1998	12.8	12.9	0.28%
1999	8.7	8.8	1.35%
2000	8.5	8.7	1.62%
2001	8.6	8.6	-0.46%
2002	9.3	9.3	-0.17%
2003	8.8	8.8	0.00%
Average	8.8	8.9	0.75%

Source: ICF 2010:Appendix B

Changes in Upstream Movement of Adult Smelt from January to May

Both Delta and longfin smelt migrate upstream to spawn. Project water diversions from December to March have the potential to stimulate a migration further upstream than normal if the smelts are following a flow-based cue such as X2 position. Although entrainment at the project diversions is unlikely to be an issue because the project fish screens will be installed to Delta smelt standards, movement further upstream than normal would potentially increase the proportion of the population susceptible to entrainment by the SWP/CVP export facilities. A general pattern of increased smelt entrainment at the SWP fish collection facility during drier years was noted by Sommer et al. (1997). The potential for the Proposed Action to cause adult smelts to be distributed further upstream than normal was examined.

Methods

Monthly smelt density data from a series of DFG Spring Kodiak trawl survey stations (California Department of Fish Game 2009a) along an estuarine transect from Carquinez Strait to the Delta (Figure F-8) were extrapolated to total estimated numbers of fish upstream and downstream of the confluence of the Sacramento and San Joaquin rivers. Stations assumed to be above the confluence were numbered 801 and higher. Volumes used in the extrapolations were calculated from areas in the vicinity of each trawl location provided by Miller (2005a, 7) multiplied by 4 m, the assumed depth of the water column that smelt occupy (Kimmerer 2008, 12). The percentage of the population upstream of the confluence was taken as an indicator of the susceptibility of these individuals to entrainment. The percentage upstream of the confluence was compared to estimated X2 position for evidence of X2 position influencing upstream distribution. The analysis relied upon calculated end-of-month X2 positions, so the timing of each survey was examined to decide which X2 values were appropriate to include for a given survey. If the survey took place in the first week or so of a month, then the previous month's end-of-month X2 was used. If the survey was close to the end of a month, then that month's X2 value was used. If a survey was near the middle of a month, then the average X2 of the same and previous months was used.

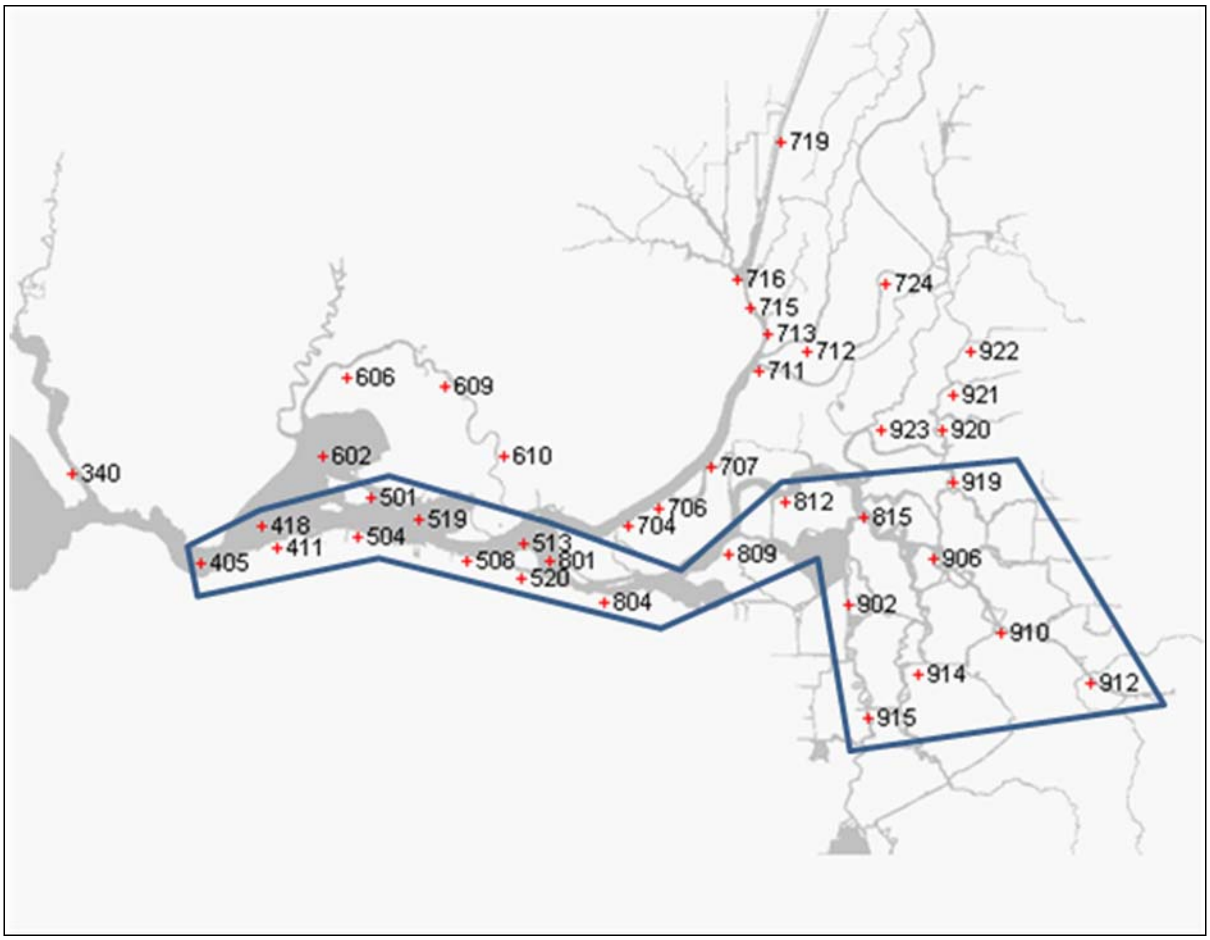


Figure F-8. Spring Kodiak Trawl Sampling Stations in the Bay-Delta. Data from stations enclosed by the blue polygon were used in the analysis of upstream smelt movement in relation to X2. Modified by ICF:2010 (Appendix B) from California Department of Fish and Game (2009c).

