Environmental Water Account Expenditures for Protection of the Delta Smelt in Water Year 2004

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Introduction

This report updates previous narrative accounts of the expenditures of the Environmental Water Account (EWA) for the protection of the threatened delta smelt (*Hypomesus transpacificus*). Because this report is the fourth in a series[1] aimed at a narrow audience of readers, much of the background information contained in previous reports has been omitted. This report includes a description of environmental conditions in the Delta, summary data on the distribution and abundance of delta smelt in water year 2004, and a brief assessment of the performance of the EWA with respect to the protection of the delta smelt and its habitat. Finally, this report discusses accomplishments and limitations of the EWA in 2004.

Delta Smelt

The delta smelt was listed as a threatened species by the U.S. Fish and Wildlife Service (Service) under the Endangered Species Act (ESA) of 1973, as amended, effective April 5, 1993. Delta smelt are endemic to the San Francisco Estuary and the Sacramento-San Joaquin Delta, which has undergone a profound transformation over the past 150 years. This small euryhaline planktivore is generally found in or just upstream of the region of fresh and saltwater mixing, in shallow, open waters with relatively low current velocities (Moyle, 2002). Factors thought to have contributed to the decline of the species include reductions in freshwater outflow, entrainment losses to water diversions, entrainment at power plant intakes, extreme high outflow years, changed abundance and composition of food organisms, toxic substances, disease, competition, and predation (U.S. Fish and Wildlife Service, 1993).

On March 31, 2004 the Service completed a five-year status review for the delta smelt as a partial settlement for two lawsuits. The Service utilized a variety of information to conduct the review, including all available scientific data, monitoring results and a paper submitted by the plaintiffs. The review concluded that the delta smelt population remains relatively low, compared to

[1] Previous years' reports may be found on the web at http://science.calwater.ca.gov/workshop/past_workshops.shtml and clicking on "EWA Review" I, II or III

historical levels, and that many of the threats to the species identified at the time of listing still exist, precluding de-listing of the species at this time (USFWS, 2004).

Expenditure of Environmental Water Account Assets

The EWA acquires and manages assets to provide water for the protection and recovery of fish beyond water available through existing regulatory actions related to SWP and CVP operations (CALFED 2000b). The implementation of "fish actions" using EWA assets can occur upstream of the Delta to augment stream flow and Delta inflow, or at the export pumps, to reduce the rate of pumping when at-risk native species appear in daily salvage at high numbers. Flow augmentation, which primarily benefits salmonids, is achieved by timing the movement of EWA assets to coincide with instream flow needs, to the extent practicable. Fish actions taken to protect delta smelt consist of export pumping curtailments, which directly reduce incidental take. Pumping curtailments from January through March protect pre-spawning and spawning adult delta smelt. Actions taken in April through June may protect late-spawning adults or young-of-the-year. Early life-stages less than 20 mm in length are too small to be identified and counted in daily salvage operations, however, once spawning has begun the take of these individuals is assumed to occur, even though it cannot be quantified or evaluated by existing monitoring programs.

Protection of both adults and young-of-the-year may be important when abundance indicators are low and density-dependent effects would not be expected to exert an influence. In water year 2004, the need for fish actions was assessed following the delta smelt decision process developed in 2000 (Nobriga et al, 2001). Interagency technical staff comprising the Delta Smelt Working Group and the Data Assessment Team (DAT) considered incidental take at the export facilities, physical conditions in the Delta, and the distribution and abundance of the species in formulating recommendations for the modification of SWP and CVP operations, with oversight and final approval at the management level (Water Operations Management Team, or WOMT). Following the issuance of the 2004 Biological Opinion for the Operations Criteria and Plan (OCAP), a new decision process will be instituted for water year 2005 (USFWS, 2004). The Delta Smelt Risk Assessment Matrix (DSRAM, Attachment 1) was formulated by the Delta Smelt Working Group, building on the 2000 decision process and incorporating more recent science, to better reflect the process used by the DAT in evaluating real-time monitoring data.

Over the four years of EWA implementation, the use of EWA assets has shifted to reflect changes in understanding of species biology and of the ecology and physical processes operating in the Delta. Management of winter-run Chinook

salmon is based upon a more accurate adult abundance estimate that led to an updated decision process. Use of assets for delta smelt focuses on SWP and CVP Delta export curtailments timed to protect of spawning and pre-spawning adults and/or to promote young-of-the-year emigration. EWA asset use for delta smelt is driven not so much by incidental take *per se* as by an assessment of overall trends among many relevant variables. Implementation of the new delta smelt risk assessment matrix (DSRAM; USBR 2004) is intended to monitor trends in delta smelt abundance and distribution and Delta conditions such as hydrology, risk of entrainment, spawning readiness, and water temperature, so that science-based recommendations for modifications to Project operations can be made proactively, to avoid instances of elevated incidental take. The late-May export curtailment referred to as the "post-VAMP shoulder" is intended to improve south Delta habitat and afford delta smelt larvae greater opportunity to move from the sloughs and channels in which they were hatched to their rearing areas in Suisun Bay, Suisun Marsh and the lower Sacramento River (Poage, 2004). This action also potentially benefited juvenile fall-run Chinook emigrating from the San Joaquin River tributaries.

Environmental Conditions/Delta Smelt Situation in WY 2004

December precipitation was about 150 percent of average, but as in the previous year, January precipitation was only about 55 percent of average. In February, a mid-month storm carrying subtropical moisture produced moderate flood flows on many California streams. A late-February storm produced substantial gains in snowpack and pushed monthly precipitation to 160 percent of average. March turned unusually warm and dry, setting new temperature records and causing early snowmelt. Precipitation during March was about 40 percent of average statewide, however, runoff was about 95 percent of average, indicating an overall loss of snowpack. April continued warm and dry, with precipitation at only about 50 percent of average. The snowpack continued to melt at above-normal rates, contributing to near-normal streamflow in some areas despite the lack of precipitation. Although reservoir storage was near average at the beginning of April, runoff forecasts were lowered due to the dry weather, and few of the foothill reservoirs were expected to fill. By May 1, snowpack was about 50 percent of average. By the beginning of June, the snowpack had almost completely melted and runoff and snowmelt were about one month ahead of average in many basins. A levee break in early June drove the CVP and SWP to curtail exports and increase reservoir releases, to minimize salt water intrusion into the Delta (California Department of Water Resources, 2004).

Although incidental take of delta smelt at the State and Federal export facilities was low to moderate, concern for delta smelt was high in water year 2004. The 2003 Recovery Index was 101, up from the 2002 index of 33 but well below the

target abundance criterion of 239[2] specified in the Recovery Plan (U.S. Fish and Wildlife Service, 1996). As adults moved into their spawning areas in the Delta and adjacent river channels and sloughs in January and February, the California Department of Fish and Game (CDFG) spring Kodiak trawl survey detected few fish, relative to previous years. Unseasonably warm weather in March and April caused water temperatures in the Delta to warm relatively rapidly, potentially creating a situation in which there were relatively few adult spawners with a relatively narrow spawning window. Cooler air temperatures in May resulted in decreasing water temperatures in the Delta, and length frequencies from CDFG's 20-mm survey indicated the presence of three to four cohorts. By early May the export facilities were no longer salvaging adult delta smelt. Young-of-the-year delta smelt sampled in the earliest stages of the 20-mm survey appeared to be most abundant in the central Delta, east of the Sacramento/San Joaquin River confluence. Salvage remained low, but because concern for the species was high overall, the Delta Smelt Working Group recommended implementing a two-week post-VAMP shoulder beginning May 16, to support growth and emigration of young-of-the-year delta smelt. As later stages of the 20-mm survey indicated that smelt were moving toward their rearing areas, exports ramped up to levels permissible under baseline conditions. The following monthly summaries were adapted from notes from the weekly Data Assessment Team conference calls, unless otherwise referenced.

December 2003

Overall, weather in the western United States was warmer and drier than average in 2003, creating mild to moderate drought conditions that left many reservoirs with below-average storage (NOAA, 2004). The Delta Cross Channel (DCC) gates were closed on December 1, to protect emigrating juvenile Chinook salmon; export reductions required to meet Water Quality Control Plan (WQCP) standards incurred a (b)(2) cost but not an EWA cost. Water quality was a concern in the Delta early in the month, but improved inflow prompted the Project Agencies to declare excess conditions in the Delta on December 15. Incidental take of adult delta smelt began at the CVP on December 25 and at the SWP on December 31 (Table 1).

January 2004

Abundant winter precipitation brought many Central Valley reservoirs to flood encroachment levels, causing increased releases and driving improved water quality in the Delta. There was concern that January's wet hydrology would sufficiently lower salinity in the Delta to require the Project Agencies to place X2

[2] the median of delta smelt abundance in pre-decline years

west of Chipps Island in February, which could become a problem if February were to be dry[3]. High flows on the Sacramento River kept the DCC gates closed to prevent scouring, providing a collateral benefit for emigrating juvenile salmon. Salvage of hatchery Chinook from the Coleman National Fish Hatchery late fall releases, which are monitored as "surrogates" for spring-run Chinook, was very high; however, as there were no reconsultation criteria for these fish, no action was proposed or taken. Incidental take of adult delta smelt was moderate, peaking on the 19th and dropping to 30-120 per day by the end of the month. The 14-day average peaked at 212 on the 23rd. The CDFG Spring Kodiak Trawl Survey, designed to intensively sample those areas in which delta smelt have been known to spawn, began on January 12. By mid-month, adult males and females, most in the earliest stages of gamete development, had begun moving into their spawning areas in the south and central Delta, Montezuma and Cache slough areas. Water temperatures were still below the threshold where most successful spawning was believed to occur. The Project Agencies identified an upcoming opportunity to relax the Export-to-Inflow[4] (E/I) standard beginning on February 1, prompting the Management Agencies to commit to further discussion of the issue.

February 2004

Delta outflow in January triggered the need for the Project Agencies to maintain X2 west of Chipps Island during the month of February. The outflow requirement was met by increasing reservoir releases compared to the base condition. After reviewing the January forecast of the San Joaquin River Index, the USBR petitioned the SWRCB for relief from the 2,280 cfs Vernalis dry-year flow standard contained in the 1995 biological opinion on the SWP/CVP OCAP (USFWS 1995) and the Water Quality Control Plan (as implemented by the State Water Resources Control Board's Water Rights Decision 1641 (D-1641)). Citing a low reservoir carry-over level, USBR indicated that for the third year in a row, New Melones Reservoir would be unable to both provide late-summer and fall environmental flows on the Stanislaus River and meet its permit conditions and Project demands. After re-initiation of consultation with the USFWS and CDFG, USBR agreed to a 500 cfs increase in New Melones releases and a concurrent decrease in CVP exports to approximately 3,700 cfs, as a functional equivalent of 2,280 cfs at Vernalis. With increased flow later in the month from precipitation,

[3] the Delta outflow standard from February through June is dependent upon the previous month's hydrology; the standard may be met with increased reservoir releases, decreased export pumping or a combination of both (SWRCB 1995)

[4] SWRCB D-1641 limits Project exports to 35% of inflow from February through June; at the Management Agencies' discretion, the E/I standard may be relaxed to allow increased Project exports, which accrue to the EWA as an operational asset (SWRCB 1999, 1995)

New Melones releases were decreased to 300 cfs and CVP exports were increased to 4,400 cfs.

Incidental take of adult delta smelt was very low in February, dropping to near zero early in the month and picking up again at the end of the month. Beginning on the 1st, with the E/I standard controlling export pumping at a maximum of 35% of Delta inflow, an opportunity to gain assets for the EWA became available. Review of the delta smelt decision criteria early in the month revealed the following:

- The delta smelt Recovery Index, derived from the Fall Mid-Water Trawl index, was low enough at 101 (less than half of the recovery goal of 239) to generate concern;
- Adult delta smelt did not appear to be concentrated in the vicinity of the export facilities;
- Incidental take levels were not a concern;
- Spawning had not yet been observed; however, ova sizes at 0.7 mm were approaching the laboratory-observed spawning size (0.9 – 1.1 mm) and water temperatures were approaching those assumed to represent the bulk of delta smelt spawning activity (12-18^{0}C; Swanson et al, 2000).

