Annual Report on the Implementation of the Biological Opinion on the Coordinated Operations of the Central Valley Project and State Water Project ("OCAP" Biological Opinion)

Water Year 2011

Prepared for the Delta Science Program Independent Review
By Bay-Delta Fish and Wildlife Office Staff
U.S. Fish and Wildlife Service

Sacramento, California

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Acronyms and Abbreviations

BDFWO	Bay-Delta fish and Wildlife Office
BO	Biological Opinion
CDEC	California Data Exchange Center
[C]DFG	California Department of Fish and Game
[C]DWR	California Department of Water Resources
CFS	Cubic Feet per Second
CVP	Central Valley Project
ESA	Endangered Species Act
FMWT	Fall Mid-Water Trawl
IEP	Interagency Ecological Program
NMFS	National Marine Fisheries Service (NOAA Fisheries)
NTU	Nephelometric Turbidity Unit
OCAP	Operations Criteria and Plan
OMR	Old and Middle River Flow (combined, in cubic feet per second)
QWEST	A calculation of net flow in the lower San Joaquin River, in cubic feet per second
Reclamation	U.S. Bureau of Reclamation
RPA	Reasonable and Prudent Alternative
Service	U.S. Fish and Wildlife Service
SKT	Spring Kodiak Trawl Survey
STNS	Summer Tow-Net Survey
SWP	State Water Project
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VAMP	Vernalis Adaptive Management Program
WOMT	Water Operations Management Team
WY	Water Year (October 1 – September 30)

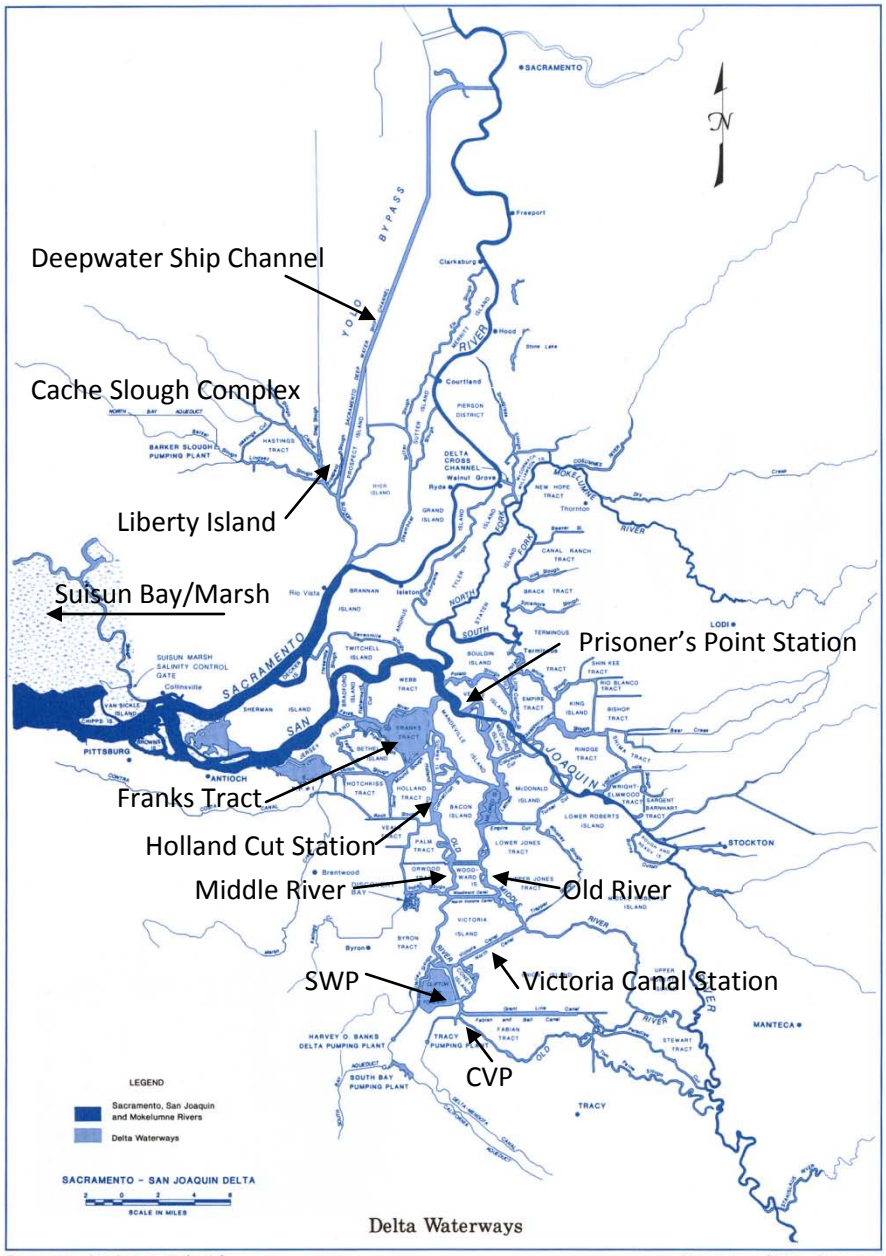

Figure 1. Map of the Sacramento-San Joaquin Delta

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Chapter 1—Background

In an effort to enable review of the coordinated operation decisions implemented under the Endangered Species Act Consultation on the Proposed Coordinated Operations of the Central Valley Project (CVP) and State Water Project (SWP) ("OCAP") and the real-time species information underlying those decisions, the Bay-Delta Fish and Wildlife Office (BDFWO) has prepared the following report. The report is intended to facilitate review by the Independent Technical Panel, and includes introductory text as well as a summary of the actions implemented under the Reasonable and Prudent Alternative (RPA).

The reader should be aware that the tables and figures in this document were constructed from the data available to and used by the Smelt Working Group (SWG) in near-real-time. In some instances, these data may have been updated. However, the data provided herein reflect that which was reviewed by the SWG at the time, irrespective of whether updates may have subsequently become available.

1.1 Background

The federal Endangered Species Act (ESA) is administered primarily by the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (Service). A *biological opinion* is a product of an interagency consultation under section 7 of the ESA, which provides that "each federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded or carried out by such agency….is not likely to jeopardize the continued existence of any endangered species or threatened species of result in the destruction or adverse modification of [critical] habitat…" In December 2008 the Service completed a biological opinion ("OCAP" opinion or BO) on the effects of the coordinated operations of the Central Valley Project (CVP) and the State Water Project (SWP) (Projects) on the federally-listed threatened delta smelt (*Hypomesus transpacificus*). The biological opinion includes the written opinion of the Service, a summary of the information used, and a detailed discussion of the effects of the proposed action on the listed species or its critical habitat, and reasonable and prudent measures necessary in order for the project to move forward.

