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SPRING 2000 DELTA SMELT SALVAGE AND DELTA HYDRODYNAMICS AND AN INTRODUCTION TO THE DELTA SMELT WORKING GROUP'S DECISION TREE

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Introduction and Background

The delta smelt (*Hypomesus transpacificus*) is listed as a threatened species under both the Federal Endangered Species Act (FESA) and the California Endangered Species Act. Through formal consultation under Section 7 of the FESA, USBR and DWR received a biological opinion from USFWS, which allows for the incidental take of delta smelt arising through operation of the Central Valley Project (CVP) and the State Water Project (SWP). The incidental take of delta smelt is estimated as part of CVP and SWP fish salvage operations. Salvage levels of young delta smelt have exceeded incidental take levels every spring and summer since 1996, except in the very high spring outflow year of 1998 (Table 1). These high salvage levels have resulted in changes to project operations, often leading to the curtailment of water exports.

Nobriga and others (2000) reviewed data on delta smelt distribution, recruitment patterns and salvage, as well as Delta hydrodynamics during the moderately wet springs of 1996 and 1999 to provide hypotheses about why springtime delta smelt salvage has been consistently high. Based on their review, Nobriga and others (2000) suggested the following:

- Moderate winter-spring flows in the San Joaquin River may result in attraction of spawning delta smelt into the central Delta.

- Maintenance of moderate central Delta flows during the Vernalis Adaptive Management Plan (VAMP) provides good larval rearing habitat within the Delta[1].

Table 1 Estimated combined CVP and SWP salvage of delta smelt from April through August, 1994 through 2000[a]

Year	Water year type[b]	Month				
		Apr	May	Jun	Jul	Aug
1994	B	945	31,901	8,801	1,509	0
1995	A	24	0	0	0	0
1996	A	111	**30,099**	9,465	148	0
1997	A	1,159	**32,828**	7,876	228	0
1998	A	48	4	66	124	0
1999	A	410	**58,943**	**73,368**	**20,272**	48
2000	A	1,746	**49,401**	**49,124**	1,513	6

[a] Total salvage numbers that exceeded the red light take levels are shown in bold type. Red light take levels for above normal water years (1995–2000) are April = 2,378, May = 9,769, June = 10,709, July = 9,617, and August = 4,818. Red light take levels for below normal water years (1994) are April = 12,345, May = 55,277, June = 47,245, July = 35,550, and August = 25,889.

[b] B = below normal, A = above normal.

Although delta smelt salvage was very high in both 1996 and 1999, total salvage was much higher in 1999. Nobriga and others (2000) suggested two factors were primarily responsible for the higher salvage in 1999.

- The apparent recruitment of delta smelt, as inferred from the DFG 20-mm Survey, occurred for a longer period in 1999 than in 1996.

- Net flows in Old and Middle rivers at Bacon Island during the 1999 VAMP remained near zero much of the time, whereas they were typically positive during 1996. Presumably, positive net central Delta flows during the 1996 VAMP helped move larval delta smelt downstream away from the zone of influence of the south Delta facilities before they reached a size they could be observed in the salvage operations when exports were ramped up following the VAMP.

Based on data from 1996 and 1999, and forecasts of central Delta flows for spring 2000, Nobriga and others (2000) predicted delta smelt salvage would exceed the red light levels in 2000. As predicted, delta smelt salvage did

1. See also "Vernalis Adaptive Management Plan 2000 Salmon Smolt Survival Investigations" on page 47.

exceed red light levels in May and June 2000. In this article we review data on delta smelt salvage in conjunction with hydrodynamic data for spring and early summer 2000 to provide additional evidence that high spring salvage may result from VAMP operations. We also provide an overview of the Decision Tree Process used by the Delta Smelt Workgroup to help determine when changes to water project operations may be warranted.

Overview of Hydrodynamics Methods

The USGS collected tidal flow data on a 15-minute interval at Old and Middle rivers using ultrasonic velocity meters (UVM) (Oltmann 1998). These data were tidally averaged to provide net flow at each location. The net flow at Old and Middle rivers will be referred to as central Delta flows throughout this article.

Vernalis Flow and Delta Smelt

Nobriga and others (2000) hypothesized the occurrence of intermediate flows on the San Joaquin River in late winter 1996 and 1999 provided attractive conditions for adult delta smelt moving upstream to spawn. During winter and spring 2000, San Joaquin River flow at Vernalis was similar in timing and magnitude to the other recent moderately wet years reviewed by Nobriga and others (2000) (Figure 1). However, it is unknown what proportion of adult delta smelt spawned in any particular part of the Delta during any of these years. DFG is conducting a study designed to better characterize delta smelt spawning habitats. The results of this study may be very useful to forecasting high salvage events.