Considering that to date the EWA had not expended assets, USBR did not expect to meet the Vernalis flow standard, and the uncertainty of storage capacity in San Luis Reservoir (EWA assets would convert to Project water if the reservoir filled), the USFWS did not recommend a relaxation of the E/I standard. By the end of the month, the Spring Kodiak Trawl Survey was sampling relatively greater numbers of ripe delta smelt, Delta water temperatures were warming into the spawning range and incidental take numbers began to climb.

March 2004

By early March, the adult delta smelt population was centered in the area of the confluence of the Sacramento and San Joaquin Rivers and was moving east. More than half of the females sampled were ripe, with males lagging somewhat. Delta water temperatures averaged approximately 12^{0}C, suitable for spawning. CDFG reported during the DAT call on March 2 that larvae had been sampled in small numbers in the North Bay Aqueduct, indicating that spawning had begun in some areas. By the March 9th DAT call, CDFG reported south Delta water temperatures at 14^{0}C[5], appropriate for delta smelt to begin spawning, and had sampled larvae in the Cache Slough area. No larvae were sampled in the south Delta, but the salvage facilities reported a few spent fish. By month's end, the

[5] from Spring Kodiak Trawl Survey sampling

Spring Kodiak Trawl Survey detected spawning activity throughout the Delta, although overall numbers of spawners appeared to be low, compared to previous years. Incidental take peaked on March first and declined fairly steadily through the month, with smaller peaks on the 8th and 12th. Overall, take never became a concern in March. However, by the end of the month, water temperatures in the south Delta had warmed to approximately 18^0C, prompting concern that the 2004 spawning window could be a narrow one, producing few cohorts. The 20-mm Survey began on March 29.

April 2004

Hydrologic conditions in March required that the Projects meet X2 at Roe Island for 16 days in April, which was accomplished with reservoir releases and export reductions prior to the VAMP. This "extension" of the flood hydrograph was thought to be protective of young-of-the-year delta smelt. By early April, the Spring Kodiak Trawl Survey was sampling pre-spawning, spawning and spent female delta smelt in roughly equal numbers. Numbers of all species sampled, including delta smelt, were very low, compared to previous years. As water temperatures continued to warm, concerns for a brief, punctuated spawning season with few cohorts grew; longfin smelt, which generally spawn slightly ahead of delta smelt, had apparently completed spawning, an indicator that the delta smelt spawning season was also nearly complete. However, subsequent surveys later in the month sampled greater numbers of fish of all species, with most delta smelt either spawning or spent, and water temperatures remaining appropriate for spawning. The first sampling period of the 20-mm Survey, completed April 1, sampled only 1 delta smelt at 8 mm in length. It was thought likely that most juveniles were still too small to be vulnerable to the sampling gear; however, CDFG noted during the March 29 DAT call that very few larvae of any species were sampled. Incidental take of young-of-the-year began at the CVP on April 26; take was very low in April as adults completed spawning and juveniles were too small to be detected at the salvage facilities (Figure 2). CDFG reported during the April 20 DAT call that juvenile delta smelt were beginning to be taken at the export facilities, but were too small to be counted (counts do not begin until larvae reach 20 mm in size, as the fish screens do not efficiently remove them (Foss, 2004). The VAMP began on April 15, with exports held at a combined 1,500 cfs and a San Joaquin River flow target of 3,200 cfs. The Head-of-Old-River fish barrier (HORB) was closed on April 15 and completed on April 21. Except for Grant Line Canal (GLC), the south Delta agricultural barriers were closed on April 15 (the GLC barrier was not closed until modeling demonstrated a need to do so). The HORB was operated with three of its six culverts opened until April 28, when two more culverts were opened. Except for GLC, the agricultural barriers were operated tidally. Delta smelt larvae were sampled in the North Bay Aqueduct on April 29 in excess of the threshold for pumping

restriction; however, by the time the take excedence was discovered, catch rates had dropped below the threshold, and operations continued normally.

EWA Costs. The Department of Water Resources estimated that SWP exports were reduced by approximately 13,000 acre-feet as a result of Fish Action #1-04 (April 15-30, first half of VAMP). Future settlements of EWA costs and credits will reflect the actual cost of water, energy, storage and conveyance incurred.

May 2004

Hydrologic conditions in April required that the Projects meet X2 at Chipps Island for 16 days in May. Despite low monthly incidental take numbers for water year 2004, concern for delta smelt was high due to the low recovery index and low overall numbers seen in routine survey sampling. Management agency staff continued to monitor Delta water temperatures, incidental take of young-of-the-year delta smelt and abundance and distribution of delta smelt from the 20-mm Survey, to determine the need for a post-VAMP shoulder. Incidental take of young-of-the-year delta smelt began at the SWP on May 11. Take at both the SWP and the CVP was light compared to previous years, totaling 5,749 for the month (Figure 3). Water temperatures in the south Delta averaged about 23^0C early in the month, but declined with the onset of unseasonably cool weather mid-month (Figure 4). Sacramento River temperatures averaged approximately 2^0C cooler than the Delta, and the sampling of a few adults in trawls and beach seines raised the possibility that spawning was still occurring in the lower Sacramento River. By the end of the month, length frequencies from the 20-mm Survey indicated the presence of three to four cohorts. On May 10, management agency biologists utilized the delta smelt decision criteria to determine the need for a post-VAMP shoulder, and found that:

- The 2003 recovery index (101) did not meet the recovery goal of 239;
- Numbers of young-of-the-year sampled in the 20-mm Survey were low compared to past years, with their distribution apparently centered east of Frank's Tract (Figure 5);
- Incidental take was very low; and
- Water temperatures had risen past the point where most spawning was assumed to have ceased, but remained below the laboratory lethal limit of approximately 25^0C.

On May 11th the DAT affirmed the Delta Smelt Working Group's recommendation that a post-VAMP shoulder be implemented, due to the overall high concern for the species brought about by apparent low numbers, narrow spawning window and vulnerability to entrainment at the export facilities. The shoulder would run for at least one week, or as long as water temperatures

remained favorable for young-of-the-year emigration, but no longer than May 31 unless concern remained very high and there was a reasonable expectation of benefit from the action. The Delta Smelt Working Group recommended that the HORB be breached on May 16; however, the EWA salmon biologists recommended that the HORB remain in place for the duration of the VAMP shoulder; this conflict was elevated to the Water Operations Management Team, who decided that the HORB should be breached one week post-VAMP (see below on the Stanislaus River pulse flow). The flap gates on the agricultural barriers were tied open during the VAMP shoulder, in accordance with the Biological Opinion on the South Delta Temporary Barriers (USFWS 2001). On May 18th the DAT recommended an extension of the VAMP shoulder through May 31, as water temperatures indicated a reasonable expectation of benefit. South Delta water temperatures ranged from 20.2^{0}C on May 15 to 23.7^{0}C on May 31 (CDEC, 2004), indicating that conditions remained favorable for emigration until the end of the month. Distribution plots from the 20-mm Survey indicated that, by the end of the month, most delta smelt had moved west of Frank's Tract, where they were thought to be beyond the influence of the south Delta export facilities (Figure 5). On May 25 the DAT recommended that ramping begin May 28. Exports would begin at 2,000 cfs and increase by 1,000 cfs per day to a target level of 6,000 cfs. The CVP and SWP had resumed full baseline operations by June 1.

Contemporaneously with the VAMP, the EWA salmon biologists requested a pulse flow on the Stanislaus River to stimulate emigration of juvenile fall-run Chinook before instream and Delta water temperatures reached the lethal limit for salmonids. They also requested that the HORB remain in place for the duration of the pulse flow, to reduce the potential for emigrating salmon to stray into the south Delta, where they would be vulnerable to entrainment at the export facilities. The pulse flow, which ran from May 14 through May 21, may have incidentally benefited delta smelt by temporarily lowering water temperatures in the south and central Delta. However, the retention of the HORB until May 19 may have contributed to increased vulnerability of delta smelt to entrainment at the export facilities.

EWA Costs. The Department of Water Resources estimated that exports were reduced by approximately 7,000 acre-feet as a result of Fish Action #1-04 (May 1-15, second half of VAMP) and by 104,000 acre-feet as a result of Fish Action #2-04 (May 16-31, the post-VAMP "shoulder"). Future settlements of EWA costs and credits will reflect the actual cost of water, energy, storage and conveyance incurred.

June 2004

The Project Agencies declared balanced conditions[6] in the Delta on June 1. Delta smelt of about 20 mm in length were still being seen at the export facilities on June 1, an indicator that incidental take was likely to continue for some time, but by June 3, take had peaked, and had dropped below concern levels by June 12, ending the month at 6,392. 20-mm Survey results from the last week of May indicated that most delta smelt had moved to the area of the Confluence and the lower Sacramento River, beyond the influence of the export facilities. The culvert flap gates on the agricultural barriers were untied on June 2 and the barriers began operating tidally. Water quality was good, and the DAT did not object to a request from the Project Agencies that the Delta Cross Channel gates be opened for weekend recreation. However, a Delta levee failure on June 3 prompted the Projects to increase reservoir releases, open the Delta Cross Channel gates and decrease exports, to minimize the potential for salt water intrusion. The Project Agencies formally requested and received relief from salinity standards in the western Delta from the SWRCB. There was concern that water quality conditions might preclude moving EWA assets purchased north of the Delta; however, by the end of June Delta exports had ramped up to baseline levels. The Summer Tow-Net Survey, which runs from June through August and collects data on the relative abundance of delta species, began on June 14.

Discussion

EWA 2003 Technical Review Panel. The third Technical Panel review focused not only on EWA activities in water year 2003, but also on challenges and concerns facing EWA should it be continued into the future. The Panel did not repeat its recommendations from previous years' reports, but indicated that they were still relevant to year three and beyond. The Panel acknowledged that progress on previous years' recommendations would be modest and incremental, considering the nature of the challenges facing the EWA. The Panel was, however, disappointed with the apparent lack of progress in two specific areas: (1) program integration and evaluation and (2) addressing critical scientific needs. The Panel commended water acquisition, increased cooperation and EWA workshops and symposia and noted that the previous recommendations had been given serious consideration by the EWA agencies. The Panel called out two new challenges should the EWA be extended: (1) the need to manage long-term risks, and (2) demands for increasing accountability. The Panel recommended (1) continuation of annual science reviews, (2) improved program documentation and program-wide reviews, (3) better integration of EWA with other programs, (4) more effective incorporation of science into the policy and regulatory measures that form the context for EWA implementation, and (5) increased mobilization of resources to address critical science needs. The EWA

[6] Reservoir releases plus unregulated flow equal in-basin needs plus exports

agencies planned to address most of the Panel's comments and recommendations at the upcoming EWA Workshop (September 8-9, 2004) and EWA Technical Panel Review (November 8-10, 2004).

Performance of the EWA. Over the four years of EWA implementation, EWA actions have likely contributed to the avoidance of reinitiation of Section 7 consultation in some months (Figure 1). Because EWA biologists monitor Delta conditions and delta smelt relative abundance and distribution in real time, situations in which incidental take may become problematic may be identified early and specific operational changes may be implemented by which take limitations can be avoided. The impact of incidental take on delta smelt populations is unknown; however, it is a research priority of the CBDA Science program.

Underlying the concept of the EWA is the assumption that the protections in the regulatory baseline (WQCP, D-1641, USFWS 1995 Biological Opinion, CVPIA 3406(b)(2)), while sufficiently protective to avoid jeopardy to listed species, were insufficient to bring about recovery. Therefore, to evaluate the performance of the EWA, two general questions must be addressed:

Has EWA contributed to the recovery of at-risk species?

What was the overall cumulative effect of EWA actions?

Because these questions raise complex issues that defy ready answers, the EWA agencies have tended to evaluate the EWA in smaller pieces that more readily lend themselves to evaluation. For example, EWA has successfully purchased sufficient assets to implement its priority activities, and has kept its purchases within budget. However, there are at present no meaningful biological indicators that have been defined scientifically, such as measures of ecosystem response and species protection and recovery. Efforts to fulfill these data needs have been proposed by the Ecosystem Restoration Program, Interagency Ecological Program and others but are not yet available. At present, all that can be said with certainty is that, since the inception of the EWA, operation of the CVP and SWP has not resulted in reinitiation of consultation for incidental take. Expected outcomes of program evaluation are improved decision-making, implementation, definition and/or recognition of strengths and limitations, adaptive management and effectiveness of overall species and habitat conservation (U.S. Fish and Wildlife Service, 2003).