Main Assumptions

The main assumptions of this analysis included:

- Smelt presence in the central Delta above the confluence of the Sacramento and San Joaquin Rivers indicates a susceptibility to entrainment by the SWP/CVP export facilities;
- The central Delta can be represented by DFG trawl stations 801 and higher (excluding the Mokelumne River stations);
- Smelt occupy the uppermost 4 m of the water column;
- The relationship between the proportion of smelt in the central Delta and X2 position can be assessed using multiple surveys within a single year—this assumption may be inappropriate because surveys within the same year may not be independent, so it is appropriate to consider averaging all surveys from the same year and comparing only across years.

Results

No longfin smelt were collected at the subset of stations included in the analysis. For delta smelt, there was no apparent relationship between X2 position and percentage of population along the Bay-Delta transect that was upstream of the Sacramento-San Joaquin confluence (Figure F-9). Averaging each year's monthly values did not give a different result (Figure F-10).

USFWS (2008a, 212) noted that "there is wide, apparently random variation in the use of the Central and South Delta by spawning delta smelt." The results of the analysis of potential effects of DW diversions on distribution of adult delta smelt support this statement.

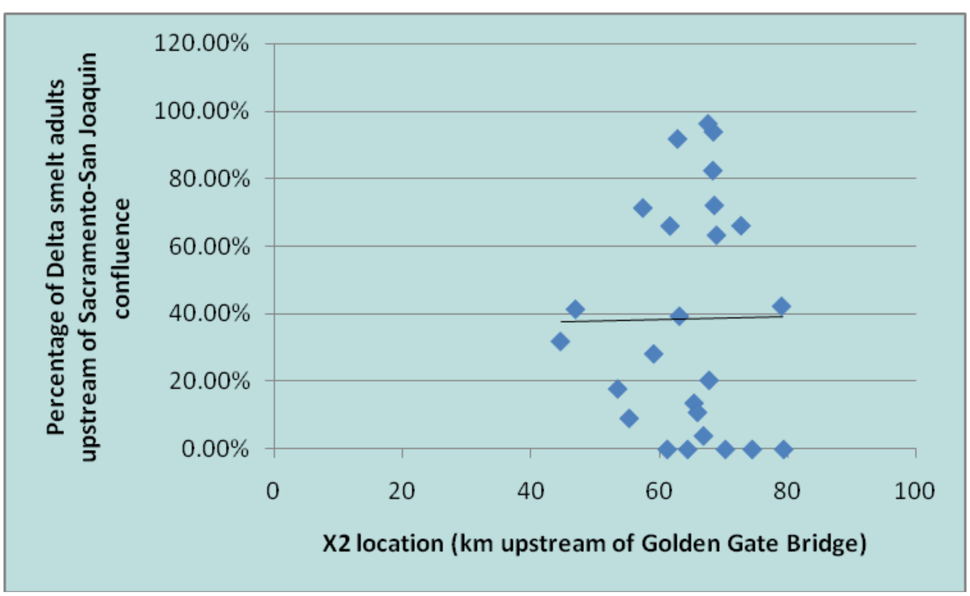


Figure F-9. Percentage of Delta Smelt Adults along an Estuarine Transect from Carquinez Strait to the Delta that were Upstream of the Sacramento-San Joaquin Confluence. A trendline is shown to demonstrate the lack of a relationship. Values are monthly estimates based on extrapolations of total abundance from Spring Kodiak trawling (January to May, 2002 to 2007) and do not include regions beyond the main transect (i.e., Montezuma Slough, the Sacramento River, and Cache Slough). Source: ICF 2010:Appendix B.