There are three major factors related to operations of the CVP/SWP affecting delta smelt population resilience and long-term viability. These three factors are: 1) direct mortality associated with entrainment of pre-spawning adult delta smelt by CVP/SWP operations; 2) direct mortality of larval and early juvenile delta smelt associated with entrainment by CVP/SWP operations; and, 3) indirect mortality and reduced fitness through reductions to and degradation of Delta habitats by CVP/SWP operations, with the fall as a particular concern (BO, p 325). Entrainment of all life stages of delta smelt may occur irrespective of Delta hydrology, but increases with reverse flows. Reverse flows on Old and Middle Rivers (OMR) resulting from Project export pumping is a proximal cause of entrainment, while the position of the two-parts-per-thousand isohaline (termed "X_2" and measured as kilometers from the Golden Gate) is a distal cause of entrainment.

In formal consultation with the U.S. Bureau of Reclamation (Reclamation) and the California Department of Water Resources (DWR), the Service determined that the coordinated operations of the CVP and SWP, as proposed, were likely to jeopardize the continued existence of the delta smelt and adversely

modify its critical habitat. Thus, in collaboration with Reclamation and DWR, the Service developed a *reasonable and prudent alternative* (RPA). The Service's biological opinion for delta smelt ("OCAP") includes five RPA components to protect different delta smelt life stages and minimize impacts to critical habitat. The two primary Components affecting CVP and SWP operations are Components 1 and 2. Component 1 protects adult delta smelt by reducing Old and Middle River (OMR) flows to a range of -1,250 to -5,000 cubic feet per second (cfs) at times when the fish are most vulnerable to entrainment at the project diversions, occurring as early as December and continuing until spawning has begun. Component 2 protects larval and juvenile delta smelt by reducing OMR flows to a range of -1,250 to -5,000 cfs at times when these life stages are vulnerable to entrainment. Component 2 is implemented from the onset of spawning until June 30, or when water temperatures reach 25° Celsius.

Table 1. Simple illustration of the first two components of the OCAP RPA

Component 1			Component 2
Action 1(a)	Action 1(b)	Action 2	Action 3
Dec 1-20			
	Dec 20 – Action 2		
		Immed. Following Action 1	
			Onset of Spawning

These Components are implemented through an adaptive process that is guided by hydrological and biological data, an interagency team of experts, and real-time project operational decisions.

1.2 Adaptive Decision Process

Real-time decision-making to assist fishery management is a process that promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. For CVP and SWP operations, high uncertainty exists for how to best manage water operations while protecting listed species. Sources of uncertainty relative to CVP and SWP operations include hydrologic conditions and the biology and ecology of species.

Under current Project operations, the goals for real-time decision-making to assist fishery management are to minimize impacts to water deliveries and minimize adverse effects to listed species. Decisions regarding CVP and SWP operations to avoid and minimize adverse effects on listed species must consider factors that include public health, safety, water supply reliability, and water quality. To facilitate such decisions, the Project agencies and the Service, NMFS, and the California Department of Fish and Game (DFG) have developed and refined a set of processes to collect data, disseminate information, develop recommendations, make decisions, and provide transparency. This process consists of three types of groups that meet on a recurring basis. Management teams (e.g., the Water Operations Management Team or WOMT) are made up of management staff from Reclamation, DWR, the Service, NMFS, the U.S. Environmental Protection Agency (USEPA) and DFG. Information teams are teams whose role is to disseminate and coordinate information among agencies and stakeholders. Fisheries and Operations Technical Teams are made up of technical staff from state and Federal agencies. These teams review the most up-to-date information on fish status and Delta conditions, and

develop recommendations that fishery agencies' management can use in identifying actions to protect listed species.

The process to identify actions for protection of listed species varies to some degree among species but follows this general outline: a Fisheries or Operations Technical Team compiles and assesses current information regarding species, such as stages of reproductive development, geographic distribution, relative abundance, and physical habitat conditions; it then provides a recommendation to the agency having the statutory obligation to enforce protection of the species in question. The agency's staff and management then review the recommendation and use it as a basis for developing, in cooperation with Reclamation and DWR, a modification of water operations that will minimize adverse effects to listed species by the Projects. If the Project agencies do not agree with the action, then the fishery agency with the statutory authority makes the final decision on an action that they deem necessary to protect the species. The outcomes of any protective actions that are implemented are monitored and documented, and this information informs future recommended actions (BO, pp 27-29).

1.3 Smelt Working Group(SWG)

The SWG is a Fisheries Technical Team that evaluates biological and technical issues regarding delta smelt and develops recommendations for consideration by the Service. Since the longfin smelt (*Spirinchus thaleichthys*) became a state candidate species in 2008, the SWG has also developed for DFG recommendations to minimize adverse effects to longfin smelt. The SWG consists of representatives from the Service, NMFS, DFG, USEPA, DWR, and Reclamation. The Service chairs the group, and members are assigned by each agency.

The SWG compiles and interprets the latest near-real-time information regarding state- and federally-listed smelt, such as stages of development, distribution, and salvage. After evaluating available information and if they agree that a protection action is warranted, the SWG will submit their recommendations in writing to the Service and DFG.

The SWG may meet at any time at the request of the Service, but generally meets weekly during the months of December through June, when smelt salvage at Jones and Banks has occurred historically. However, the Delta Smelt Risk Assessment Matrix (Attachment 1) outlines the conditions when the SWG will convene to evaluate the necessity of protective actions and provide the Service with a recommendation. Further, following the State of California listing of longfin smelt, the SWG will also convene based on longfin salvage history at the request of DFG (BO, pp 30-31).

Typically, around the beginning of December, the SWG begins meeting weekly to review information about Delta hydrology and smelt distribution and abundance. Once data indicate that smelt may be at risk for entrainment, the SWG recommends OMR flows within the ranges in the RPA to the Service. The Service's staff and managers then review the recommendation and, if warranted and in cooperation with Reclamation and DWR, use it to develop a modification of water operations that will minimize adverse effects to listed species caused by operations. If Reclamation and DWR do not agree with the action, the agency with statutory authority will make a final decision on the action. This adaptive process continues throughout the winter and spring until smelt are no longer vulnerable to entrainment. For detailed notes on the SWG 2011 Water Year meetings please visit http://www.fws.gov/sfbaydelta/ocap .

Chapter 2—Summary of Actions and Outcomes

The SWG held regular conference calls that were well-attended. At least one representative from each agency was able to participate on all calls. Weekly discussion topics included salvage for the SWP and CVP fish salvage facilities, CDFG and Service biological surveys, Delta hydrology, projected operations for the coming week, status of NMFS BO actions, and risk of entrainment for delta and longfin smelt. Periodic discussion topics included applicable sections of the Service BO for delta smelt, updates for ongoing field studies, historical survey results, hydrology patterns, water quality requirements, and the status of temporary Delta barriers.

The WOMT met in person or via conference call throughout the December through June implementation period.