A successful adaptive management strategy for the EWA would provide the necessary flexibility to provide for species protection and contribute to species recovery, while increasing our understanding of the functioning of the Bay-Delta

system. Adaptive management, which involves the formulation and testing of hypotheses, has the potential to provide scientifically rigorous insight into Delta species and processes. However, because variables cannot be precisely manipulated and replication and maintenance of a "control" condition is usually not possible, opportunities are extremely limited and results may be ambiguous.

An initial set of performance criteria were proposed at the 2003 EWA Technical Panel Review (Briggs et al, 2003). To date the EWA agencies have not discussed the development or adoption of performance criteria.

Implementation of the VAMP Shoulder

Each year since its inception, the EWA has extended export curtailments beyond the end of the VAMP period for approximately two weeks, in an action referred to as the post-VAMP shoulder. The curtailments were intended to improve Delta habitat and delta smelt survival by affording larval delta smelt greater opportunity to move north and west to their rearing areas in Suisun Bay, Suisun Marsh and the lower Sacramento River. The technical basis for the post-VAMP shoulder relies in part on Bennett's stage-structured matrix model results, indicating that small gains in young-of-the-year survival may have large impacts on population growth and, until a better understanding of the potential importance of density dependent survival of juveniles is realized, these results recommend that management efforts focus on maximizing the survival of all young-of-the-year delta smelt (Bennett 2004). The decision to implement a post-VAMP shoulder was based upon interagency staff-level discussions reviewing the criteria set down in the delta smelt decision tree and approved by the WOMT. The Delta Smelt Working Group generally recommends that the HORB be removed and tidal operations be suspended at the agricultural barriers when the post-VAMP shoulder is implemented. Exports are curtailed until incidental take of delta smelt is reduced, the center of distribution of delta smelt moves north and west of Frank's Tract, and/or water temperatures in the south Delta approach the laboratory lethal limit of approximately 25^0C (Poage, 2004).

Different decision criteria were more heavily weighted by the Delta Smelt Working Group in different years (Table 3). In 2001, the VAMP ran from April 20 through May 20 (Table 4). The decision to implement a post-VAMP shoulder derived from early 20-mm Survey sampling indicating that juvenile smelt were distributed primarily in the south and central Delta, where they were thought to be vulnerable to entrainment at the State and Federal export facilities. Incidental take reached the concern level (14-day average of 400) on May 21, the first day of the shoulder. In 2002, concern increased as incidental take rose past the concern level on May 12. In 2003, implementation of the shoulder was driven primarily by the 2002 Recovery Index, which at 33 was the fifth-lowest since 1967,

combined with overall low numbers from routine survey sampling. In a year featuring such low apparent abundance, it was believed that factors potentially leading to density dependence were negligible, making every life-stage important. In 2004, the comparatively low abundance of delta smelt in early survey sampling combined with a relatively narrow spawning window to drive the decision to implement a shoulder. By all indications, there were few adults, spawning over a relatively brief period of time, leading to the production of relatively few cohorts, making it important to protect as many cohorts as possible.

As of the release of this document, the effectiveness of the post-VAMP shoulder has not been quantitatively evaluated. Changes in the center of delta smelt distribution as indicated by successive 20-mm Survey plots have shown that young of the year tend to move downstream of Frank's Tract from early May to early June (Figure 5); however, important evidence to support the conceptual model, such as identification of the physical and biological cues that prompt emigration, are presently lacking. Without corroborating studies, it would be premature to conclude that delta smelt movements were affected by the post-VAMP shoulder.

Accomplishments During EWA Implementation in WY 2004.

- EWA-supported commitments under the CALFED ROD and ESA

Expenditure of EWA assets reduced the direct effects of water exports on delta smelt through its contributions to VAMP export curtailments and the implementation of the post-VAMP shoulder. Implementation of the EWA enabled the Management Agencies to provide the Project Agencies with regulatory commitments under the Endangered Species Act as described in the CALFED ROD.

- Continued communication, cooperation and coordination for effective implementation

Implementation of the EWA was discussed and carried out in an open process, through regular meetings of the Environmental Water Account Team (EWAT), DAT, WOMT, and the CALFED Operations Group. The Delta Smelt Working Group and the Data Assessment Team continued to use a structured process for evaluating data (the delta smelt decision process), to assess conditions and to formulate recommendations for EWA actions. This process relied heavily on extensive, reliable and timely monitoring efforts to elucidate relative abundance and distribution of delta smelt and anticipate periods of heightened concern. Through this process of close coordination, a post-VAMP shoulder was implemented to minimize hydraulic impacts to delta smelt. Implementation of the EWA was closely coordinated with management of CVPIA 3406 (b)(2) water, to provide expanded fish benefits and water supply reliability.

- Interagency collaboration on environmental documentation

The EWA agencies produced a final environmental impact report/statement for the Stage-1 EWA and action-specific implementation plan in January 2004. The Service and NOAA Fisheries conducted formal consultation under Section 7 of the Endangered Species Act, resulting in the issuance of a Biological Opinion on the effects of EWA implementation on the delta smelt and the giant garter snake and a letter of concurrence from NOAA Fisheries on effects to salmonids. CDFG prepared a Natural Communities Conservation Plan for species under its purview.

- Dissemination of information, public involvement and review of performance

The CBDA Science Program will sponsor a workshop on September 8 and 9, 2004, the purpose of which is to examine the first four years of EWA implementation and assess its operations and benefits, to place the EWA within the context of other protection and restoration efforts, and to identify the scientific questions and information needs relevant to a potential long-term EWA. Material presented at the workshop will form the basis for conclusions and recommendations that will be presented to the EWA Technical Review Panel when it is convened November 8, 9 and 10, 2004.

- Revision of the Delta Smelt Decision Criteria

As part of an interagency effort to draft a Biological Assessment for OCAP, the Delta Smelt Working Group drafted new decision criteria, known as the Delta Smelt Risk Assessment Matrix (DSRAM). The DSRAM provides a science-based guideline for the formulation of recommendations for modifications of water project operations, for the protection of delta smelt. It is both a product and a

tool of the Delta Smelt Working Group and will be modified by the Working Group, with the approval of the WOMT, as new knowledge becomes available.

- Preparation for the extension of the EWA through Stage 1 of CALFED implementation

The EWA and ERP implementing agencies prepared a document to support the reinitiation of consultation under ESA section 7 and the Natural Community Conservation Planning Act to assess progress on the MSCS Milestones and the efficacy of the EWA. At the time of the preparation of this document, the EWA agencies were in the process of drafting a Memorandum of Understanding to extend the EWA through December, 2007.

Limitations Encountered During EWA Implementation in WY 2004.

- Funding

Despite the fact that EWA has never been funded to the levels envisioned in the 2000 CALFED ROD, during its first four years it has acquired assets sufficient to implement most of its priority actions. The EWA purchase target for 2004 was 250 thousand acre-feet, adequate for forecast conditions, but high prices for water acquired south of the Delta limited the amount of water that could be purchased to 155 thousand acre-feet and forced the EWA Team to consider rearranging priorities and potentially taking fewer fish actions. The EWA agencies expended water assets only twice in 2004, for the VAMP and the post-VAMP shoulder; had there been a need for more fish actions, the EWA agencies would have been forced to consider carrying debt, potentially limiting fish actions in subsequent years.

- Inability to take upstream actions

The EWA Technical Review Panel has repeatedly commented on the paucity of upstream fish actions taken by EWA. When appropriate, EWA could potentially take upstream actions, in cooperation with other programs (Water Acquisition Program, Environmental Water Program and others), if it were adequately funded and if assets could be procured in such a way as to enable those actions to take place.

- Opportunities for adaptive management

Because the EWA agencies have been unable to devote substantive resources to experimentation, they have missed opportunities for adaptive management as envisioned by CBDA Science (CALFED 2000a). Another factor leading to missed

opportunities has been the lack of formal performance criteria against which to evaluate actions and recalibrate program goals, tools and conceptual models.

The Proposed Long-Term EWA

Over the past year, the EWA agencies have engaged in various planning and pre-planning activities centered on the development of an EWA to extend through completion of the CALFED By-Delta Program implementation. These activities included gaming exercises to determine the amount of assets needed by a long-term EWA. Modelers at DWR and USBR updated the CALSIM 2 model to more accurately represent the EWA, and DWR developed a spreadsheet application to allow manipulation of variables to predict outcomes under a wide range of management scenarios. This modeling and post-processing was included in the 2004 Operations Criteria and Plan (OCAP) representation of a long-term EWA. The EWA agencies are presently engaged in drafting a new Operating Principles Agreement and a Memorandum of Understanding to extend the EWA as currently implemented through December 31, 2007, the end of the CALFED Stage 1 implementation period.

Questions for Further Consideration

In the 2003 report, the Service presented five questions pertinent to the protection and recovery of delta smelt that had not yet been addressed. In 2004, these questions remain unanswered, and remain relevant to further discussion and project development on the part of the IEP and the EWA implementing agencies.

(1) How can the EWA agencies better assess the implications of incidental take at the pumps? Can an experiment be designed to facilitate evaluation of take, and if so, what might it look like?

(2) How much water is "enough" to provide good habitat conditions in Suisun Bay/Marsh? And how frequently "should" these conditions prevail?

(3) Technically, delta smelt met the recovery criteria last year, but numbers are apparently still very low; perhaps our criteria are based upon false or incomplete assumptions, since our recovery activities have not appeared to be effective. Alternatively, it may be that recovery activities have been effective but carrying capacity in the Delta has been reduced, preventing a return to pre-decline conditions. How can the EWA agencies assess progress toward recovery, and determine which activities have the potential to make the greatest contribution?

(4) How have changes in timing of Delta exports post-WQCP, D-1641 and VAMP affected delta smelt?

(5) How can we achieve a better understanding of factors that potentially lead to density dependence, such as habitat volume, food supply, and spawning locations?

In addition, there is a need to develop biological and non-biological performance criteria for the EWA that are measurable, precise, consistent and sensitive to the phenomena being tracked, as well as cost-efficient and appropriate (U.S. Fish and Wildlife Service, 2003).

Acknowledgements

This paper and its predecessors have benefited from the generous comments of several reviewers, including Bruce Herbold, Zach Hymanson, Matt Nobriga, Ryan Olah and Jim White.

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Table 1. Tabular summary of incidental take of delta smelt at the State Water Project (SWP) and federal Central Valley Project (CVP) export facilities since the implementation of the Environmental Water Account.

Month	WY 2001 Combined Take[a] (Below Normal)	WY 2002 Combined Take[a] (Below Normal)	WY 2003 Combined Take[a] (Below Normal)	WY 2004 Combined Take[a] (Below Normal)	Reconsultation Level[a]	
					↑ Normal	↓ Normal
December	192	1,129	2,776	126	733	8,052
January	181	5,231	9,561	4,594	5,379	13,354
February	3,870	280	1,494	1,161	7,188	10,910
March	3,772	225	483	2,177	6,979	5,386
April	520	372	492	276	2,378	12,354
May	13,170	47,361	16,309	5,749	9,769	55,277
June	2,418	11,926	10,096	6,392	10,709	47,245
Total	26,124	66,526	41,211	20,475		

[a] Incidental take reported by both the SWP and CVP on USBR's Central Valley Operations website, www.mp.usbr.gov/cvo/html/fishrpt.html
[b] Water year-type as defined by the USFWS 1995 Biological Opinion on the Long-Term Operation of the Central Valley Project (CVP) and the State Water Project (SWP)

Table 2. Summary of EWA expenditures for Water Years 2001-2004, in thousands of acre-feet.

Month	WY 2001	Species Benefited	WY 2002	Species Benefited	WY 2003	Species Benefited	WY 2004	Species Benefited
October			5[a]	Salmonids	13[b]	Salmonids		
November			15[a]	Salmonids				
December					32	Salmonids		
January	69	Salmonids	66	Salmonids/Smelt	89	Salmonids/Smelt		
February	69	Salmonids/Smelt						
March	65	Salmonids/Smelt						
April	29	Salmonids/Smelt	28	Salmonids/Smelt	19	Salmonids/Smelt	13	Salmonids/Smelt
May	49	Salmonids/Smelt	149	Salmonids/Smelt	208	Salmonids/Smelt	111	Salmonids/Smelt
June	9	Salmonids/Smelt	5	Salmonids/Smelt				
Total	290		248		348		124	

[a]release of PCWA purchase from Folsom Reservoir, timed for flow and temperature benefits
[b]power generation bypass at Folsom Dam
source: EWA *Fish Action* summaries for water years 2001-2004

Table 3. A comparative summary of the assessment of decision criteria for implementation of the post-VAMP shoulder, water years 2001-2004. Shaded cells indicate priority concerns driving the decision to implement the shoulder.