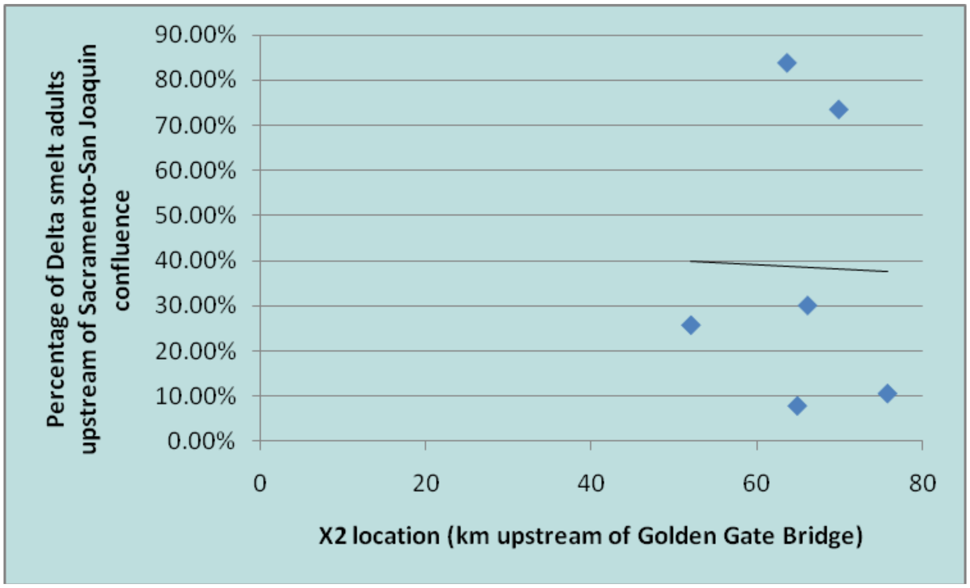


Figure F-10. Percentage of Delta Smelt Adults along an Estuarine Transect from Carquinez Strait to the Delta that were Upstream of the Sacramento-San Joaquin Confluence. A trendline is shown to demonstrate the lack of a relationship. Values are averaged of monthly estimates based on extrapolations of total abundance from Spring Kodiak trawling (January to May, 2002 to 2007) and do not include regions beyond the main transect (i.e., Montezuma Slough, the Sacramento River, and Cache Slough). Source: ICF 2010:Appendix B.

Entrainment Loss of Zooplankton from June to September

Juvenile delta smelt feed on zooplankton, primarily copepods. Moyle et al. (1992) described a shift in diet from *Eurytemora affinis* copepods in 1972–1974 to *Pseudodiaptomus forbesi* copepods following *P. forbesi*'s introduction to the Bay-Delta in 1987. The 2008 OCAP Delta smelt BO noted that the entrainment loss of *P. forbesi* during the June–September period of the juvenile-subadult phase of Delta smelt could be important in terms of food limitation. The Proposed Action proposes to discharge water from the reservoir islands for export during July–November. The potential effect of the Proposed Action's July–November discharges for export on entrainment of *P. forbesi* was examined using June–September IEP zooplankton monitoring data.

Methods

The analysis used IEP monitoring program zooplankton data from 1989 to 2003. Average monthly densities of *P. forbesi* in several regions of the Bay-Delta (Figure F-11) were extrapolated to total numbers using volume estimates for each region provided by Miller (2005a) (Table F-118). The percentage loss of *P.*

forbesi in each month and region was then calculated based on the E/I ratio and sigmoidal loss relationships described above under the Methods for “Losses of Fish Eggs and Larvae by Entrainment” (Figure F-12). The overall effect on the whole population was then assessed by combining the results from all regions. It was assumed that there were no entrainment losses attributable to the SWP/CVP or Proposed Action exports for the Suisun Bay, Suisun Marsh, and Chipps Island regions. Note that zooplankton data were not all available for all regions shown in Figure F-11 and so the analysis was only conducted for the eight regions shown in Table F-118. Zooplankton sampling did not take place in all months in all regions. Therefore results are presented in their entirety for individual regions and when results are combined for all regions, they omit the months that were missing in some regions.

The zooplankton loss calculation was performed for simulated baseline conditions (SWP/CVP exports only) and the results were compared with the results obtained from the simulated Proposed Action (baseline + discharge for exports), baseline + existing agricultural diversions, and the baseline + habitat island diversion conditions assumed for the Proposed Action. As with the fish egg/larval analysis, it was assumed that changes in E/I ratio due to agricultural habitat island diversions would affect the percentage loss of zooplankton in a similar manner to SWP/CVP exports.

The zooplankton entrainment index under the Proposed Action indicates the direction and magnitude of potential change in entrainment loss relative to conditions simulated for the baseline conditions. The entrainment index should not be construed as the actual level of entrainment that would occur, but an indication of loss based on flow diversions and assumptions of loss rates.