2.1 Component 1: Adult Entrainment

Incidental take is that take which occurs as a direct effect of the project, but not as an intentional effect. The incidental take statement of the biological opinion, which exempts the Projects from the prohibition against take of a listed species, is based on historical take but also uses the Fall Mid-Water Trawl (FMWT) index to scale allowable take to apparent abundance (BO, pp 285-288). The FMWT index for delta smelt for 2010 was 29. The authorized incidental take for adult delta smelt in WY 2011 was 210 fish, cumulative, for the December-through-March period; the concern level was 157 fish.

Action 1.

Adult delta smelt entrainment generally occurs when a pulse of pre-spawning migrants enters the central and south Delta following the first winter pulse of precipitation in the watershed. This event is characterized by the first substantial flow increase of the winter and is generally coincident with an increase in turbidity. Flow and turbidity are believed to serve as cues for adult delta smelt migration. Action 1, once triggered, requires OMR flow be managed to no more negative than -2,000 cfs for 14 days. This decrease in reverse OMR flow results in the draw of little or no Sacramento River water into the central and southern Delta and typically allows some portion of the San Joaquin River flow to reach the confluence area. Action 1 is intended to decrease the risk of entrainment for pre-spawning adult delta smelt, and improve habitat conditions for the species. Additionally, Action 1 is intended to decrease the risk of entrainment to larval and juvenile delta smelt later in the season by allowing environmental cues to encourage the species to spawn in the northern delta.

The SWG monitored turbidity and flow as an indicator of the occurrence of the first winter pulse flow in their effort to assess the risk of entrainment. Additionally, the SWG monitored salvage and survey results as an indicator of relative abundance and distribution. Action 1 was not implemented in WY 2011 because the criteria for its implementation were not met.

Action 2.

Action 2 reflects the period when OMR prescriptions for pre-spawning adult delta smelt are still required to protect parental stock prior to reproduction, however, such controls may be relaxed because the main pulse of fish migration has occurred and adults are holding more tightly to their selected spawning areas. Action 2 may also be needed to extend protections consistent with Action 1 in

years of longer spawning migration periods or changing environmental conditions. Conditions are highly variable both between and within years. Rather than provide a prescription that is protective under all circumstances, an adaptive process based on the RPA guidelines is appropriate. This process can most efficiently and effectively provide protections utilizing analysis of all available data and seasonal conditions. The SWG monitors environmental conditions including turbidity, flow, and water temperature, as well as relative fish abundance, distribution and spawning readiness, and salvage at the export facilities, to assess the risk of entrainment. The RPA describes a variety of potential recommendations, according to the assessed level of risk (BO, pp 354-356).

The SWG monitored Delta hydrology, turbidity, and delta smelt distribution as indicated by the Spring Kodiak Trawl (SKT). Because net Delta flows were strongly positive and delta smelt were largely distributed to the north or west of Franks Tract, the risk of entrainment was estimated to be low, and Action 2 was not implemented.

Combined salvage of delta smelt (CVP and SWP fish facilities) was 48 adults for the December-through-March period, well below the authorized take of 210 adults. As expected, cumulative salvage roughly reflected Sacramento River flow (Figure 2).

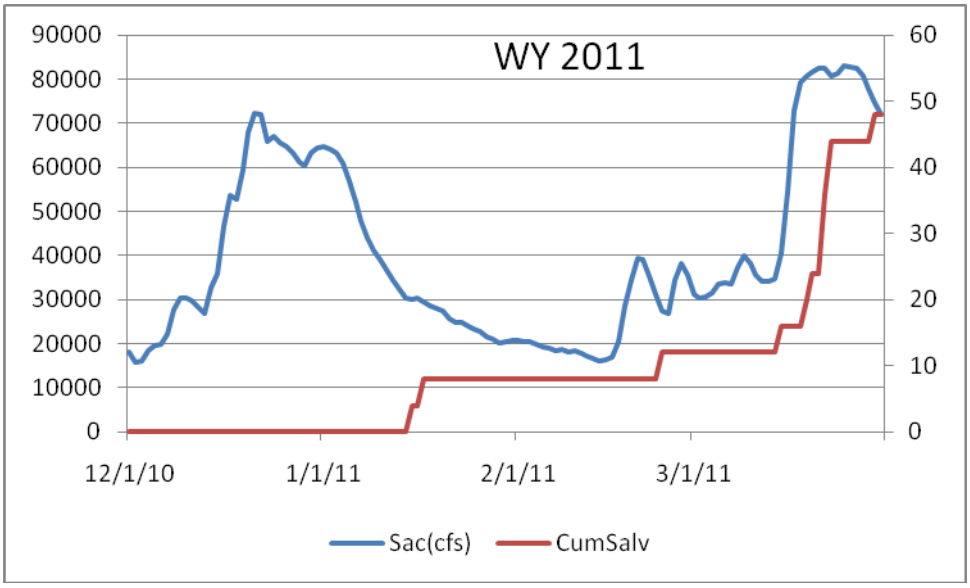

Figure 2. Graphic depiction of Sacramento River flow in cubic feet per second and cumulative adult salvage at the CVP and SWP fish salvage facilities in water year 2011.

2.2 Component 2: Juvenile Entrainment

Incidental take for juvenile delta smelt is, like adult take, based upon historic observed take as well as upon apparent abundance (BO, pp 289-293). Because of the difficulty in distinguishing between larval smelts, only delta smelt greater than 20 mm in length are counted in salvage. Juvenile take is estimated by month for the April-through-July period. Authorized take for WY 2011 is provided in Table 2, below.

Table 2: Incidental take for juvenile delta smelt at least 20 mm in size, WY 2011

	Concern Level	Authorized Take
April	9	13
May	378	567
June	958	1436
July	1086	1630

Action 3.

Implementation of Action 3 begins when the SWG determines that spawning has begun and larval fish are present in the Delta. It is likely that Delta conditions (primarily water temperature) will be appropriate for the presence of larvae before larvae are detected by routine survey sampling. Therefore, the SWG monitors water temperature, adult spawning condition (i.e., gonad development) and larval occurrence and distribution to assess the relative risk of entrainment. Action 3 concludes when Delta water temperatures reach a daily average of 25^0C at Clifton Court Forebay for three consecutive days, or until June 30 (BO pp 357-359).

The SWG monitored Delta hydrology and juvenile distribution as indicated by the 20-mm Survey. Survey catches were low, but fish were collected north or west of Franks Tract and Delta outflow was strongly positive during most of the April-through-July period. By the time of the first Tow-Net Survey in mid-June, all juvenile delta smelt were collected west of the confluence in Suisun Bay and Marsh. The SWG estimated that the risk of entrainment for juvenile delta smelt was low; no salvage of juveniles was observed in WY 2011.

2.3 Follow-up to the Panel's Recommendations

In the March 9, 2011 letter to the Delta Science Program, the Service outlined how they would address specific Panel recommendations regarding the RPA. This letter can be found at: http://deltacouncil.ca.gov/sites/default/files/documents/files/workshop_OCAP_2010_review_detailed_response_letter_032111.pdf

This update follows the "Response to Narrative Notes for Table 4" of the Report, on pages 14-18.