Decision Criterion	2001	2002	2003	2004
Recovery Index[a]	Low Concern	Low Concern	High Concern	High Concern
Distribution and Abundance[b]	Central & South Delta, Confluence of Sacramento and San Joaquin Rivers	Central & South Delta, Lower Sacramento River	Central Delta, Lower Sacramento River, Suisun Bay/Marsh, Napa River	Central and South Delta
Spawning Window[c]	High Concern	High Concern	Low Concern	High Concern
Incidental Take[d]	Low Concern	Moderate Concern	Moderate Concern	Low Concern
Hydrology[e]	Dry	Dry	Above Normal	Below Normal
So. Delta Water Temperature[f]	Warming → Warm	Warming → Warm	Warming → Warm	Warm

[a]indicates the value of the Recovery Index from the previous fall; concern was assessed as "high" if the value was below 239 (USFWS, 1996)
[b]as indicated by current (May 1-May 15) 20-mm Survey sampling
[c]number of days with mean water temperatures between 15^0C and 20^0C, a predictor of the number of delta smelt cohorts; concern is "high" if the number of days is below the median of 61
[d]from data collected at the State and Federal export facilities; assessment was by consensus of the Delta Smelt Working Group, but generally, concern was "high" if take approached or exceeded the reconsultation level and "low" if take did not exceed the heightened-concern (14-day average of 400) level in early May
[e]water year-type according to the 40-30-30 Sacramento River Index
[f]general trends in south Delta water temperatures for May 1-31; 10-15^0C=Cool, 16-20^0C=Warming; >20^0C=Warm

Table 4. Summary of Vernalis Adaptive Management Plan (VAMP) and post-VAMP actions, 2001-2004.

	VAMP Period		Post-VAMP Shoulder	
	Dates	EWA Assets Used	Dates	EWA Assets Used
2001	Apr 20-May 20	43 TAF	May 21-May 31	15 TAF
2002	Apr15-May 15	45 TAF	May 16-May 31	132 TAF
2003	Apr 15-May 15	32 TAF	May 16-Jun 2	195 TAF
2004	Apr 15-May 15	20 TAF	May 16-May 31	104 TAF

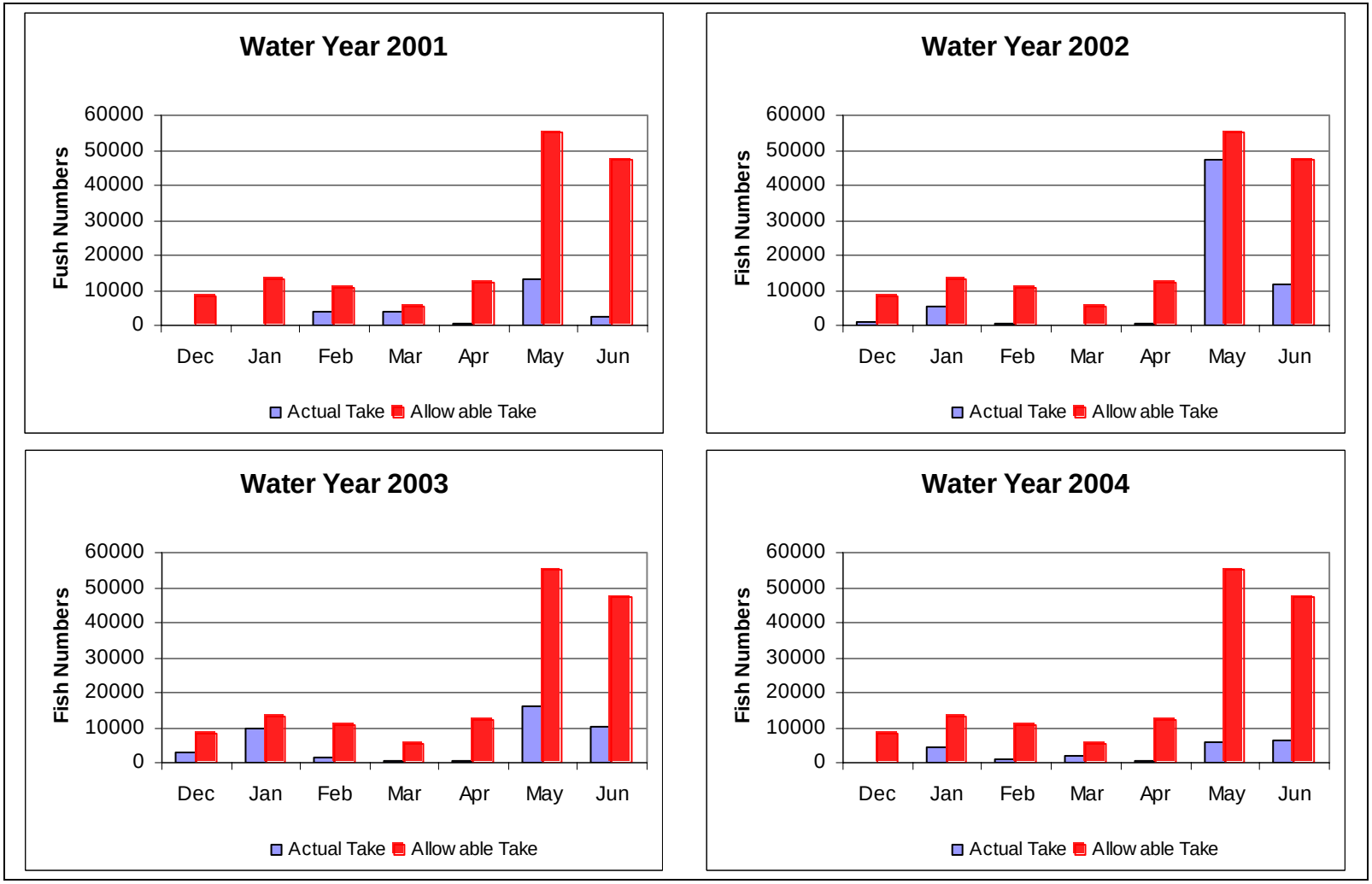


Figure 1. Graphic depiction of incidental take of delta smelt at the State Water Project (SWP) and federal Central Valley Project (CVP) export facilities since the implementation of the Environmental Water Account.

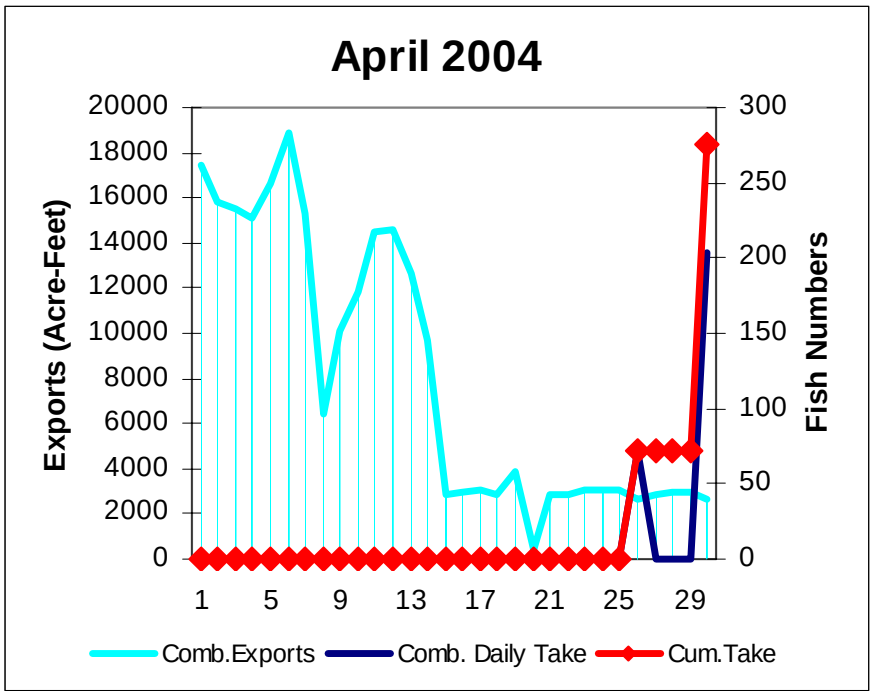


Figure 2. Incidental take of delta smelt at the CVP and SWP overlaid on combined Project exports for April 2004, illustrating the first half of the VAMP.

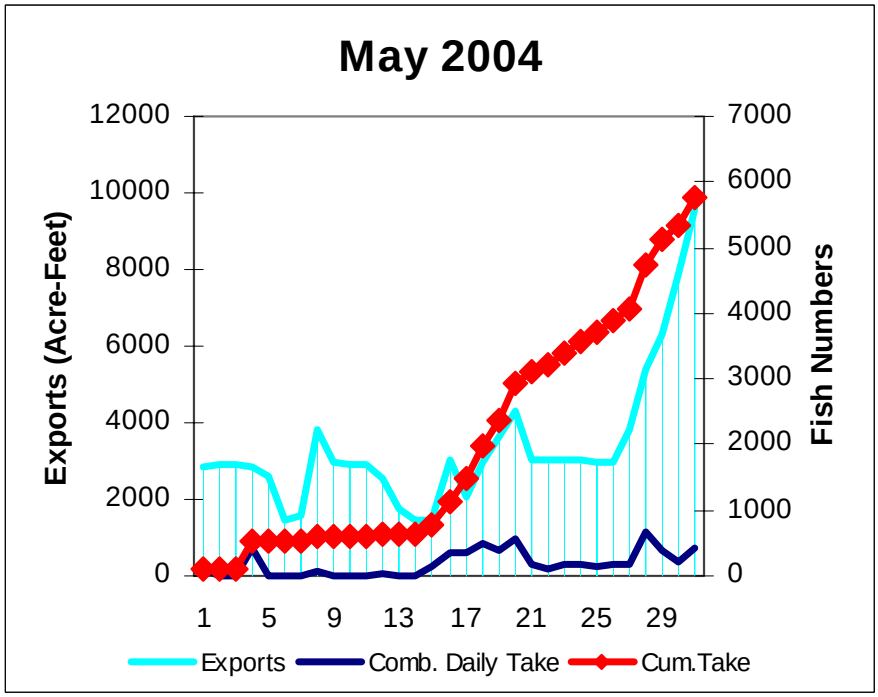


Figure 3. Incidental take of delta smelt at the CVP and SWP overlaid on combined Project exports for May, 2004, illustrating the second half of the VAMP and the post-VAMP shoulder.