Since 1996, additional reservoir releases from the San Joaquin system have been provided for a 30-day period from mid-April to mid-May as part of the VAMP. This "pulse flow" was designed to provide transport flows for chinook salmon emigrating from the San Joaquin basin. The pulse flow is also thought to provide beneficial transport and habitat enhancement flows for delta smelt larvae spawned in the central and south Delta. However, by improving in-Delta habitat conditions and reducing net negative flows, VAMP may be responsible for the consistent exceedance of red light take levels in late spring and early summer. In years before the implementation of the VAMP, central Delta flows were typically negative throughout the spring. Presumably delta smelt spawned in the south Delta would have been entrained as larvae before they grew large enough to be salvaged at the facilities (see below). With the implementation of the VAMP pulse flow period, there is a window of time each spring during which central Delta flows range from only slightly negative to slightly positive. Nobriga and others (2000) hypothesized that the pulse flow allows delta smelt spawned in the central and south Delta to rear and grow large enough to be observed in the salvage (see below) once the pulse flow ends.

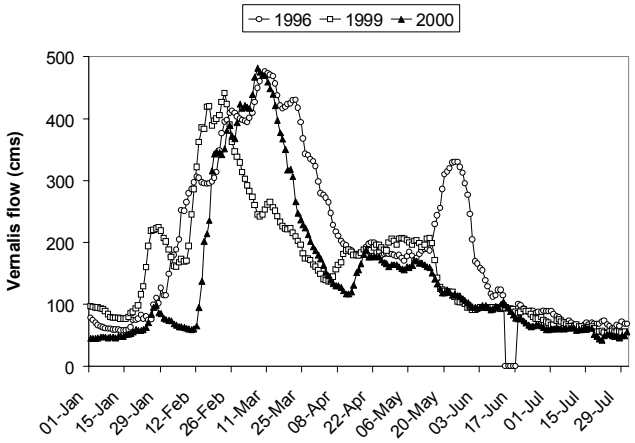

Figure 1 San Joaquin River flow at Vernalis (cubic meters per second) from January through July for moderately wet years 1996, 1999, and 2000

Overview of Salvage Patterns and Delta Hydrodynamics

Salvage of young delta smelt at the SWP and CVP Delta fish facilities begins to be quantified each spring when the smelt reach a length of about 25 mm. In terms of total delta smelt salvaged, 2000 was similar to recent years with high salvage occurring in May and June (Table 1). As in previous years (Nobriga and others 2000) delta smelt salvage began to increase, particularly at the SWP, at the end of the VAMP, about May 20 (Figure 2). Interestingly, the salvage increase was associated with only a very slight change in central Delta flows (Figure 3), suggesting the increase was triggered by smelt residing near the facilities. In response to the abrupt increase in delta smelt salvage, SWP exports were cut back and CVP exports were increased for a few days beginning about May 25 (see article by Le on page 9 for details about operations changes). Salvage densities decreased in response to this change in operations, but increased again when the SWP increased exports beginning about May 27. Despite a noticeable decrease in salvage density throughout June, the total number of delta smelt salvaged

during June was about the same as in May (Table 1) due to the larger volume of water exported in June (Figure 4).

In conclusion, San Joaquin River flows during winter and early spring 2000 were similar to other years hypothesized by Nobriga and others (2000) to attract spawning delta smelt into the central Delta. Delta smelt salvage quickly exceeded red light levels following the VAMP in 2000 as it has in most recent years. This lends additional support to the hypothesis that the VAMP results in suitable larval rearing conditions within the central and south Delta, and therefore high salvage when CVP and SWP exports ramp up after VAMP. This should not be interpreted as meaning entrainment losses of delta smelt are higher now than they were historically. We believe the difference is that some of the fish that would historically have been "silently" entrained as larvae, now grow to a detectable size during the VAMP period and are therefore counted in salvage during late May and June.

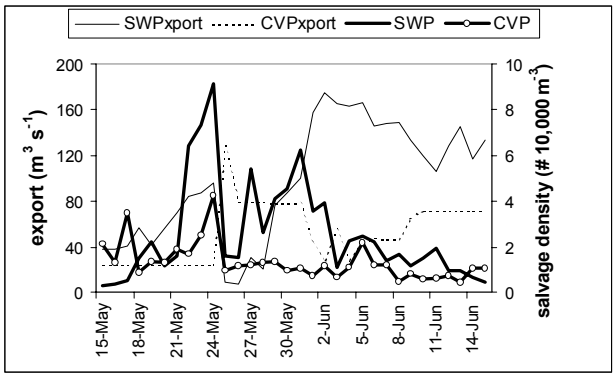

Figure 2 Daily CVP and SWP export rates and delta smelt salvage density for the 30-day period following the conclusion of the VAMP pulse flow in 2000