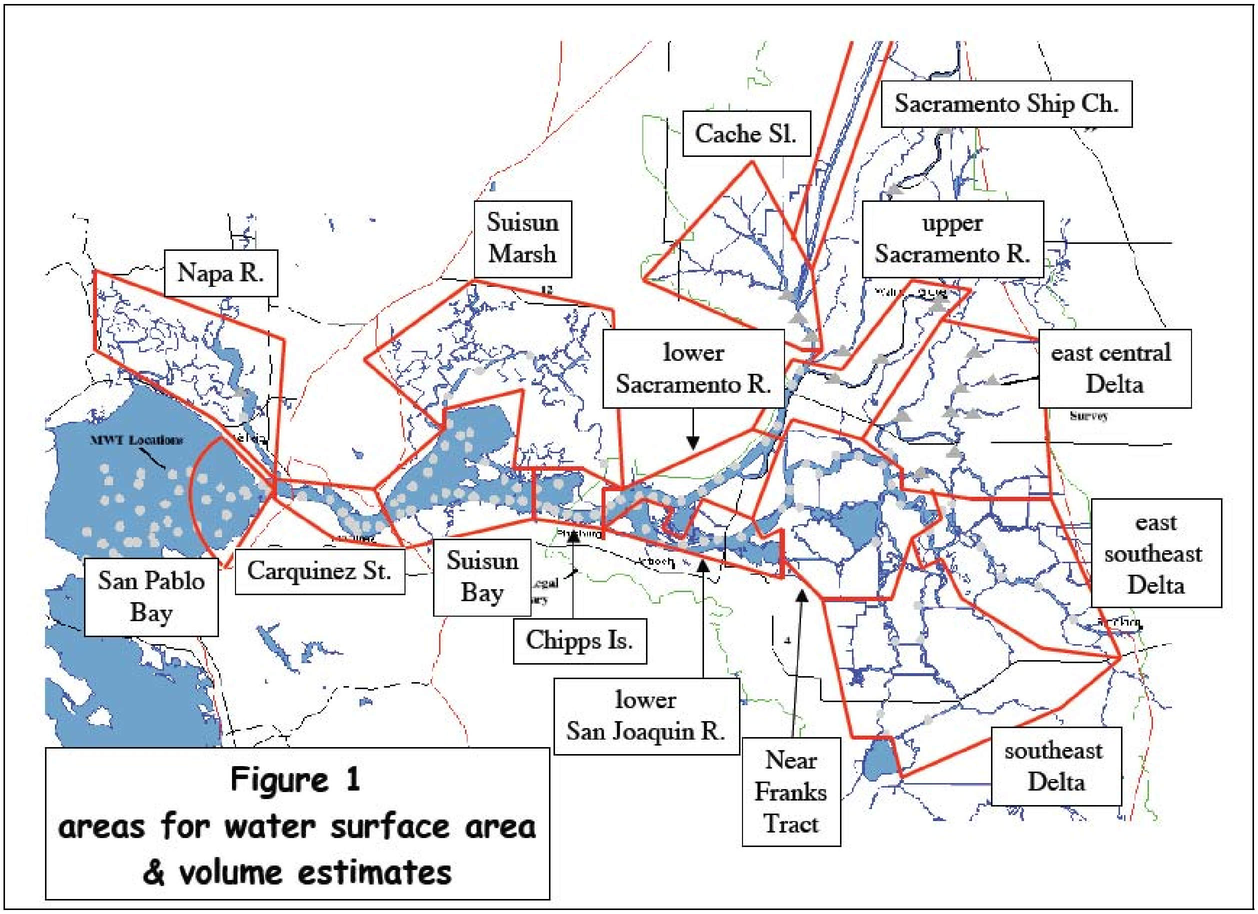
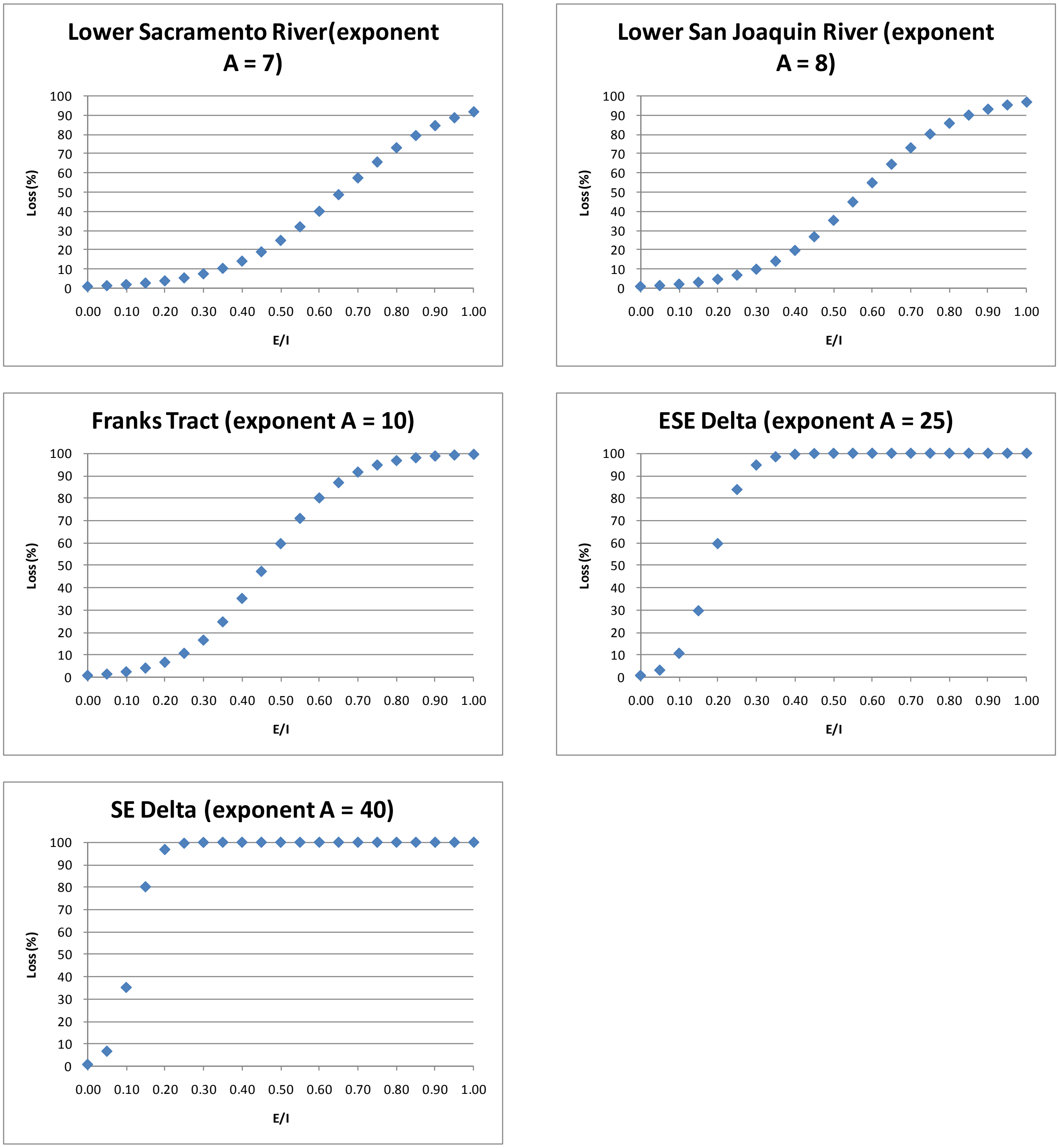


Figure F-11. Regions of the Bay-Delta for which Miller (2005a) provided area and volume estimates. Figure copied from Miller (2005a) by ICF in 2010 (Appendix B).