> N. The "new delta smelt studies" on tides and turbidity
> The Panel recommended that the Service focus its management strategies according to relevant tidal and seasonal characteristics. This is a future goal toward which the Service is moving. A pilot study was conducted in 2010 and a first full study was conducted in 2011. The Service participated in the IEP review and guidance process for this study and, due to concerns for the large amount of take anticipated, staffed a real-time team to monitor take. The Smelt Working Group was able to take advantage of knowledge of trends in delta smelt movement in the area of the confluence and lower Sacramento River in near-real-time. The implementation of some protocols for the second year of the study has been delayed due to a number of factors, but is expected to resume in 2013. The Service expects to remain involved with permitting, guidance, and review through the IEP process.

P. Panel concerns regarding Action 1 implementation

The Service remains concerned that the criteria for the implementation of Action 1 are inadequate to meet the intent of the Action. The SWG monitored turbidity conditions at the three criterion stations as well as the three additional stations noted in the March 9 letter to the DSP. Please turn to the discussion of the turbidity criteria in Chapter 6 for more information.

Q. Panel concerns regarding OMR flow

i) Clarity of outcomes: The Panel noted that it was at times difficult to make the link between SWG recommendations and Service determinations. The Service agreed to improve the clarity of these linkages; however, since no recommendations or determinations were made, this could not be acted upon in WY 2011.

ii) The Service, NMFS and DFG continued to work collaboratively with the Project Agencies to develop an OMR transition protocol that is appropriate to the intent of both biological opinions. Significant progress has been made, but at the time of this report, the protocol has not yet been completed.

T. Life Cycle Models

Efforts to develop a delta smelt life-cycle model and life-history model have made progress in WY2011, but have not yet been completed.

Chapter 3. Summary Narrative of Smelt Working Group Discussions

During WY2011, the SWG began meeting November 29, 2010 and last met June 27, 2011. For the meetings in December and January, members were especially interested in river flows and turbidity. The SWG particularly watched for signs of the first winter pulse as an indication of potential upstream movement and increased vulnerability to entrainment. In addition to the turbidity stations mandated in the RPA (criterion stations), the SWG monitored several other turbidity stations to obtain a better picture of overall conditions.

By late December, SWG members were in agreement that delta smelt appeared to have begun upstream migration, although the turbidity criteria for the implementation of Action 1 of the RPA were not met or exceeded. The SWG estimated that the risk of entrainment was low, as flows on the San Joaquin River were sufficient to maintain more positive flow conditions in the Old and Middle River channels, and did not provide a recommendation to the Service.

On January 1, the NMFS RPA set OMR flows at no more negative than -5000 cfs. Strong river flows and turbidity conditions continued into early January. Wind events periodically suspended sediments in the interior Delta, but the higher turbidities associated with the increased river flows did not propagate into the interior Delta. The estimated risk of entrainment remained low, due to the high and increasing river flows on the San Joaquin River. On January 2, 2011, the SWG indicated that the high flows on the San Joaquin River figured strongly in their estimate of risk.

By mid-January, the first winter pulse flow had passed. Field surveys consistently collected delta smelt in the Sacramento River system and downstream of the confluence. A very small number of adults (8) were observed in salvage in mid-January. The SWG did not believe that salvage or distribution (two adults were collected in the south Delta in SKT #1) indicated a need for an operational change. A single longfin smelt larva was observed at the CVP on January 14; however, the Smelt Larval Survey collected most longfin in the lower Sacramento River and Suisun Bay. With a positive QWEST (net flow in the lower San Joaquin River) and a salvage threshold of 955, no advice to CDFG was warranted.

Strong outflow conditions persisted through February. Most SKT collections occurred either in the Sacramento River side or well downstream of the confluence. The SWG estimated that the risk of entrainment remained low. Longfin smelt distribution remained favorable, with no further salvage. On February 19, flows on the San Joaquin River again surpassed 8,000 cfs, suspending OMR criteria for longfin smelt.

On March 10, the 3-day, 3-station average temperature surpassed 12^{o}C, the temperature at which it is assumed widespread spawning has begun. SKT #3 (March 7-10) collected adult delta smelt in the Cache Slough/Liberty Island area, lower Sacramento River, and in Suisun Bay and Marsh, indicating that the risk of entrainment remained low.

Two spent female delta smelt were collected during the Spring Kodiak Trawl #3 (one each in the vicinity of Liberty Island and the Deepwater Ship Channel) confirming the occurrence of spawning . Additionally, from March 15 to April 5, 39 adult delta smelt were salvaged at the CVP fish facility. Although this information was important in SWG discussions, the strongly positive Delta outflow combined with field survey data on distribution indicated that the risk of entrainment remained low. No further salvage of

longfin smelt was observed, and the distribution remained favorable. San Joaquin River flow continued to surpass 8,000 cfs, suspending OMR criteria.

By early April, the San Joaquin River was forecast to increase to at least 20,000 cfs throughout the months of April and May. On April 18, CDFG staff asked the SWG whether they would like to have stations in eastern San Pablo Bay added to the 20-mm Survey. Due to the high outflow, the SWG agreed that adding these non-core stations to the survey might provide more information on the location of delta smelt in the upper estuary. No further salvage of longfin smelt was observed, and the distribution remained favorable. San Joaquin River flow continued to surpass 8,000 cfs.

On May 2, anticipated restrictions in export pumping related to the VAMP experiment[1] and expected flow increases on the San Joaquin River prompted the Service to tentatively postpone SWG calls until May 31. Data on Delta conditions, Project operations and field survey collections were continuously monitored by the Service and were reported to the SWG weekly. By the end of May, the distribution of longfin smelt obviated further discussion.

By May 31, the end of the VAMP period meant that export pumping was to imminently increase. The San Joaquin River remained above 10,000cfs. The NMFS RPA requirement for OMR to be no more negative than -5000 cfs remained in effect until June 15. The SWG discussed the high outflow that had persisted throughout much of the winter and spring, noting that very few delta smelt larvae had been collected. The SWG expressed concern because given strong Delta outflow, 20-mm Survey catch per unit of effort (CPUE) was expected to have been greater. However, the SWG noted that although CPUEs were very low and export pumping was anticipated to increase, net Delta outflow was projected to remain high. The SWG estimated that the risk of entrainment remained low due to flow conditions and survey results that indicated that most of the population was well away from the influence of the export pumps.

Collections from 20-mm Survey #7 (June 6-9) indicated a favorable distribution, as well as increases in the size of larvae collected. The SWG believed that the average size of the larvae (24.1 mm) would soon approach a range where they would begin moving downstream. Some hydrologic variables appeared to be in flux (OMR, QWEST, and temperature), which contributed to the SWG requesting an additional meeting to review updated data. Due to apparent stabilization of some variables and continued positive distribution of larvae, no recommendation was made.