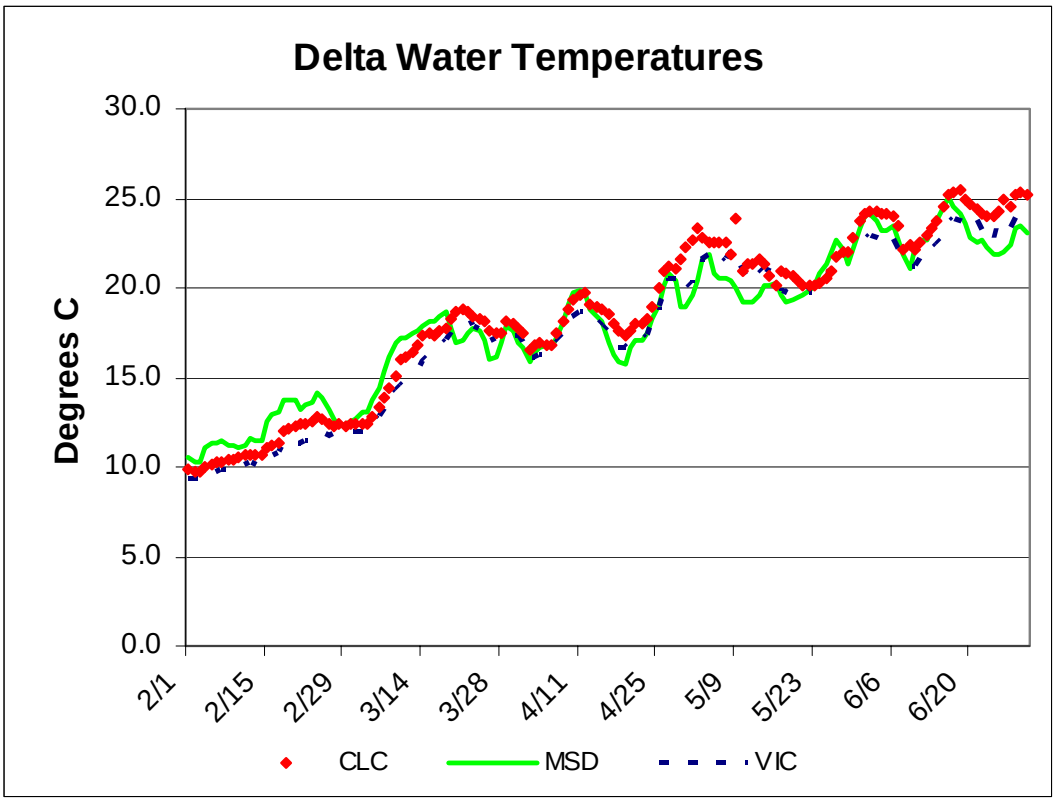


Figure 4. Summary of South Delta water temperatures, late winter through spring, 2004, at Clifton Court Forebay (CLC), Mossdale (MSD) and Victoria Island (VIC), from the California Data Exchange Center (CDEC).

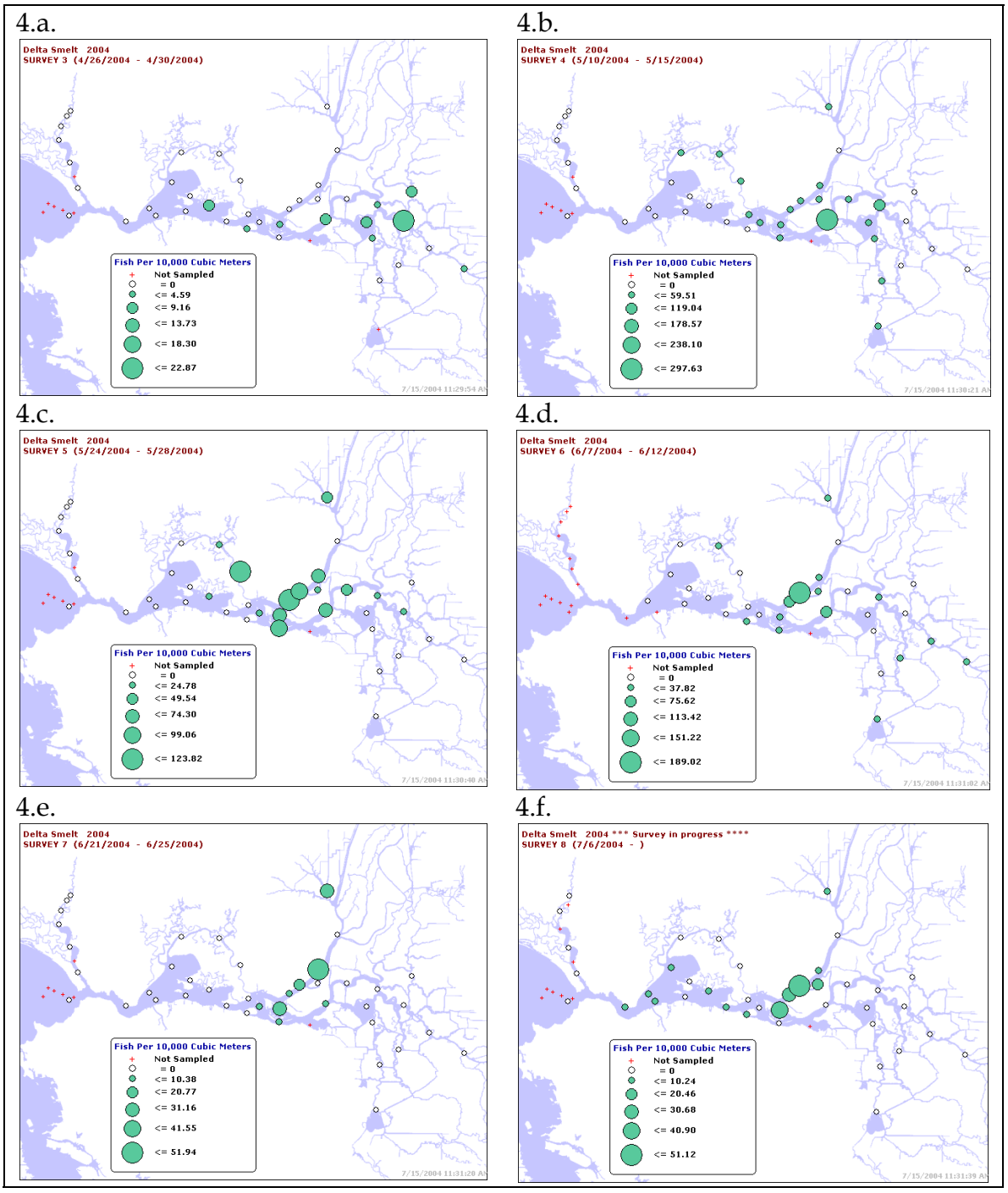


Figure 5. Graphic representations of abundance and distribution of delta smelt in water year 2004, as indicated by CDFG 20-mm Survey sampling.

Attachment 1. The Delta Smelt Working Group and the delta smelt risk assessment matrix

The delta smelt risk assessment matrix (DSRAM) consists of month by month criteria which, when exceeded will trigger a meeting of the Delta Smelt Working Group (Working Group). The purpose of the DSRAM is to take actions to protect delta smelt in a proactive manner prior to salvage events. Reclamation and/or DWR are responsible for monitoring the DSRAM criteria and reporting back to the Service and the Working Group. The DSRAM has been modified from the delta smelt decision tree which was peer reviewed and presented in the IEP Newsletter. The DSRAM will be sent out for independent peer review. The DSRAM is an adaptive management tool which may be further modified by the Working Group/WOMT as new information becomes available, without undergoing formal reconsultation. An informative link to an existing website will be developed that compiles monitoring data from IEP and DFG to enable members of the Working Group to easily track the progress of the triggering criteria. Data will be updated at least weekly to determine the need for a meeting.

Should a triggering criterion be met or exceeded, Reclamation and/or DWR will inform the members of the Working Group and the Working Group will determine the need to meet. Any member of the Working Group may set up a meeting of the Working Group at any time. A meeting of the Working Group may consist of an in-person meeting, a conference call, or a discussion by email. If needed, the Working Group will meet prior to the weekly meetings of the DAT and the WOMT and information will be shared with these groups.

Should a meeting of the Working Group prove necessary, the group will decide whether to recommend a change in exports, change in south delta barrier operations, San Joaquin River flows, or a change in delta cross channel operations, and the extent and duration of the potential action. These potential actions are listed in the DSRAM by the months wherein each of these tools generally become available. The group will recommend actions which will be shared with the DAT and forwarded to the WOMT for discussion and potential implementation. This recommendation will include a discussion of the level of concern for delta smelt and will include who participated in the working group discussions. All dissenting opinions and/or discussion points will also be forwarded to the WOMT. The Working Group will meet at least weekly throughout the period in which the triggering criteria are met or exceeded, to determine the need to provide further recommendations to the WOMT.

Notes and findings of Working Group meeting will be submitted to the Service and members of the WOMT for their records. The WOMT will respond to the Working Group's recommendations and the actions taken by the WOMT will be summarized by Reclamation and/or DWR annually and submitted to all WOMT agencies.

If an action is taken, the Working Group will follow up on the action to attempt to ascertain its effectiveness. An assessment of effectiveness will be attached to the notes from the Working Group's discussion concerning the action.

Delta smelt Risk Assessment Matrix (DSRAM)

Life Stage	Adults	Adults	Adults	Adults and larvae	Adults and larvae	Larvae and juveniles	Larvae and juveniles	Juveniles
Previous Year's Fall Midwater Trawl Recovery Index (1)	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74	Index below 74
Risk of Entrainment (2)				X2 upstream of Chipps Island and temps are ≥ 12°	X2 upstream of Chipps Island and temps are between 12° and 18°C	X2 upstream of Chipps Island and mean delta-wide temps <18°C and south delta temps below 25°C	X2 upstream of Chipps Island and temps are below 25°C	X2 upstream of Chipps Island and temps are below 25°C
Duration of Spawning period (number of days temperatures are between 12 and 18°C) (3)					39 days or less by April 15	50 days or less by May 1		
Spawning Stage as determined by spring Kodiak trawl and/or salvage (4)			Presence of Adults at spawning stage ≥ 4	Adult spawning stage ≥ 4	Adult spawning stage ≥ 4			
smelt distribution (5)	See footnote #5	See footnote #5	See footnote #5	See footnote #5 or negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance	Negative 20mm centroid or low juvenile abundance
Salvage Trigger (6)	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation	Adult concern level calculation		If salvage is above zero	If salvage is above zero	

Tools for Change (7)	**December**	**January**	**February**	**March**	**April**	**May**	**June**	**July**
Export reduction at one or both facilities	X	X	X	X	X	X	X	X
Change in barrier operations						X	X	X
Change in San Joaquin River flows				X	X	X	X	X
Change position of cross channel gates						X	X	

Delta Smelt Risk Assessment Matrix Footnotes (note: the references for the DSRAM are also included in the literature cited section of the biological opinion)

1 The Recovery index is calculated from a subset of the September and October Fall Midwater Trawl sampling (http://www.delta.dfg.ca.gov/). The number in the matrix, 74, is the median value for the 1980-2002 Recovery Index (Figure DS1)

2 The temperature range of 12 to 18 degrees Celsius is the range in which most successful delta smelt spawning occurs. This has been analyzed by using observed cohorts entering the 20-mm Survey length frequency graphs (1996-2002). Cohorts were defined by having a noticeable peak or signal and occurring over three or more surveys during the rearing season. Back calculations were made using the first survey of that cohort with fish less than 15 mm fork length. Temperature data from IEP's HEC-DSS Time Series Data web site was compiled using three stations representing the south Delta (Mossdale), confluence (Antioch), and north Delta (Rio Vista) and averaged together. Spawning dates for each cohort were back-calculated by applying an average daily growth rate (wild fish) of 0.45 mm/day (Bennett, DFG pers. comm.) and egg incubation period of 8-14 days (Baskerville-Bridges, Lindberg pers. comm.)(Mager et al. 2004) from the median value of the analyzed cohort. Each spawning event was then plotted against temperature over time (Figure DS2.1). While spawning does occur outside of the 12-18 degree range, larval survival is most likely reduced when temperatures are either below (DFG pers. comm.) or above this range (Baskerville-Bridges & DFG pers. comm.).

Critical thermal maxima for delta smelt was reached at 25.4 degrees Celsius in the laboratory (Swanson et al., 2000); and at temperatures above 25.6 degrees Celsius smelt are no longer found in the delta (DFG, pers. comm.).

Websites for the temperature data:
http://iep.water.ca.gov/cgi-bin/dss/dss1.pl?station=RSAN007
http://iep.water.ca.gov/cgi-bin/dss/dss1.pl?station=RSAN087
http://iep.water.ca.gov/cgi-bin/dss/dss1.pl?station=RSAC101

Mager RC, Doroshov SI, Van Eenennaam JP, and Brown RL. 2004. Early Life Stages of Delta Smelt. American Fisheries Society Symposium 39:169-180.

Swanson C, Reid T, Young PS, and Cech JJ. 2000. Comparative environmental tolerances of threatened delta smelt (*Hypomesus transpacificus*) and introduced Wakasagi (*H. nipponensis*) in an altered California estuary. Oecologia 123:384-390.

3 Figure DS3: The working hypothesis for delta smelt is that spawning only occurs when temperatures are suitable during the winter and spring. In years with few days having suitable spawning temperatures, the spawning "window" is limited, so the species produces fewer cohorts of young smelt. When there are fewer cohorts the risk that mortality sources such as entrainment may substantially reduce population

size increases. The figures below were used to help define years when there were relatively few days with suitable temperatures. For April 15 and May 1, the figures show the cumulative spawning days for each year during 1984-2002. The cumulative spawning days for each year were calculated based on the number of days that the mean water temperature for three Delta stations (Antioch; Mossdale and Rio Vista) was in the 12 - 18 C range starting on February 1. The results are plotted in terms of the ranks to identify the lower quartile. In other words, years in the lower quartile represent examples of years with relatively few spawning days.