Table F-118. Volume Estimates of Various Regions of the Bay-Delta (Miller 2005a) for Extrapolations of Zooplankton Total Abundance

Region	Volume (m3)
Suisun Bay	361,878,949
Suisun Marsh	93,090,887
Chipps Island	125,408,115
Lower Sacramento River	186,292,786
Lower San Joaquin River	134,104,163
Franks Tract	242,724,588
ESE Delta	94,410,712
SE Delta	89,205,418

Note: m3 = cubic meters
Source: ICF 2010:Appendix B



$$Loss = \frac{Maximum\ (100\%)}{1 + 100 \times e^{\left(-A \times \frac{E}{I}\right)}}$$

Figure F-12. Sigmoidal Relationships Between Export:Inflow Ratio (E/I) and Monthly Percentage of Zooplankton Lost to Entrainment for Various Regions in the Bay-Delta. The exponent A of the exponential equation was varied to give the different sigmoidal curves.

Source: ICF 2010:Appendix B

Main Assumptions

The analysis assumed:

- discharges for export occur in July–November (although only the July–September period is important for *P. forbesi*);
- *Pseudodiaptomus forbesi* is the principal prey item of juvenile delta smelt and is most susceptible to entrainment from June to September;
- absolute abundance of *P. forbesi* in a region can be estimated by multiplying density data (zooplankton per unit volume) by the volume of the region;
- zooplankton are passive and cannot avoid entrainment—losses are proportional to the volume of water diverted and density of zooplankton in that water;
- entrainment of zooplankton at the SWP export facility can be estimated using relationships similar to the E/I curves developed by Kimmerer and Nobriga (2008);
- zooplankton at Chipps Island, Suisan Bay, and Suisun Marsh are not susceptible to entrainment by the Project diversions or the export facilities.

Results

All Regions

As noted above, the summary of *Pseudodiaptomus forbesi* entrainment loss for all regions combined excludes periods for which data was missing in some regions; therefore the summary in Table F-119 should be viewed with caution when comparing different years. Based solely on water volumes and assumed density of zooplankton within the water, the percentage of the zooplankton population lost due to baseline SWP/CVP pumping from June to September averaged nearly 42% of the 'cumulative population', i.e., the sum of the populations over the four months (Table F-119). The range of baseline loss was from around 27% in 1998 to over 51% in 2000 and 2003. Losses due to SWP export of water discharged from Reservoir Islands under the Proposed Action averaged 1.93% and ranged from 0.00% in several years to nearly 7% in 1992. The benefit of the Proposed Action in terms of reducing agricultural diversions averaged a reduced loss of 0.78% per year (range: 0.53% [2000] to 1.54% [2001]). Overall, the net Proposed Action effect was an average annual loss of 1.15% of *P. forbesi*, and ranged from a reduced loss of 1.54% in 2001 (no exports of project water occurred and reduced agricultural diversions were greater than Habitat Island diversions) to a loss of 6.11% in 2002 (Table F-119).

Table F-119. *Pseudodiaptomus forbesi* June–September Cumulative Population Size in all Regions Combined and Entrainment Losses due to the Baseline and Project Conditions in all Regions Combined

Year	Cumulative population size[1]	% loss (Baseline SWP/CVP exports)	% loss (Project discharges for export)[2]	% loss (Baseline Ag diversions)[3]	% loss (Project Habitat diversions)[4]	Project benefit from reduced ag diversions (% reduced loss)[5]	Net Project effect (% loss)
1989	15,829,707,306,019	44.35%	3.53%	0.87%	0.25%	0.63%	2.90%
1990	15,058,518,657,949	38.65%	0.00%	1.28%	0.34%	0.95%	-0.95%
1991	11,711,616,264,637	38.57%	0.49%	1.63%	0.43%	1.19%	-0.70%
1992	11,459,218,467,467	37.56%	6.37%	1.54%	0.41%	1.13%	5.24%
1993	7,378,582,689,517	42.29%	0.00%	0.90%	0.23%	0.67%	-0.67%
1994							
1995	4,865,282,970,170	31.83%	0.00%	0.59%	0.14%	0.45%	-0.45%
1996	3,870,142,063,002	32.64%	4.49%	0.86%	0.19%	0.67%	3.82%
1997	4,244,562,966,840	46.10%	1.95%	0.81%	0.23%	0.58%	1.37%
1998	11,567,229,769,559	27.12%	0.00%	0.72%	0.17%	0.55%	-0.55%
1999	7,642,478,696,043	39.33%	2.37%	0.80%	0.20%	0.60%	1.77%
2000	11,644,212,370,117	51.50%	0.50%	0.75%	0.22%	0.53%	-0.03%
2001	2,594,123,362,952	37.83%	0.00%	2.11%	0.57%	1.54%	-1.54%
2002	3,696,004,184,962	64.37%	6.92%	1.15%	0.34%	0.81%	6.11%
2003	5,759,417,730,958	51.53%	0.43%	0.81%	0.22%	0.59%	-0.16%
Avg.	8,380,078,392,871	41.69%	1.93%	1.06%	0.28%	0.78%	1.15%