On June 16, the SWG concurred with requests that the additional larval sampling conducted at the fish facilities be discontinued for the season; the Service subsequently authorized discontinuation.

On June 27, the SWG reviewed Delta hydrology, forecasted Project operations, and survey results and, with the June 30 RPA off-ramp date pending, concluded their regular meetings for WY 2011.

The SWG made no recommendations for modifications of water project operations to protect delta smelt or longfin smelt to the Service or CDFG during WY2011.

[1] The Vernalis Adaptive Management Plan is a 12-year experiment designed to protect emigrating juvenile San Joaquin River Chinook from entrainment. Please see http://www.fws.gov/stockton/jfmp/vamp.asp

Chapter 4—Water Operations Summary

In WY 2011, hydrologic year-types in both the Sacramento and San Joaquin River basins were classified as wet. No export curtailments were necessary at the Delta water export facilities for the protection of delta smelt. Some export curtailments were required to meet NMFS BO's RPA requirements for salmon and steelhead during the January to June period, when a -5,000 cfs OMR flow cap was in place. However, for much of this period, the Delta was in excess conditions (i.e., some provisions of the Coordinated Operations Agreement between the Projects were suspended due to the availability of ample water for export) and exports were largely unconstrained by fish protection actions.

Please refer to Figure 3 for the following discussions.

4.1 *Export Pumping*

The combined Project export rate averaged slightly less than 11,000 cfs for the months of December and January. February export rate averaged slightly lower, at 9,000 cfs; the March and April export rate declined to slightly greater than 6,000 cfs. In May, export pumping fell to a seasonal-low average rate of 3,300 cfs, due to implementation of the VAMP protocol. In June, export pumping increased to an average rate of 9,700 cfs.

4.2 River Flows

An early winter pulse, which peaked at approximately 72,000 cfs on the Sacramento River and 17,000 cfs on the San Joaquin River, lasted from mid-December to early January. After this winter pulse, which was generated mostly by increased reservoir releases, the Sacramento River returned to flows between 20,000 and 30,000 cfs and the San Joaquin River to flows between 7,000 and 11,000 cfs. A much larger pulse, accompanied by greater turbidity levels, began mid-March and continued until mid-April. This spring pulse peaked at 83,000 cfs on the Sacramento River and nearly 29,000 cfs on the San Joaquin River. From mid-April until the end of June flows on the Sacramento generally remained between 30,000 and 40,000 cfs. The San Joaquin River remained high through the end of April. In May and June, the San Joaquin River remained between 10,000 and 12,000 cfs.

4.3 Delta Outflow and the Winter Pulse

Delta outflow generally parallels Sacramento River flows, depending on the rainfall and snowfall patterns throughout the water year. Although Delta outflow exhibited an early season pulse in late December to early January, and turbidity levels did increase, the flows did not contain as much sediment as would be expected from a first-pulse turbidity event. After flows declined in mid-January, outflow exhibited a few small pulses in late February and early March, but again, they were not accompanied by the anticipated level of turbidity for a winter pulse flow. From mid-March to mid-April, outflow increased dramatically, to a peak rate of 214,000 cfs. Turbidity levels increase significantly in and around the Delta. From mid-April until the end of June, outflow gradually decreased, although remained at higher levels than at the beginning of the water year.

Although turbidity levels did not increase to a level expected for winter pulse, this is still likely to have provided a cue to adult delta smelt to begin their migration to spawning areas, and therefore was an important event for the species. As the larger pulse later in the year occurred after spawning had

already begun and X_2 was relatively downstream, it is presumed that this pulse did not serve as an adult migration cue, but rather, provided excellent outflow conditions for emerging and developing larvae and juveniles.

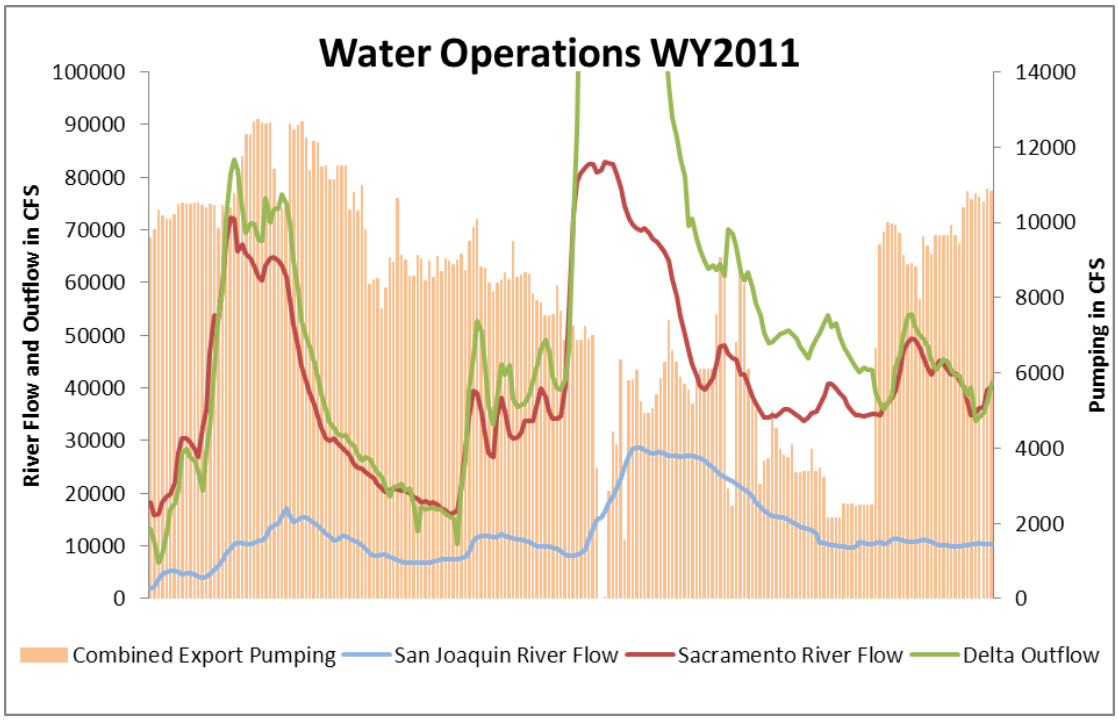

Figure 3. Export pumping, river flow, and outflow levels for WY2011.

Chapter 5—Summary of Selected Fish Monitoring Data

Most research and monitoring in the Bay-Delta are coordinated through the Interagency Ecological Program (IEP). The IEP is led by state and federal agencies, with university and private partners. There are currently 16 fish monitoring programs that are implemented each year across the entire estuary. Each captures delta smelt to some degree, however, only a few are commonly used to index the abundance and distribution of delta smelt (Figure 4).