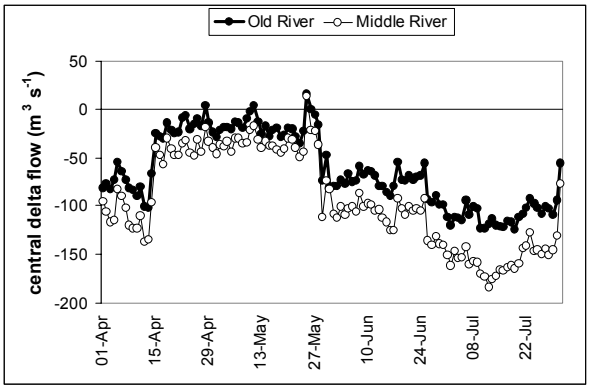

Figure 3 Tidally averaged (net) flow in Old and Middle rivers at Bacon Island from April through July as measured by ADCPs operated by USGS

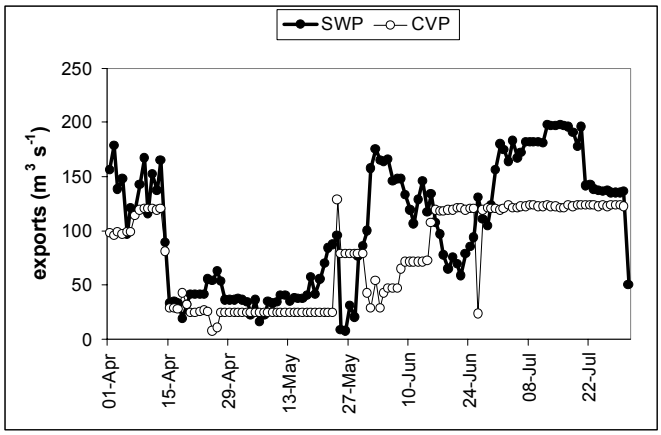

Figure 4 CVP and SWP daily export rates from April through July 2000

Delta Smelt Working Group Decision Tree Process

The Delta Smelt Working Group is a product of the 1995 delta smelt biological opinion. As defined in the opinion, the group's purpose is "…to resolve biological and technical issues raised by this opinion and to develop recommendations for consideration by the management group." Participants include agency personnel from USFWS, NMFS, DFG, USBR, EPA, DWR and SWRCB. The Delta Smelt Decision Tree (Table 2) is the written description of the types of information, questions, and thought processes the working group uses to determine if recommendations for operational changes are warranted. The decision tree is not intended to add any new requirements or criteria, but rather it is intended to inform other interested parties of the decision processes presently in use.

Reference

Oltmann RN. 19983 Measured flow and tracer-dye data showing anthropogenic effects on the hydrodynamics of south Sacramento-San Joaquin Delta, California, spring 1996 and 1997. USGS Open-File Report 98–285. Sacramento (CA): U.S. Geological Survey. 16 p.

Table 2 The Delta Smelt Decision Tree

Life stage	Adults
Timing	Pre-VAMP (February 1 through April 15)
Concerns	1) High relative densities of adults in the south Delta are a concern due to the potential for increase entrainment at the SWP and CVP.
	2) High relative densities of delta smelt in the south Delta also suggest spawning may occur in the south Delta, increasing the chances for exceeding the red light level[a] of incidental take in the late spring and early summer.
Data of interest	Before pre-VAMP, consider fall midwater trawl indices
	Spring midwater trawl
	Salvage
	Beach seine
	Chipps Island trawl
	Hydrology (wet or dry year; placement of X2)
	Water quality conditions and water temperature
	Condition of the fish
Assessment of conditions	Adult distribution in Delta and downstream of the Delta
	Salvage levels/densities, yellow light
	Potential high numbers in juvenile salvage if high numbers of adults are concentrated in the south Delta
Tools for change	Reduction in exports, either concurrently at both facilities or at the facility that is salvaging the most fish
Biological questions using the available data	1) Is the adult distribution broad or not?
	2) Is salvage elevated or not?
	3) Is previous FMWT index high or low?
	4) Are water quality conditions (e.g. water temperatures) conducive to spawning?
	5) Are fish ripe for spawning? (Both of above may help determine if there will be a protracted spawn.)
Questions concerning operations	1) Is there a need to reduce exports at either or both facilities based on either the distribution of adults and/or an increase in the salvage of adult delta smelt?
	2) Is it likely to be a difficult spring or summer? That is, do we expect high levels of delta smelt salvage in the spring or summer?
Assessment of concern	I. If the stated recovery criteria index is lower than 239, then concern is high.
	II. If distribution information shows adults delta smelt are concentrated in the south and central Delta, then concern is high.
	III. If the observed or predicted salvage of adults increases sharply, then concern is high.
	IV. If fish at the salvage facilities are on the verge of spawning and temperatures are conducive to spawning, then concern is high.
Recommendations	A) If concern is high and salvage increases abruptly, then recommendations for action is likely.
	B) If the observed or predicted salvage is at or approaching the red light or at the yellow light, then a recommendation for action is likely.
	C) If assessments II and I are true, then we expect a difficult spring or summer (June and July).
Life stage	**Larvae**
Timing	VAMP (April 15 through May 15)
Concerns	High numbers of larvae in the south Delta will likely result in higher numbers of fish rearing to juvenile stages and higher levels of entrainment.
Data of interest	Light traps surveys
	20-mm survey[b]
	Water temperatures
	Salvage[c]
	Hydrology (wet or dry year; placement of X2)
Assessment of conditions	Spawning distribution
	Percent distribution