Notes:
[1] Sum of the calculated population size in June-September.
[2] Assumes discharge for exports by SWP from July to November.
[3] Assumes similar pattern of agricultural diversions each year.
[4] Assumes similar pattern of habitat diversions each year.
[5] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.
Source: ICF 2010:Appendix B

Lower Sacramento River

The percentage of the zooplankton population lost from the lower Sacramento River due to baseline SWP/CVP pumping from June to September averaged over 23% of the cumulative population (Table F-120). The range of baseline loss was from 8.55% in 1998 to 39.41% in 2000. Losses due to SWP export of water discharged from Reservoir Islands under the Proposed Action averaged 3.00% and ranged from 0.00% in several years to 14.67% in 2002. The benefit of the Proposed Action in terms of reducing agricultural diversions averaged a reduced loss of 0.77% per year (range: 0.21% [1998] to 1.05% [1989]). Overall the net Proposed Action effect was an average annual loss of 2.23% of *P. forbesi*, and ranged from a reduced loss of 1.04% in 1994 (no exports of project water occurred and reduced agricultural diversions were greater than Habitat Island diversions) to a loss of 13.80% in 2002 (Table F-120).

Table F-120. *Pseudodiaptomus forbesi* June–September Cumulative Population Size in the Lower Sacramento River and Entrainment Losses eue to the Baseline and Project Conditions

Year	Cumulative population size[1]	% loss (Baseline SWP/CVP exports)	% loss (Project discharges for export)[2]	% loss (Baseline Ag diversions)[3]	% loss (Project Habitat diversions)[4]	Project benefit from reduced ag diversions (% reduced loss)[5]	Net Project effect (% loss)
1989	2,487,215,065,219	37.33%	10.39%	1.52%	0.47%	1.05%	9.34%
1990	3,151,664,546,469	16.11%	0.00%	1.28%	0.37%	0.91%	-0.91%
1991	2,239,575,697,278	14.62%	0.45%	1.17%	0.35%	0.82%	-0.37%
1992	2,064,841,156,890	15.26%	5.83%	1.21%	0.34%	0.87%	4.96%
1993	1,422,934,155,845	24.93%	0.00%	0.97%	0.27%	0.70%	-0.70%
1994	642,864,605,557	25.19%	0.00%	1.42%	0.38%	1.04%	-1.04%
1995	1,321,108,546,032	12.90%	0.00%	0.54%	0.13%	0.41%	-0.41%
1996	856,479,079,538	25.88%	4.94%	1.07%	0.30%	0.77%	4.16%
1997	717,389,925,574	30.77%	4.69%	1.23%	0.35%	0.89%	3.80%
1998	926,691,277,210	8.55%	0.00%	0.28%	0.08%	0.21%	-0.21%
1999	1,070,594,999,947	22.13%	2.63%	1.05%	0.26%	0.78%	1.84%
2000	2,850,059,199,610	39.41%	0.22%	1.03%	0.41%	0.62%	-0.41%
2001	597,325,190,690	10.96%	0.95%	0.91%	0.23%	0.68%	0.27%
2002	563,872,432,369	26.42%	14.67%	1.29%	0.43%	0.87%	13.80%
2003	1,332,693,245,849	34.76%	0.21%	1.30%	0.36%	0.94%	-0.72%
Avg.	1,483,020,608,272	23.01%	3.00%	1.09%	0.31%	0.77%	2.23%

Notes:
[1] Sum of the calculated population size in June-September.
[2] Assumes discharge for exports by SWP from July to November.
[3] Assumes similar pattern of agricultural diversions each year.
[4] Assumes similar pattern of habitat diversions each year.
[5] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.
Source: ICF 2010:Appendix B

Lower San Joaquin River

The percentage of the zooplankton population lost from the lower San Joaquin River due to baseline SWP/CVP pumping from June to September averaged 27.44% of the cumulative population (Table F-121). The range of baseline loss was from 11.35% in 2001 to 48.25% in 1989. Losses due to SWP export of water discharged from Reservoir Islands under the Proposed Action averaged 2.95% and ranged from 0.00% in several years to 8.63% in 1992. The benefit of the

Proposed Action in terms of reducing agricultural diversions averaged a reduced loss of 0.96% per year (range: 0.28% [1998] to 1.42% [2002]). Overall the net Proposed Action effect was an average annual loss of 1.99% of *P. forbesi*, and ranged from a reduced loss of 1.35% in 1990 (no exports of project water occurred and reduced agricultural diversions were greater than Habitat Island diversions) to a loss of 7.46% in 1992 (Table F-121).

Table F-121. *Pseudodiaptomus forbesi* June–September Cumulative Population Size in the Lower San Joaquin River and Entrainment Losses due to the Baseline and Project Conditions