4 The adult spawning stage is determined by the Spring Kodiak Trawl and/or fish collected at the salvage facilities (http://www.delta.dfg.ca.gov/). A stage greater than or equal to 4 indicates female delta smelt are ripe and ready to spawn or have already spawned (Mager 1996).

Mager RC. 1996. Gametogenesis, Reproduction and Artificial Propogation of Delta Smelt, *Hypomesus transpacificus.* [Dissertation] Davis: University of California, Davis. 115 pages. Published.

5 The spring kodiak trawl will be used to generally evaluate the distribution of adult delta smelt. However, since the spring kodiak trawl is not intended to be a survey for abundance or distribution, no definitive trigger for concern can be determined at this time.

Juveniles (March-July) – distribution of juvenile delta smelt where the centroid is located upstream (negative) or downstream (positive) of the Sacramento-San Joaquin River confluence (Sacramento RKI 81; Figure DS5.1). The 20-mm Survey centroid is calculated by multiplying the observed delta smelt station CPUE (fish/10,000 m3) by a distance parameter in km from Sacramento RKI 81. The summed result (summed over a survey) is divided by the survey CPUE which gives the survey centroid position (Figure DS5.2).

Low juvenile abundance will also be a trigger. When juvenile abundance is low, concern is high. Low abundance is indicated when the total cumulative catch in the 20-mm Survey is less than or equal to the 1995-2003 median value of cumulative 20-mm Survey catch for the same surveys (Table DS5).

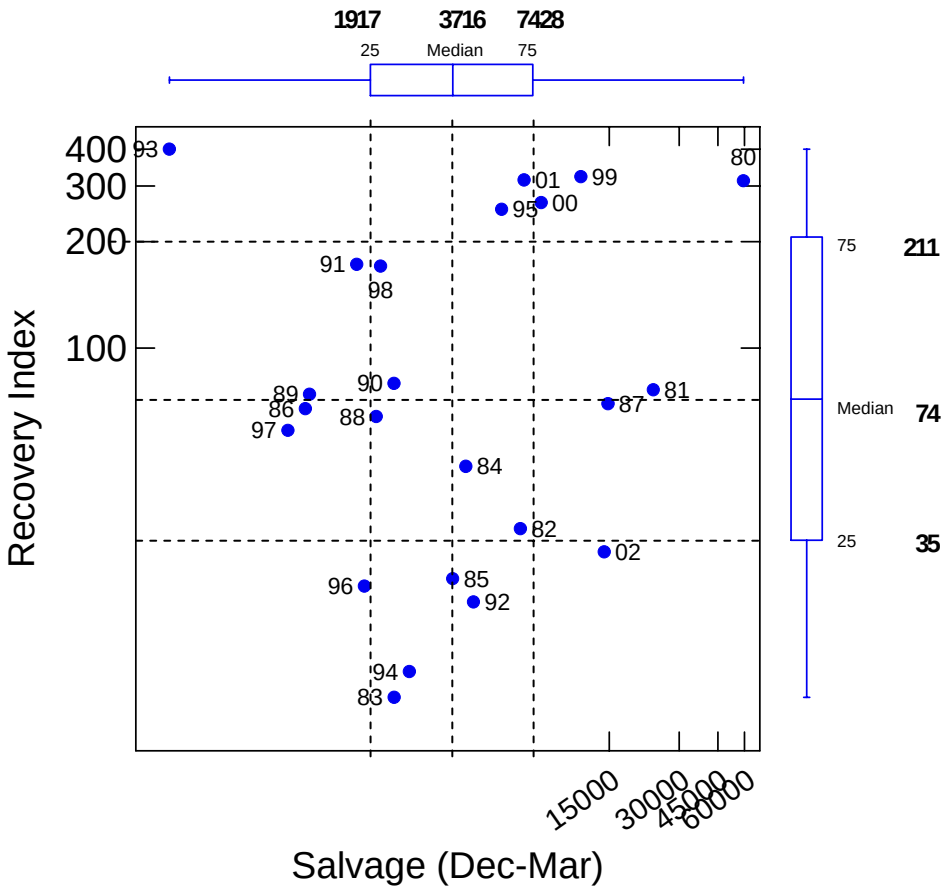
6 Adult salvage trigger: the adult delta smelt salvage trigger period is December through March and the trigger is calculated as the ratio of adult delta smelt salvage to the fall MWT index. This ratio will increase as fish are salvaged during the winter months. If the ratio exceeds the median ratio observed during December-March 1980-2002, then the trigger has been met (see Figure DS6 for more explanation of the calculation)

Juvenile salvage trigger: During May and June, if delta smelt salvage at the SWP/CVP facilities is greater than zero, then the working group will meet. This is because May and June are the peak months of delta smelt salvage and salvage

densities cannot be predicted. Therefore, during these two months, the delta smelt working group expects to meet regularly to look at relevant information such as salvage, delta temperatures, delta hydrology and delta smelt distribution and decide whether to recommend proactive measures to protect these fish.

7 The tools for change are actions that the working group can recommend to the WOMT to help protect delta smelt. Exports may be reduced at one or both of the south delta export facilities and a proposed duration of the reduction would be recommended by the working group. Export reductions and changes in San Joaquin River flows may be covered by B(2) or EWA assets. Details of past fish actions can be found at the Calfed Ops website: http://wwwoco.water.ca.gov/calfedops/index.html; >Operations [year]

Figure DS1



Points are labeled with the year representing the recovery index.
The winter salvage for this analysis starts on December 1 of the recovery index year and continues through March 31 of the following year.

Figure DS2.1. Successful delta smelt spawning periods (shaded blue area) and cohorts (black bars) plotted against water temperature (1996-2002). Spawning periods and cohorts were back calculated using 20-mm Survey catch data. Start of spawning season uses an egg incubation period of 14 d and a growth rate of 0.45 mm/day and end of spawning season 8 d with a growth rate of 0.45 mm/day. Black bars represent the range of 8-14 d egg incubation with a growth rate of 0.45 mm/day from laboratory results. Temperature data (°C) was compiled from IEP's HEC-DSS Time Series Data using mean daily temperatures from the confluence (Antioch), south Delta (Mossdale), north Delta (Rio Vista) and averaged together.

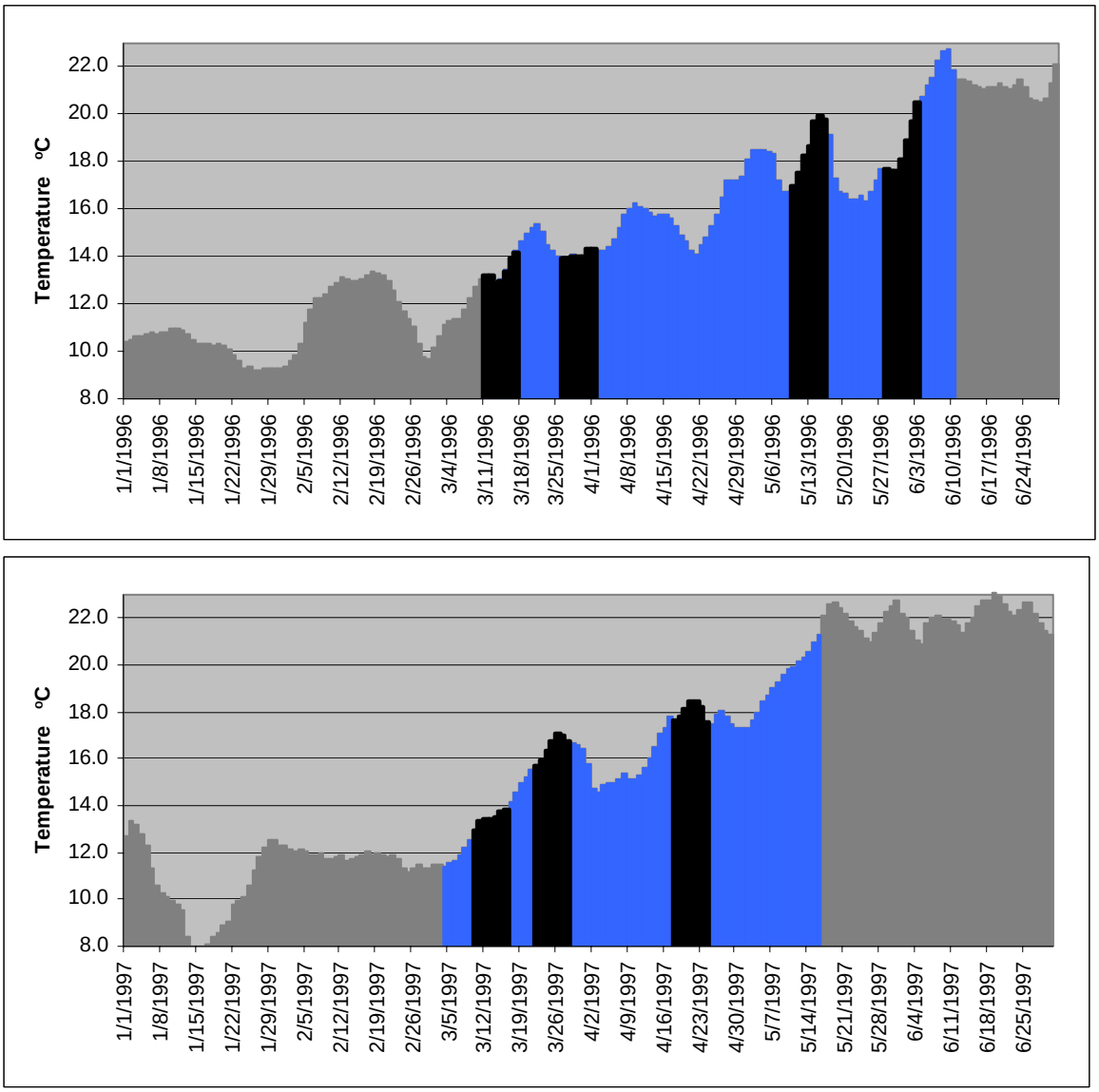
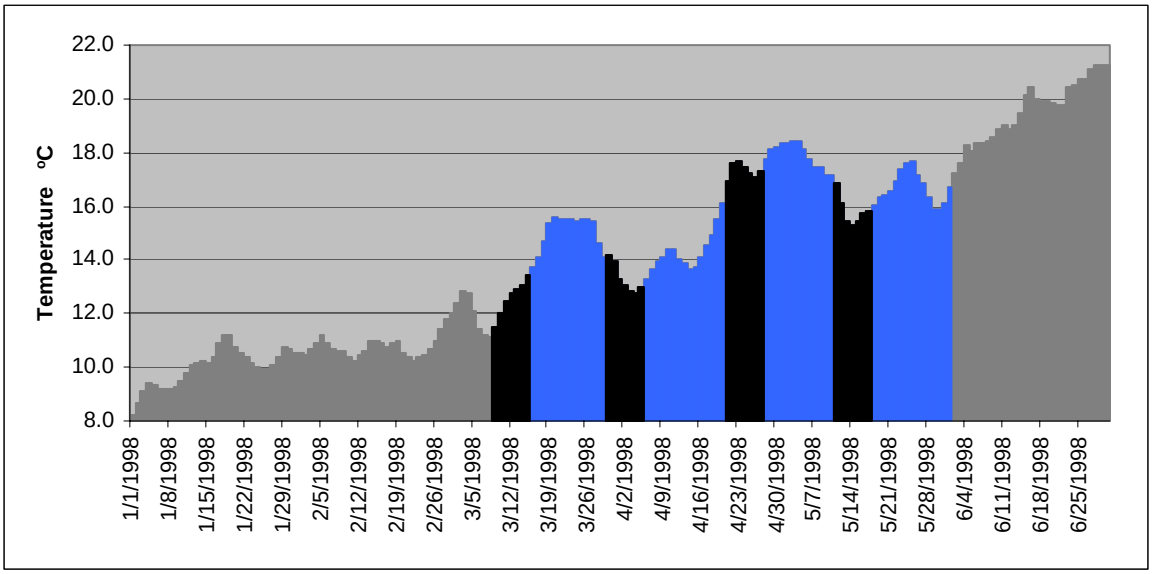
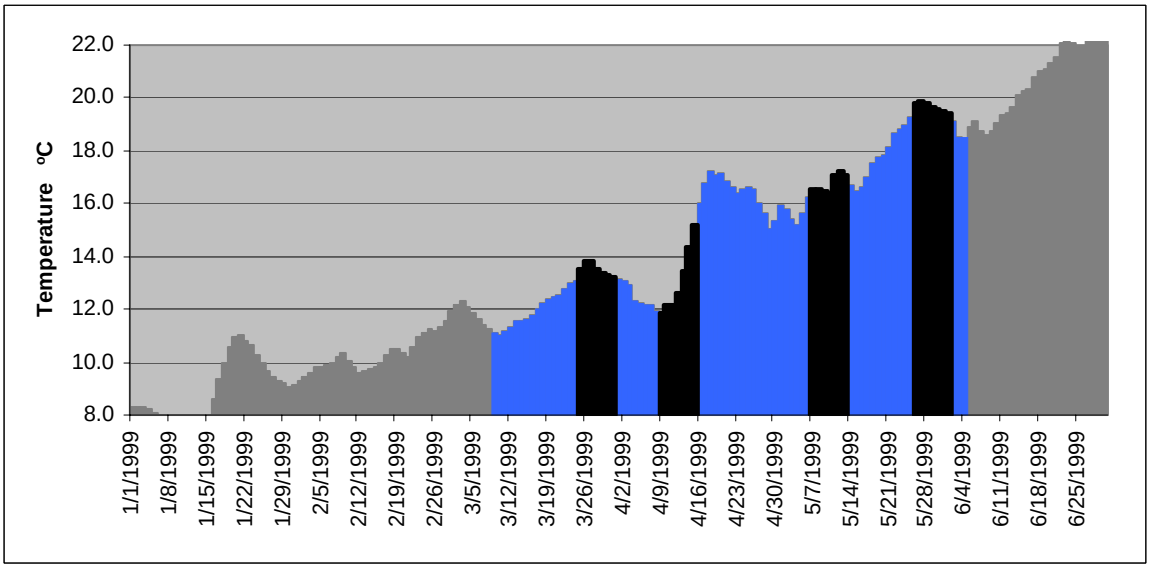