[a] Yellow light and red light as defined in the 1995 OCAP opinion.
[b] If fortnightly 20-mm survey is occurring and red light occurs, then effort will increase to weekly sampling.
[c] Salvage levels at this time will likely not reflect the number of delta smelt in the south Delta, since smelt begin to be counted at the salvage facilities at about 25 mm.
[d] The barriers shall be operated as stated in the USFWS biological opinion (1-1-96-F-53), April 26, 1996.
[e] Changes considered under “a” and “b” would aim to increase net positive flows in Old and Middle rivers downstream of the export facilities.

Table 2 The Delta Smelt Decision Tree (Continued)

Assessment of conditions (continued)	Timing: start and duration of spawning
	Implement model to predict future salvage (end of VAMP)
	Water quality conditions, water temperature
Tools for change	Change in San Joaquin River flows
	Change in export reductions (1–3 = net flow)
	Change in barrier operations
Biological questions using the available data	1) Is distribution of spawning broad or restricted?
	2) Is larval distribution broad or restricted?
	3) When does spawning start?
	4) Do we expect punctuated or protracted spawning?
	5) Do we expect SWP and CVP to reach red light salvage levels?
Questions concerning operations	Do we consider changing net flows in Old and Middle rivers?
Assessment of concern	I. If light trap results demonstrates that spawning has occurred in the south Delta, then concern is high
	II. If the 20-mm survey shows 50% of the delta smelt are in the zone of influence (e.g,. east of the confluence), then concern is high.
	III. If abundance in the 20-mm survey is low relative to other years, then concern is high.
	IV. If substantial larval recruitment is expected to occur in the south and central Delta post-VAMP, then concern is high
Recommendation	If concern is high and salvage is at or approaching red light or at yellow light, then recommendations to improve net flow in Old and Middle Rivers are likely. (This recommendation applies during VAMP and post-VAMP, although the tool used will vary.)
Life stage	**Juveniles**
Timing	Post-VAMP (May 15 through July 1)
Concerns	High numbers of delta smelt juveniles in the south and central Delta will likely result in increased entrainment when export levels increase at the end of VAMP
Data of interest	20-mm survey[b]
	Salvage
	Summer townet
	Hydrology (wet or dry year; placement of X2)
	Export rates
Assessment of conditions	Percent of the distribution outside the zone of influence (e.g., east and west of the confluence)
	Salvage level (number)
	Salvage density
Tools for change	Change in exports
	Change in agricultural barrier operations[d]
	Removal of HORB[d]
	Position of cross-channel gates
	Flow changes in San Joaquin, Old, and Middle rivers
Biological questions using the available data	1) What is the relative distribution in and outside the zone of influence (e.g. upstream and downstream of the confluence)?
	2) Is abundance high?
	3) Is salvage at or approaching red light or at yellow light?
	4) Are fish migrating west from the Delta?
Questions concerning operations	1) Do we consider changing exports?[e]
	2) Do we consider changing agricultural barrier/HORB operations?[e]
	3) Do we consider changing the position of the cross channel gates after May 20?
Assessment of concern	I. If the 20-mm survey shows 50% of the delta smelt are in the zone of influence (e.g. east of the confluence), then concern is high.
	II. If abundance in the 20-mm survey is low, relative to other years, then concern is high.
Recommendation	If concern is high and salvage is at or near red light, then recommendation for action is likely.

[a] Yellow light and red light as defined in the 1995 OCAP opinion.
[b] If fortnightly 20-mm survey is occurring and red light occurs, then effort will increase to weekly sampling.
[c] Salvage levels at this time will likely not reflect the number of delta smelt in the south Delta, since smelt begin to be counted at the salvage facilities at about 25 mm.
[d] The barriers shall be operated as stated in the USFWS biological opinion (1-1-96-F-53), April 26, 1996.
[e] Changes considered under “a” and “b” would aim to increase net positive flows in Old and Middle rivers downstream of the export facilities.