Year	Cumulative population size[1]	% loss (Baseline SWP/CVP exports)	% loss (Project discharges for export)[2]	% loss (Baseline Ag diversions)[3]	% loss (Project Habitat diversions)[4]	Project benefit from reduced ag diversions (% reduced loss)[5]	Net Project effect (% loss)
1989	2,272,916,750,881	48.25%	8.34%	1.85%	0.53%	1.32%	7.02%
1990	2,610,270,639,255	20.79%	0.00%	1.85%	0.50%	1.35%	-1.35%
1991	1,927,827,121,848	21.65%	0.64%	1.69%	0.53%	1.16%	-0.52%
1992	1,886,613,406,497	20.56%	8.63%	1.64%	0.47%	1.17%	7.46%
1993	2,207,037,010,395	33.47%	0.00%	1.20%	0.32%	0.88%	-0.88%
1994							
1995	54,625,362,926	22.26%	0.00%	0.48%	0.24%	0.25%	-0.25%
1996	887,120,475,332	24.72%	6.97%	1.33%	0.31%	1.02%	5.95%
1997	804,341,371,254	28.01%	5.29%	1.23%	0.33%	0.90%	4.38%
1998	1,095,714,238,894	11.74%	0.00%	0.40%	0.12%	0.28%	-0.28%
1999	995,688,212,727	32.09%	3.03%	1.33%	0.35%	0.98%	2.05%
2000	1,155,659,079,790	42.13%	0.48%	1.50%	0.39%	1.11%	-0.63%
2001	377,376,508,095	11.35%	0.00%	1.06%	0.29%	0.78%	-0.78%
2002	659,450,901,667	34.60%	7.35%	1.91%	0.49%	1.42%	5.93%
2003	743,760,894,816	32.54%	0.65%	1.18%	0.33%	0.85%	-0.20%
Avg.	1,262,742,998,170	27.44%	2.95%	1.33%	0.37%	0.96%	1.99%

Notes:

[1] Sum of the calculated population size in June-September.

[2] Assumes discharge for exports by SWP from July to November.

[3] Assumes similar pattern of agricultural diversions each year.

[4]Assumes similar pattern of habitat diversions each year.

[5] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.

Source: ICF 2010:Appendix B

Franks Tract

The percentage of the zooplankton population lost from the Franks Tract region due to baseline SWP/CVP pumping from June to September averaged 43.92% of the cumulative population (Table F-122). The range of baseline loss was from

30.38% in 1992 to 63.88% in 1989. Losses due to SWP export of water discharged from Reservoir Islands under the Proposed Action averaged 3.59% and ranged from 0.00% in several years to 12.20% in 2002. The benefit of the Proposed Action in terms of reducing agricultural diversions averaged a reduced loss of 1.47% per year (range: 1.01% [1995] to 2.44% [1990]). Overall the net Proposed Action effect was an average annual loss of 2.13% of *P. forbesi*, and ranged from a reduced loss of 2.44% in 1990 (no exports of project water occurred and reduced agricultural diversions were greater than Habitat Island diversions) to a loss of 10.33% in 1992 (Table F-122).

Table F-122. *Pseudodiaptomus forbesi* June–September Cumulative Population Size in Franks Tract and Entrainment Losses due to the Baseline and Project Conditions

Year	Cumulative population size[1]	% loss (Baseline SWP/CVP exports)	% loss (Project discharges for export)[2]	% loss (Baseline Ag diversions)[3]	% loss (Project Habitat diversions)[4]	Project benefit from reduced ag diversions (% reduced loss)[5]	Net Project effect (% loss)
1989	2,941,015,160,987	63.88%	3.77%	1.97%	0.50%	1.46%	2.31%
1990	2,995,786,022,517	33.98%	0.00%	3.24%	0.80%	2.44%	-2.44%
1991	3,383,238,673,413	27.67%	1.01%	2.91%	0.71%	2.19%	-1.19%
1992	3,462,838,091,973	30.38%	12.20%	2.51%	0.65%	1.86%	10.33%
1993	2,620,597,409,981	43.90%	0.00%	1.50%	0.36%	1.14%	-1.14%
1994	1,634,636,335,491	51.52%	0.00%	2.32%	0.61%	1.72%	-1.72%
1995	1,806,529,999,988	31.77%	0.00%	1.33%	0.32%	1.01%	-1.01%
1996	815,327,010,385	50.21%	8.43%	1.80%	0.46%	1.34%	7.09%
1997	1,527,756,407,098	56.14%	5.94%	1.43%	0.39%	1.04%	4.90%
1998	4,850,195,573,023	32.58%	0.00%	1.39%	0.32%	1.07%	-1.07%
1999	1,724,317,209,610	52.46%	7.01%	1.94%	0.46%	1.47%	5.54%
2000	2,093,778,662,909	39.92%	2.01%	1.83%	0.42%	1.41%	0.60%
2001	861,621,331,623	35.60%	0.71%	1.95%	0.63%	1.32%	-0.61%
2002	1,078,631,788,198	63.29%	11.56%	2.05%	0.63%	1.42%	10.14%
2003	1,244,078,869,749	45.52%	1.25%	1.45%	0.37%	1.08%	0.17%
Avg,	2,202,689,903,129	43.92%	3.59%	1.97%	0.51%	1.47%	2.13%

Notes:

[1] Sum of the calculated population size in June-September.

[2] Assumes discharge for exports by SWP from July to November.

[3] Assumes similar pattern of agricultural diversions each year.

[4]Assumes similar pattern of habitat diversions each year.

[5] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.

Source: ICF 2010:Appendix B

ESE Delta

The percentage of the zooplankton population lost from the ESE Delta due to baseline SWP/CVP pumping from June to September averaged 95.12% of the cumulative population (Table F-123). The range of baseline loss was from 77.84% in 2001 to 99.90% in 1989. Losses due to SWP export of water discharged from Reservoir Islands under the Proposed Action averaged 0.17% and ranged from 0.00% in several years to 1.18% in 1992. The benefit of the Proposed Action in terms of reducing agricultural diversions averaged a reduced loss of 0.61% per year (range: 0.02% [1989] to 4.08% [2001]). Overall the net Proposed Action effect was actually positive (i.e., a net benefit) and amounted to an average 0.44% reduction in the loss of *P. forbesi*, ranging from a reduced loss of 4.07% in 2001 to a loss of 0.48% in 1997 (Table F-123).