Figure DS2.1 cont.





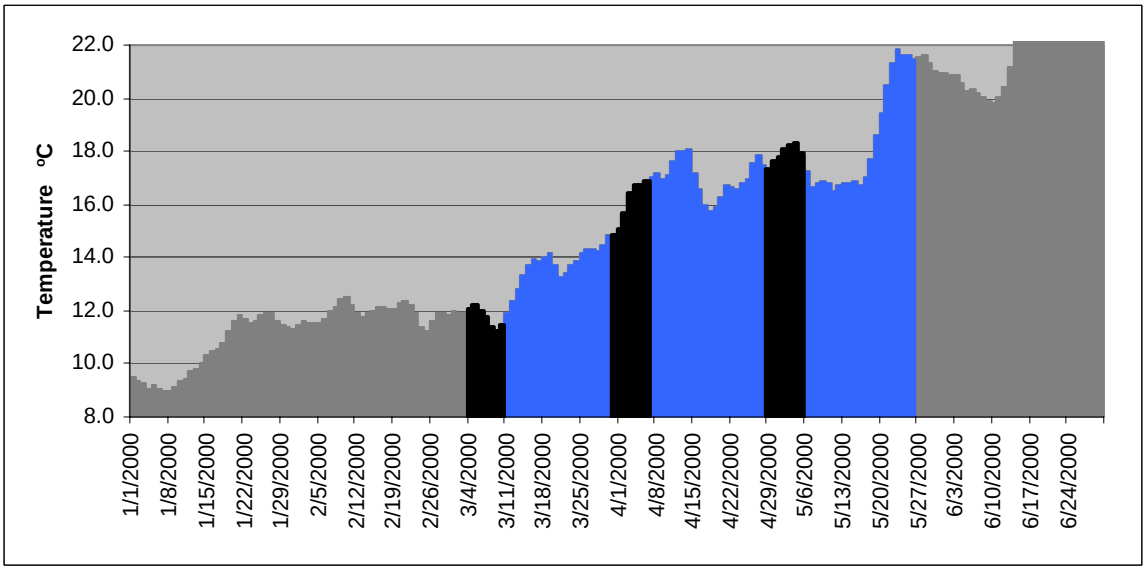


Figure DS2.1 cont.

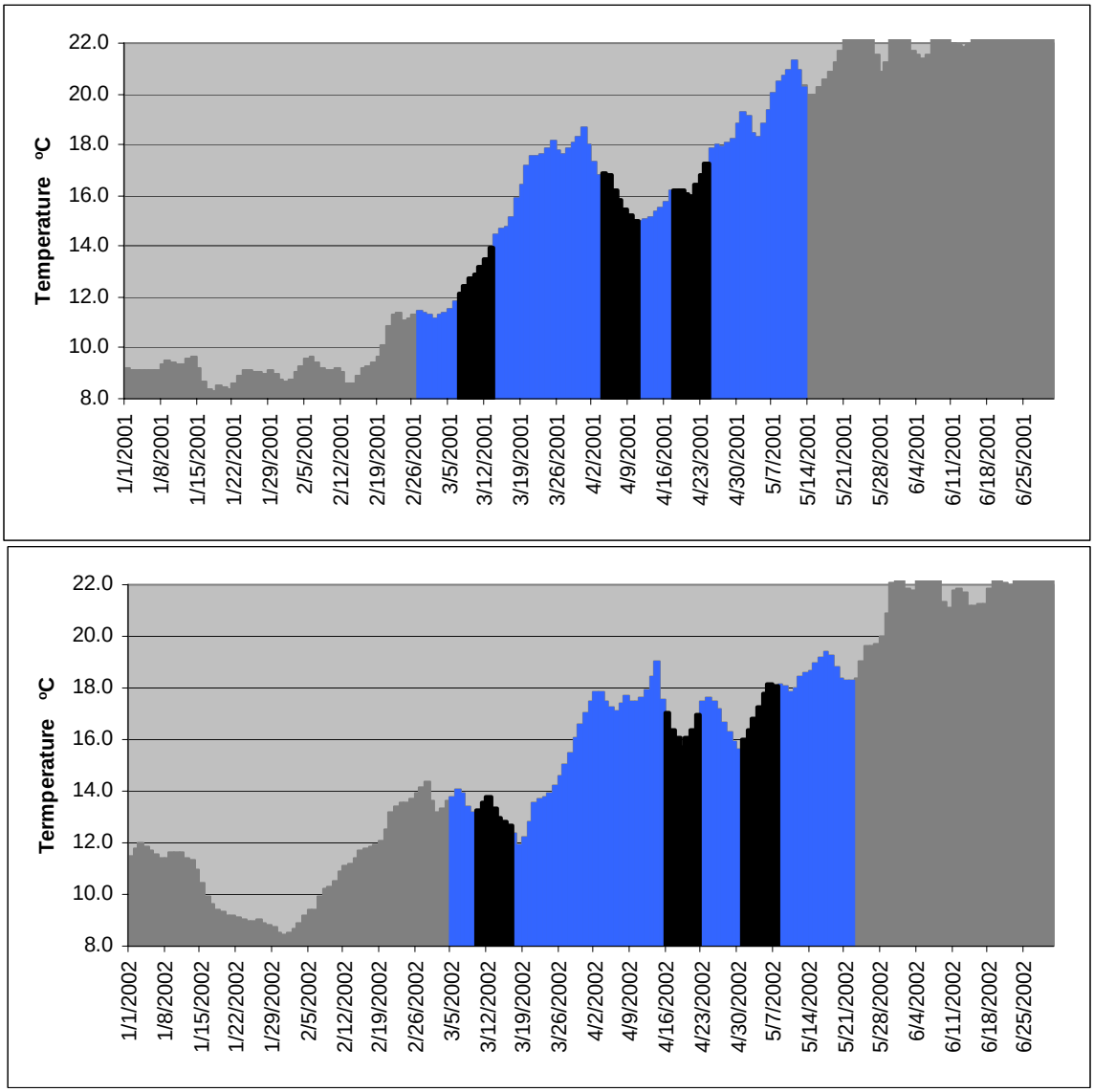
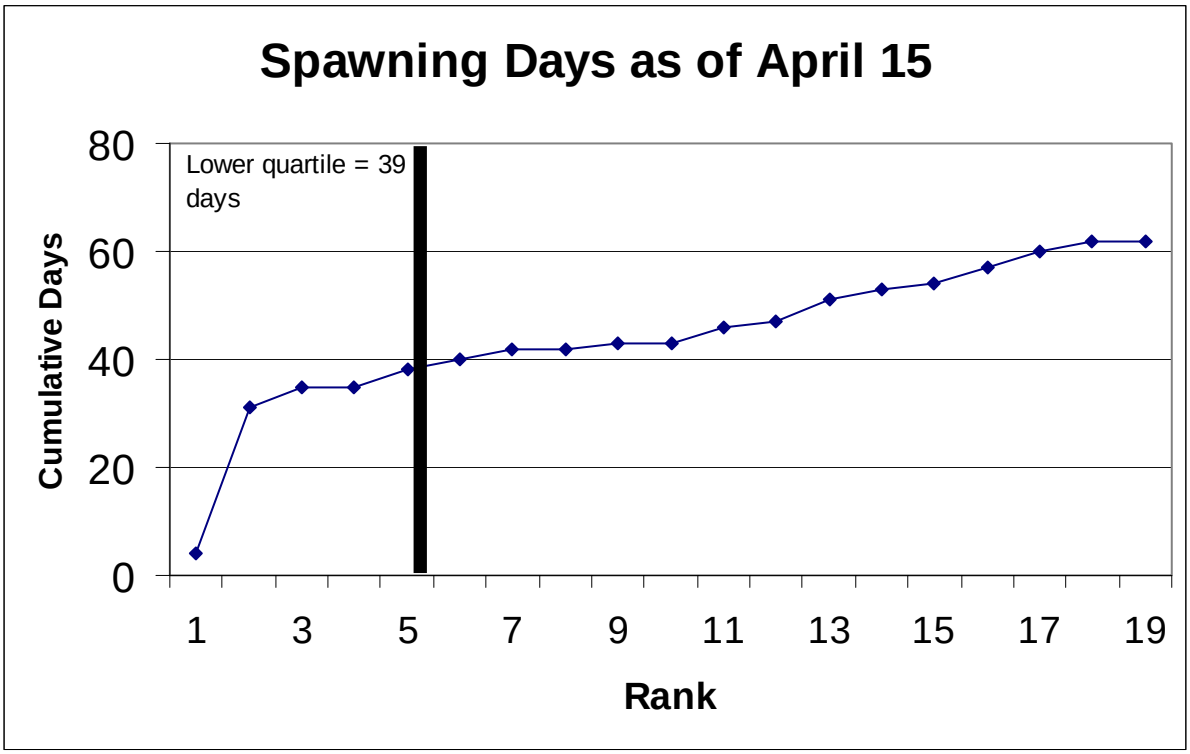


Figure DS3.