The Fall Mid-Water Trawl (FMWT) and the Summer Tow-Net Survey (STNS) are the two longest-running IEP fish monitoring programs that are used to index delta smelt abundance. Neither was designed specifically to sample delta smelt. Two more recent programs, the 20-mm Survey and the Spring Kodiak Trawl (SKT) survey, were designed specifically to sample delta smelt. Each of these four sampling programs targets different life stages and encompasses the entire life cycle and distribution. Data from the FMWT (September – December) is used to calculate relative indices of abundance and is used in the BO to set calculate allowable incidental take. Data from the SKT (January – May) is used to monitor distribution and spawning readiness of adults. Data from the 20-mm Survey (March – June) is used to monitor the distribution and relative abundance of post-larval delta smelt. Data from the STNS (June – August) is used to monitor the distribution and relative abundance of juvenile delta smelt.

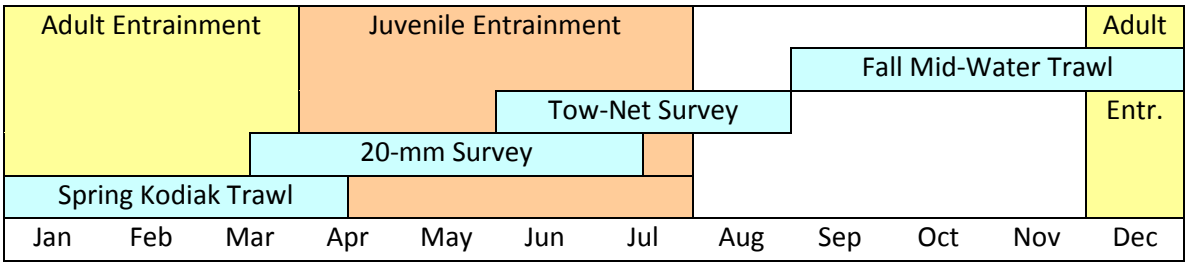

Figure 4. Approximate timetable of the primary surveys used to assess relative abundance and distribution of delta smelt.

Both the state and federal water projects utilize behavioral-barrier fish screens designed to route fish away from export water and into a fish "salvage" facility where they are collected, counted, and trucked to a release site in the Delta. The salvage process was designed for young Chinook salmon and striped bass; delta smelt that enter the facility are not thought to survive the release process and are counted as mortality. The fish salvage facilities report delta smelt and longfin smelt salvage to the Service and publish the information on a web site (BO, pp 143-145).

Hydrologic information is available from the California Data Exchange Center (CDEC) and the U.S. Geological Survey. Particle Tracking Modeling is supplied by DWR when and as requested. Please see Attachment 2, SWG Notes for June 1, 2010, for an example of how this information has been used by the SWG.

Chapter 6 – Discussion of Turbidity Criteria

The objective of Component 1, Action 1 of the RPA is to reduce entrainment of pre-spawning adult delta smelt during the December through March period by controlling OMR when fish are vulnerable. Action 1 is intended to protect delta smelt moving into freshwater prior to spawning by limiting average daily OMR for a 14-day period while the first pulse of winter precipitation is moving through the Sacramento River watershed. Movement of delta smelt during this period is associated with increased entrainment as reflected by salvage at the State and Federal facilities.

After December 20, the implementation of Action 1 is based on two criteria, one salvage-based and the other turbidity-based. The RPA specifies turbidity exceeding 12 NTU for three days at Prisoner's Point (PPT), Holland Cut (HOL), and Victoria Canal (VCU) stations as the turbidity-based criterion for implementation (Figure 5). Thus, turbidity at these three "criterion" stations must be reflective of conditions in the Sacramento River that lead to entrainment events for delta smelt in order to meet the intent of the Action.

Action 1 has not been implemented since the promulgation of the biological opinion in December 2008 because the criteria for implementation were never met or exceeded. Water years 2009 and 2010 were classified as dry and below normal, respectively. The Smelt Working Group (SWG)noted that entrainment events tend to be associated with flows on the Sacramento River in excess of 25,000 cfs. In WY 2009, flows on the Sacramento River did not exceed 25,000 cfs for three days until February 20, and in WY 2010, not until January 22. Using 25,000 cfs as an indicator of winter pulse flow conditions, the 3-station 3-day average (herein after referred to as the "3x3 rule") failed to reflect the pulse flow, even in water year 2011, when flows on the Sacramento River exceeded 25,000 cfs as early as December 8. However, OMR flows were favorable throughout the winter pulse period.

Figure 6 depicts flow on the Sacramento River at Freeport (QSac) and San Joaquin River at Vernalis (QSJR) plotted with the lowest turbidity reading at the three criterion stations (since all three must average 12 NTU or greater to implement Action 1) for each of the water years for which the RPA has been in effect. In each year, the SWG determined that the 3x3 rule had failed to detect the winter pulse flow and, except for WY 2011, initiated Action 2 based on the criteria provided in the RPA (BO, pp 352-356).

Criterion Stations

The criterion stations were initially selected because of their geographic locations and also because turbidity data was collected there. Since the BO was written, many existing U.S. Geological Survey (USGS) gauging stations have added turbidity to the data that they collect. During the OCAP Science Panel Review in 2010, the Service noted the deficiency of the 3x3 rule in detecting the winter pulse and proposed an analysis of the available data to determine how best to address the problem. The Panel agreed that this would be a valuable undertaking. This review constitutes an initial step toward such an analysis.