Table F-123. *Pseudodiaptomus forbesi* June–September Cumulative Population Size in the ESE Delta and Entrainment Losses due to the Baseline and Project Conditions

Year	Cumulative population size[1]	% loss (Baseline SWP/CVP exports)	% loss (Project discharges for export)[2]	% loss (Baseline Ag diversions)[3]	% loss (Project Habitat diversions)[4]	Project benefit from reduced ag diversions (% reduced loss)[5]	Net Project effect (% loss)
1989	2,487,215,065,219	99.90%	0.00%	0.03%	0.01%	0.02%	-0.02%
1990	3,151,664,546,469	99.32%	0.00%	0.23%	0.06%	0.17%	-0.17%
1991	2,239,575,697,278	96.02%	0.04%	1.44%	0.37%	1.07%	-1.03%
1992	2,064,841,156,890	94.68%	1.18%	1.60%	0.40%	1.20%	-0.01%
1993	1,422,934,155,845	95.98%	0.00%	0.56%	0.13%	0.43%	-0.43%
1994	642,864,605,557	99.60%	0.00%	0.11%	0.03%	0.08%	-0.08%
1995	1,321,108,546,032	88.94%	0.00%	0.72%	0.17%	0.56%	-0.56%
1996	856,479,079,538	98.94%	0.11%	0.21%	0.05%	0.16%	-0.05%
1997	717,389,925,574	98.53%	0.77%	0.38%	0.10%	0.29%	0.48%
1998	926,691,277,210	79.92%	0.00%	0.74%	0.18%	0.56%	-0.56%
1999	1,070,594,999,947	98.73%	0.16%	0.29%	0.07%	0.22%	-0.06%
2000	2,850,059,199,610	99.60%	0.16%	0.10%	0.02%	0.07%	0.08%
2001	597,325,190,690	77.84%	0.01%	5.33%	1.25%	4.08%	-4.07%
2002	563,872,432,369	99.66%	0.00%	0.09%	0.02%	0.07%	-0.07%
2003	1,332,693,245,849	99.18%	0.11%	0.18%	0.05%	0.14%	-0.03%
Avg.	1,483,020,608,272	95.12%	0.17%	0.80%	0.19%	0.61%	-0.44%

Notes:

[1] Sum of the calculated population size in June-September.

[2] Assumes discharge for exports by SWP from July to November.

[3] Assumes similar pattern of agricultural diversions each year.

[4]Assumes similar pattern of habitat diversions each year.

[5] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.

Source: ICF 2010:Appendix B

SE Delta

The percentage of the zooplankton population lost from the SE Delta due to baseline SWP/CVP pumping from June to September averaged 99.00% of the cumulative population (Table F-126). The range of baseline loss was from 93.93% in 1995 to 100% in several years. Losses due to SWP export of water discharged from Reservoir Islands under the Proposed Action averaged 0.00% and was 0.01% in 1992 and 2000. The benefit of the Proposed Action in terms of reducing agricultural diversions averaged a reduced loss of 0.11% per year (range: 0.00% [several years] to 0.65% [1995]). Overall the net Proposed Action effect was actually positive (i.e., a net benefit) and amounted to a 0.11% reduction in the loss of *P. forbesi*, ranging from a reduced loss of 0.65% in 1995 to no reduction (i.e., 0.00% loss) (Table F-124).

Table F-124. *Pseudodiaptomus forbesi* June–September Cumulative Population Size in the SE Delta and Entrainment Losses eue to the Baseline and Project Conditions

Year	Cumulative population size[1]	% loss (Baseline SWP/CVP exports)	% loss (Project discharges for export)[2]	% loss (Baseline Ag diversions)[3]	% loss (Project Habitat diversions)[4]	Project benefit from reduced ag diversions (% reduced loss)[5]	Net Project effect (% loss)
1989	631,627,436,445	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1990	622,141,399,248	99.99%	0.00%	0.00%	0.00%	0.00%	0.00%
1991	688,588,017,917	99.67%	0.00%	0.19%	0.06%	0.14%	-0.14%
1992	596,390,807,082	99.71%	0.01%	0.14%	0.04%	0.10%	-0.09%
1993	216,109,623,901	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1994							
1995	218,951,931,258	93.93%	0.00%	0.85%	0.20%	0.65%	-0.65%
1996	112,896,758,700	99.93%	0.00%	0.02%	0.01%	0.02%	-0.02%
1997	131,624,646,402	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
1998	646,781,295,362	94.05%	0.00%	0.32%	0.07%	0.25%	-0.25%
1999	487,689,675,092	99.97%	0.00%	0.01%	0.00%	0.01%	-0.01%
2000	712,250,801,673	99.99%	0.01%	0.00%	0.00%	0.00%	0.00%
2001	381,158,606,418	98.78%	0.00%	0.58%	0.16%	0.42%	-0.42%
2002	757,227,087,302	100.00%	0.00%	0.00%	0.00%	0.00%	0.00%
2003	374,277,506,190	99.98%	0.00%	0.01%	0.00%	0.00%	0.00%
Avg.	469,836,828,071	99.00%	0.00%	0.15%	0.04%	0.11%	-0.11%

Notes:
[1] Sum of the calculated population size in June-September.
[2] Assumes discharge for exports by SWP from July to November.
[3] Assumes similar pattern of agricultural diversions each year.
[4]Assumes similar pattern of habitat diversions each year.
[5] Benefit is calculated as reduction in agricultural diversion entrainment loss minus increase in habitat diversion entrainment loss.
Source: ICF 2010:Appendix B

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