Spawning Days as of April 15
Lower quartile = 39 days
Cumulative Days
0
20
40
60
80
1
3
5
7
9
11
13
15
17
19
Rank

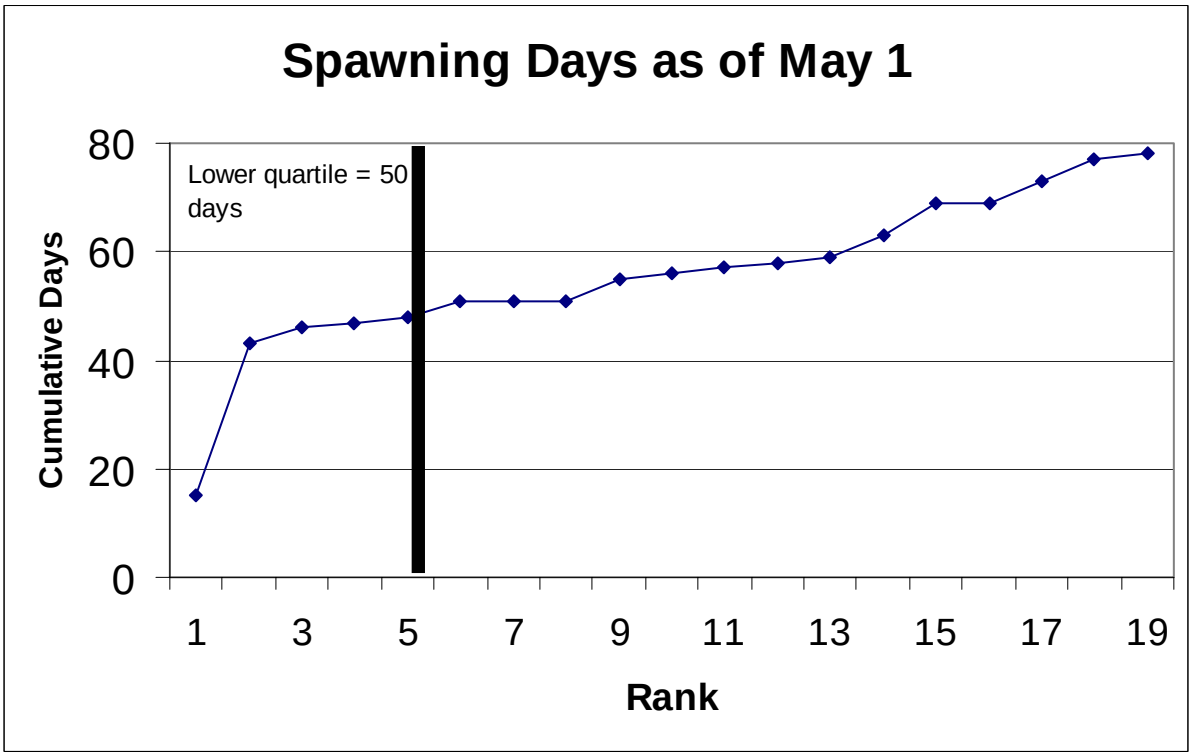

Spawning Days as of May 1
Lower quartile = 50 days
Cumulative Days
0
20
40
60
80
1
3
5
7
9
11
13
15
17
19
Rank

Figure DS5.1. A 20-mm Survey delta smelt bubble plot map with calculated centroid position from the confluence of Sacramento-San Joaquin Rivers with one standard deviation.

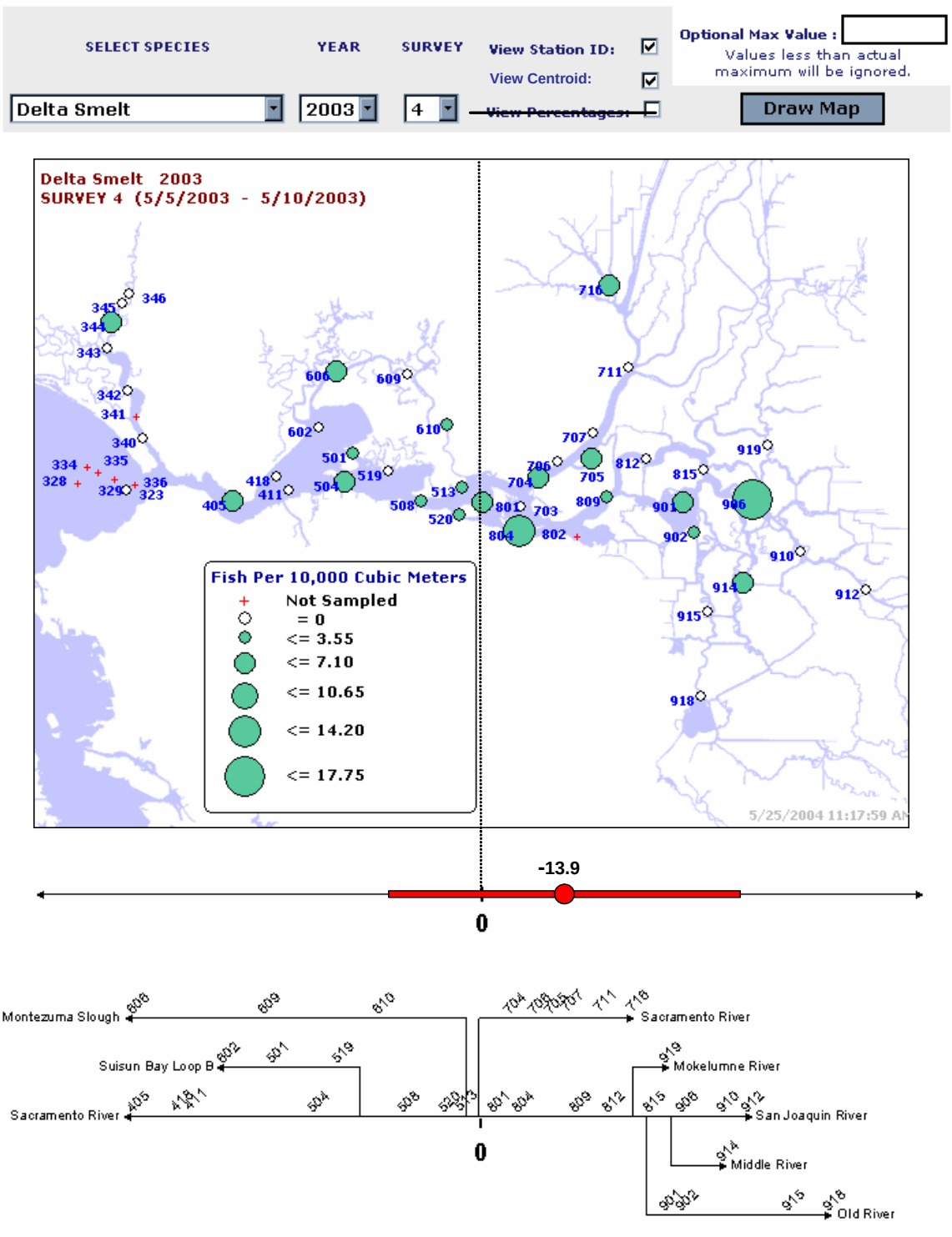


Figure DS5.2. Historic juvenile centroid position (20-mm Survey) with one standard deviation.

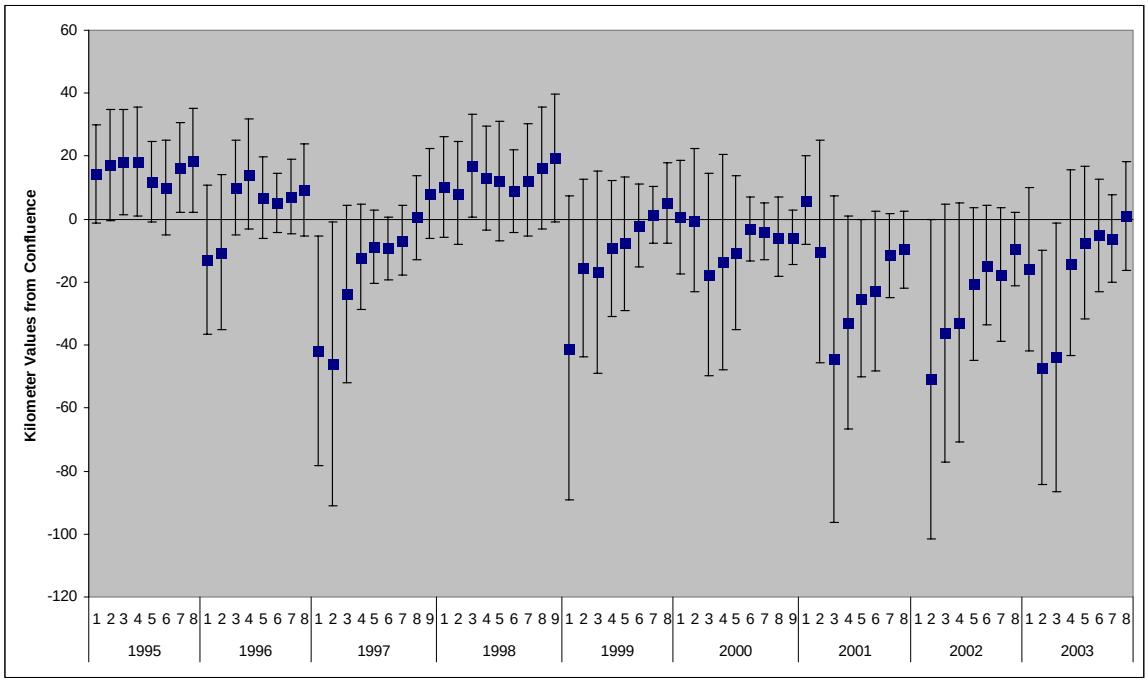


Table DS5. Median values of cumulative catch from the 20-mm Survey. When cumulative catch per survey during a season is at or below the calculated value, concern is high.

	survey 1	survey 2	survey 3	survey 4	survey 5	survey 6	survey 7	survey 8
Median Value	12	40	144	188	346	500	924	1019

Figure DS6

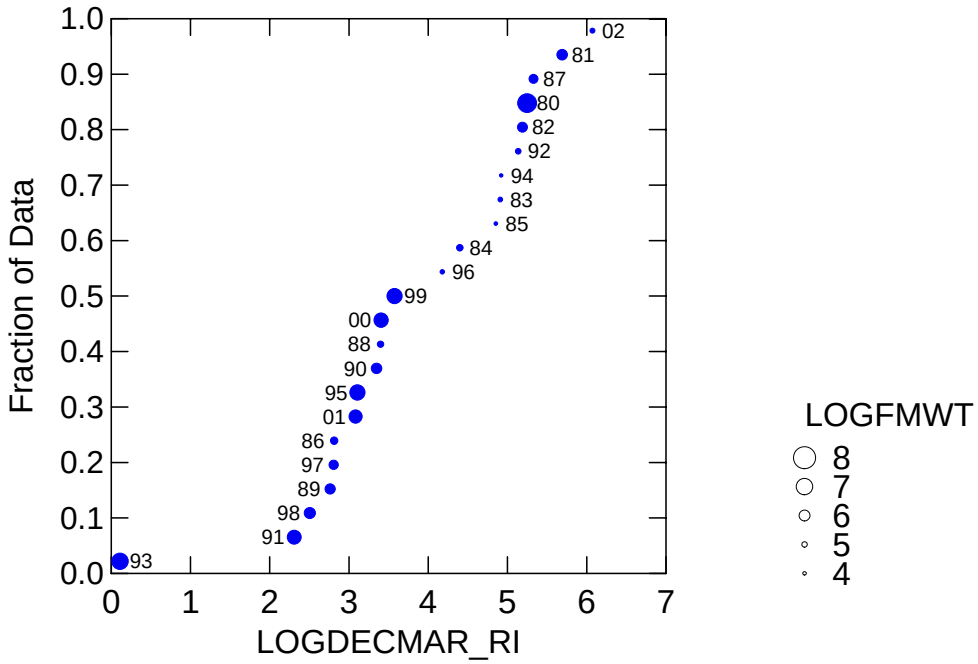
The objective is to quantify a level of concern for adult delta smelt during the winter that is based upon the number of fish salvaged and the overall abundance of delta smelt. Our trigger reflects that when abundance is low and salvage is high concern is high, and conversely when abundance is high and salvage is low that concern is low.

Below is a Quantile plot of the ratio of winter salvage to MWT index (ln(winter salvage/MWT index)). Winter salvage is defined as the total salvage from December through March. In the figure below, the size of the bubbles is proportional to the log of the fall midwater trawl to demonstrate that concern may be high in years of high or low

fall abundance. The resulting quartiles of the ratio are as follows: 25% =: 2.950; 50%= 3.575; 75% 5.029.
Using this approach to calculate winter concern levels, all years above the 1999 point in the graph would have been years of concern. In other words, these are the years in which we may have recommended some protection. Comparing it to the protection afforded adult delta smelt in the winter by the 1995 Biological Opinion: "red light" was, or would have been, reached in fewer winters (1980, 1981, 1982, 1984 and 1999) .

The median was selected as the measure of concern and will be calculated by:

concern level = anti ln(3.575)* MWT index



The goal for the DSRAM is to avoid the upper quartile of the above graph, which the Working Group thinks will avoid salvage events that are high relative to fall abundance. Actions may be taken prior to major salvage events.