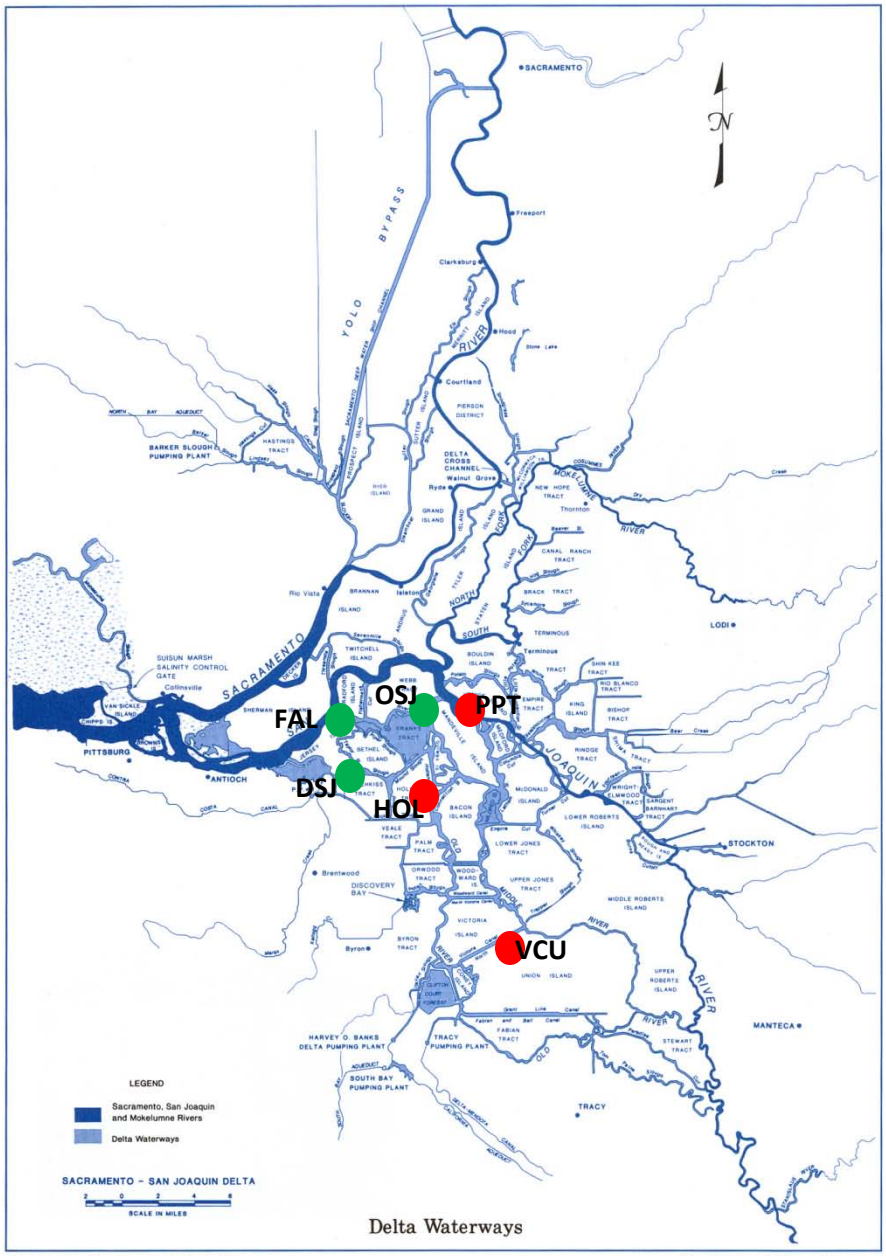

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Figure 5. Map of turbidity stations monitored by the Smelt Working Group. Red dots are criterion stations specified in the RPA and green dots are additional stations.

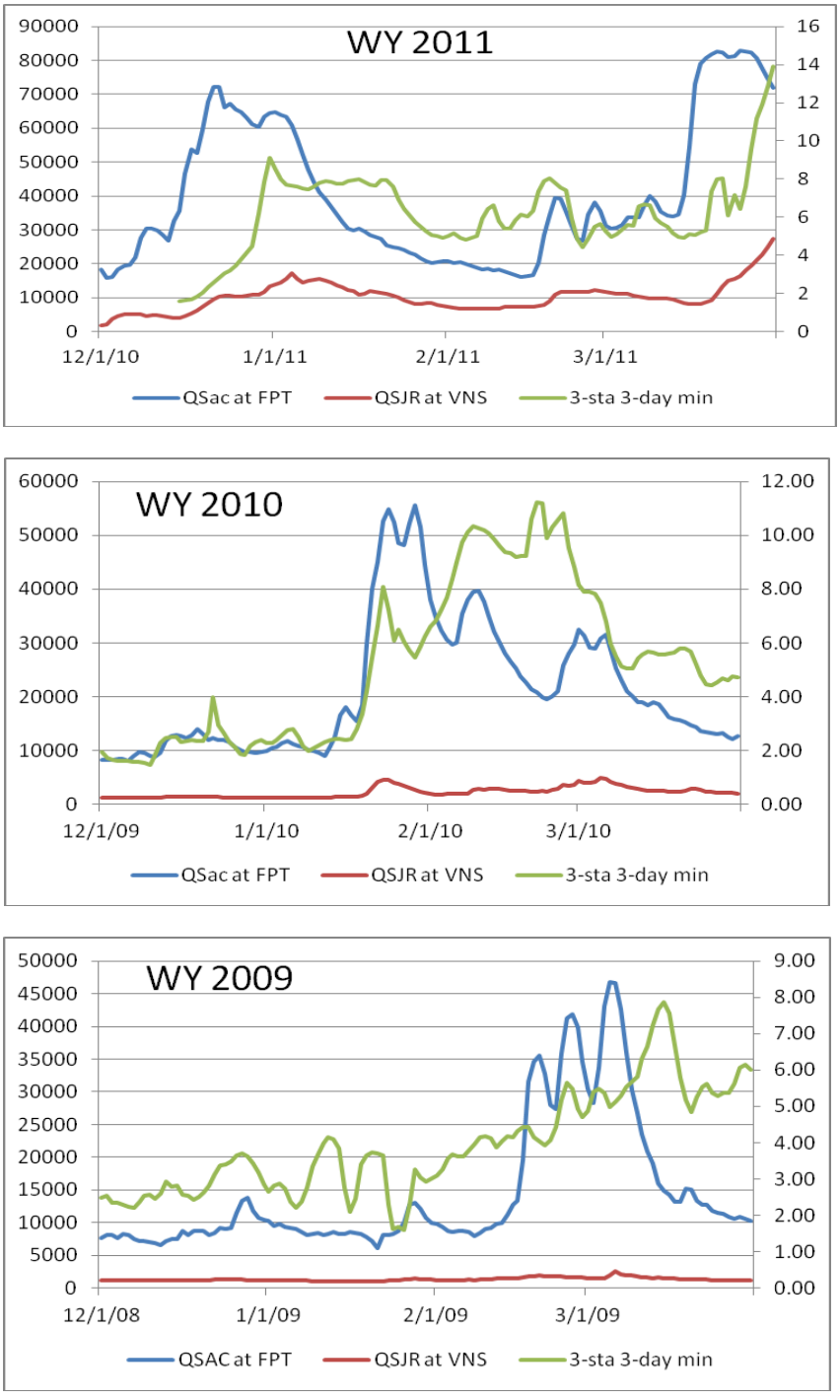

Figure 6. Sacramento (QSAC) and San Joaquin (QSJR) during the RPA Component 1 period (left vertical axis) plotted with the three-day three-station minimum turbidity (right vertical axis). The turbidity-based criterion for implementation of Action 1 is exceedence of 12 NTU at all three stations.

For this preliminary exercise, we looked at the relationship of three-day average turbidities with three-day average flows on the Sacramento River. The three-day three-station minimum is the daily minimum value of the three-day average turbidity among the criterion stations. In each of the three years of RPA implementation, turbidity at the Prisoner's Point (PPT), Holland Tract (HOL) and Victoria Canal (VCU) stations were well-correlated with Sacramento River flow, with the exception of VCU in WY 2009 (Table 3). The three-day three-station minimum was also well-correlated. However, lag times were often substantial. In WYs 2010 and 2009, PPT lagged the Sacramento River by four days, but lagged by more than two weeks in WY 2011. HOL lagged the Sacramento River by at least 10 days in all three years, while VCU never exceeded 12 NTU in WYs 2010 and 2009 and required nearly a month to surpass 12 NTU in WT 2011 (Table 3).

Table 3. Summary of turbidity station correlation data during the rising limb of the hydrograph. Values depicted are Pearson's "r" statistic. The number of days required to reach the three-day average turbidity after the Sacrament River surpassed 25,000 cfs are in parentheses.

Station	WY 2011	WY 2010	WY 2009
Prisoner's Point (PPT)	0.945577 (16)	0.80379 (4)	0.812242 (4)
Holland Tract (HOL)	0.884082 (62)	0.879689 (10)	0.604633 (32)
Victoria Canal (VCU)	0.706782 (29)	0.929146 --	0.062882 --
3-sta 3-day min	0.93813 (112)	0.920294 --	0.640327 --
Old River San Joaquin (OSJ)	0.928819 (16)	0.882615 (1)	
False River (FAL)	0.736604 (17)	0.874883 (0)	
Dutch Slough at Jersey Is. (DSJ)	-0.1169 (6)	0.615935 (0)	

Additional Stations

To address the apparent deficiency in the 3x3 rule, the Service undertook to track turbidity at several additional stations in the Delta and the lower tributaries. For this exercise, we will consider turbidity from Old River at San Joaquin (OSJ), False River (FAL) and Dutch Slough at Jersey Island (DSJ) (Figure 5). Turbidity data for these stations became available during December of 2009. Each of these stations is located near Franks Tract, and in relative proximity to PPT and/or HOL. Of the three additional stations, OSJ and FAL were well-correlated with Sacramento River flow in both years; DSJ was well-correlated only in WY 2010. All the additional stations exceeded 12 NTU in both years. In WY 2010, the additional stations did not lag Sacramento River flows, but in WY 2011, turbidity lagged flow by at least two weeks at OSJ and FAL. (Because DSJ was not correlated with flow in 2011, we did not give consideration to the lag time.)

Discussion

Salvage of adult delta smelt is a function of relative distribution (X_2), reverse flow (OMR), and relative abundance. The onset of salvage tends to be related to flow in the Sacramento River (QSac), a component of which is turbidity. As flows in the Sacramento River increase, sediments are mobilized, turbidity increases, and delta smelt begin to move upstream. As they move, delta smelt become vulnerable to entrainment. The intent of Action 1 is to decrease the Projects' entrainment footprint during a time when pre-spawning adult delta smelt are likely to be particularly vulnerable. Adjusting OMR to a less-negative rate decreases the entrainment footprint and allows adult smelt to move upstream at a decreased risk of entrainment. Additionally, if delta smelt "follow" the turbidity distribution up the Sacramento River, they are more likely to spawn in the northern part of the Delta, where they and their progeny are less vulnerable to entrainment than were they to enter the lower San Joaquin, and the central and southern Delta. Therefore, the ability to anticipate the onset of smelt movement is critically important to the effort to minimize adult entrainment.

The existing monitoring specified in the RPA is insufficient to accurately predict the onset of upstream movement of adult delta smelt. The purpose of monitoring turbidity is to anticipate risk to pre-spawning adults as they move upstream; therefore, station turbidity must provide a near-real-time indicator or its usefulness is lost. Depending upon rates of negative OMR flow, transit times for water (and smelt) from the lower San Joaquin River to the export facilities may be on the order of three to five days. Thus, stations that exhibit a lag time in excess of about three days may not provide a sufficient indication of the risk of entrainment.

The Service agreed to monitor additional turbidity stations in the Delta and the lower tributaries to try to find additional stations that better reflect the response of Delta turbidity to increased river flow. To date, none of the additional stations has clearly reflected the first pulse. The reason for this is unclear, and likely due to a number of factors. As river flows first enter the broad reaches of the Delta they slow markedly, decreasing their ability to carry sediment and dampening turbidity. As inflows enter some of the narrower Delta channels, velocities may increase, but consistently high velocities in some channels likely minimizes the amount of sediment available for resuspension. Delta turbidities may be highly localized; submerged islands, with their increased wind fetch, may experience sediment resuspension that may or may not be exported to adjacent channels. Also, turbidity tends to ebb and flow with the tidal cycle; the highest turbidity readings tend to occur on the flood tide, both diurnally and bi-weekly.

Further, it is important to note that the original criterion stations were selected primarily because turbidity data was available there, rather than for their suitability *per se*. The proximity of the VCU station to the export facilities is somewhat problematic. It is possible, perhaps likely, that once turbidity exceeds 12 NTU at VCU for three days, the entire Delta would be similarly turbid, thwarting the intent of the Action and making it unlikely that an entrainment event could be avoided or minimized. Once this condition occurs, it likely would take considerable "dilution" with clearer riverine inflow and significant settling for Delta channels to clear. If pre-spawning adult delta smelt distribute themselves along this turbidity gradient, then salvage is likely to occur over an extended period. Even if modified Project

operations (i.e., more positive OMR flows) reduce adult salvage, in the long run, juvenile salvage may also be high. This calls the essential suitability of the VCU station into question. Additional turbidity data from other stations must be reported to the SWG to assist in their assessment of the onset of adult smelt movement.

Conclusion

Three years of station turbidity data are not sufficient to construct a meaningful analysis. At this point, the only conclusion that we are able to reach is that more years of observation and analysis are needed before the Service is able to use turbidity to reflect the winter pulse with confidence. We will continue to collect additional turbidity data in the Delta and the lower tributaries and provide that information to the SWG for review and discussion.

Chapter 7—Year in Review and Request for Feedback

7.1 Issues that arose during 2011 that are likely to be revisited by the SWG in 2012

The Service began working with the Project agencies to revise the existing protocol for handling large amounts of debris and high fish counts at the fish salvage facilities. This work is on-going, but is expected to be completed by early 2012.

The SWG was consulted by the Project agencies concerning the timing of larval sampling at the fish salvage facilities. A larval sampling protocol has not yet been developed; the Service will work with the Project agencies to develop and implement a protocol for larval sampling.

7.2 Successes and request for feedback

The SWG met regularly in WY 2011, mainly via conference call. Participation from all member agencies was generally very good. Discussion has been facilitated through the development and use of a standardized meeting agenda beginning in WY 2010. The process of preparing, reviewing, and distributing the SWG meeting notes has been facilitated through an improved internal process of management review and website coordination.

The Service worked closely with USGS staff to better interpret turbidity data in WY 2011. The Service will continue to work with USGS staff and to monitor additional turbidity stations in WY 2012. Because most Delta turbidity stations are so new and have very few years of data available, we have not yet undertaken an in-depth analysis of turbidity station suitability. Any suggestions that the Panel may have regarding evaluation of the turbidity stations with respect to the implementation of Action 1 will be warmly welcomed.