Environmental Water Account Expenditures for Protection of the Delta Smelt in Water Year 2003

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Introduction

This report provides a narrative account of the expenditures of Environmental Water Account (EWA) assets on behalf of the threatened delta smelt during water year 2003. This report also includes a brief description of environmental conditions in the Delta, the distribution of delta smelt in 2003, and a brief assessment of the performance of the EWA with regard to the protection of the delta smelt and its habitat. Finally, this paper provides conclusions and recommendations for EWA use in the future.

Delta Smelt

Status. The delta smelt (*Hypomesus transpacificus*) 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. Although highly variable, delta smelt fall abundance indicators have exhibited a marked decline over the past 30 years. Key factors in the decline likely include reductions in freshwater outflow related to increased upstream storage and diversion of water from the Sacramento and San Joaquin Rivers and tributaries, as well as to entrainment losses to water diversions at the Central Valley Project (CVP), State Water Project (SWP), and numerous small agricultural diversions throughout the Delta. Other factors also thought to have contributed to the decline of the species include 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).

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 above the region of fresh and saltwater mixing, in shallow, open waters with relatively low current velocities (Moyle, 2002). The pre-settlement Delta was a large wetland complex, dissected by shallow, meandering channels between seasonally flooded islands. The modern Delta consists of intensively farmed islands separated by dredged channels, with numerous diversions and a highly altered ecology and hydrologic regime. The small size, rapid growth, early maturity and semelparity of delta smelt implies that, historically, the Delta presented a stable environment wherein successful reproduction and larval survival were fairly certain (Moyle, 2002; Moyle et al., 1992). However, of the 24 species (excluding salmon races) native to the Delta, one is extinct, one is listed as threatened,

five are rare, and eight are declining. Only one native species, the prickly sculpin, is considered abundant (U.S. Fish and Wildlife Service, 1996).

In 2002, delta smelt met the Service's five-year recovery goals for distribution and abundance as specified by the Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes, but did not meet the de-listing criteria (U.S. Fish and Wildlife Service, 1996). We note that the Recovery Plan and the listing of the delta smelt is currently being challenged in the cases San Luis and Delta Mendota Water Authority, et al. v. U.S. Department of the Interior, et al. and California Farm Bureau Federation, et al. v. U.S. Department of the Interior, et al. As a partial settlement, the Service has begun a five-year status review of the species.

Distribution and Abundance Monitoring. The objective of any recovery plan is to de-list a species through restoration of its abundance and distribution, and removal of the threats to the species[1]. The Recovery Plan directs that "delta smelt will be considered restored when its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period." Several monitoring methods have been used to obtain information on the various life-stages of delta smelt and its abundance and distribution in the Delta. For adult fish, these tools include the fall and spring mid-water trawls, beach seining, the Chipps Island trawl, and estimation of gonadal development. For larval delta smelt, these methods include light trapping and 20-mm surveys (Fig. 7). For juvenile fish, these methods include the 20-mm and summer tow-net surveys. Indicators of distribution and abundance common to all life stages include year-type hydrology (wet vs. dry), location of the salt/freshwater mixing zone (X2), water quality, water temperature, rate of export pumping, and salvage at the export facilities, although this "sampling" method was less effective for larval and early juvenile fish. All life stages of delta smelt are vulnerable to entrainment at the CVP and SWP export facilities.

In 2002, the Recovery Index was 33, the fifth lowest since 1967. The Recovery Index is a composite score, assembled from a subset of the September and October fall mid-water trawl (FMWT) catches. This lead to a heightened concern for the species going into water year 2003, which was reflected in the recommendations of the Delta Smelt Working Group and Data Assessment Team for fish actions believed to be protective of critical life stages.

Expenditure of Environmental Water Account Assets

The Environmental Water Account (EWA) acquires and manages assets for the dual but complementary purposes of limiting incidental take at the South Delta export pumps, and providing general ecological benefits that contribute to the recovery of listed species (CALFED 2000). 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

[1] The EWA was not considered in the Recovery Plan, as it did not exist at the time that the Recovery Plan was written.

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. For example, in October and November of 2001, EWA assets were released from Folsom Reservoir at a time wherein they would provide flow and temperature benefits to spawning Chinook salmon.

In order to be effective, the use of EWA assets must be based upon an overall understanding of species biology and of the ecology and physical processes operating in the Delta. Fish actions taken on behalf of 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, which are considered the most critical life-stage, since in an annual species they represent the individuals who have successfully avoided risk occurring at earlier life stages to achieve reproductive maturity. Actions taken in April through June may protect late-spawning adults or larvae and juveniles. Early life-stages (less than 20 mm) are too small to be identified and counted in daily salvage operations, however, salvage techniques are continually refined, and development of keys for larval fish is ongoing. Export curtailments in January were intended to protect pre-spawning adults, while export curtailments in late May were intended to improve habitat and afford larvae the opportunity to move north and west toward rearing areas in Suisun Bay. Nevertheless, protection of both larvae and juveniles may be important when abundance appears to be low and density-dependent effects do not appear to exert an influence. Fish actions are taken following interagency discussion at the staff level (Data Assessment Team, or DAT) using the delta smelt decision tree (Attachment 1). The DAT considers incidental take at the pumps, Delta conditions, and the distribution and abundance of the species as indicated by the monitoring measures above, with oversight and final approval at the management level (Water Operations Management Team, or WOMT).

Performance of the EWA

In its 2001-2002 review of the Environmental Water Account, the EWA Science Review Panel wrote: “The environmentalists expect EWA to help the fish populations, and water-users want to know the dollars spent to save each fish.” The EWA agencies were subsequently tasked by the Panel with the development of performance measures for the objective assessment of the relative value of different fish actions. These indicators will take on increasing importance as the CALFED agencies consider whether or not to continue the EWA beyond its first four years, and in determining what form the EWA might take in the future.

The CALFED agencies have focused their collective restoration strategies on the reduction of the most critical and/or persistent stresses to the living resources of the Delta. With respect to the stresses implicated in the decline of the delta smelt, the EWA was designed primarily to contribute to the abatement of entrainment losses at the

export pumps; thus, any evaluation of the effectiveness of the EWA must be based upon whether or not its actions have reduced the impact of this stressor to native fish species. However, the EWA also provides a social benefit in that it creates an additional forum through which the interests of a variety of stakeholder groups may provide input. This function must also be evaluated.

To accurately model the impact of human activity in the Delta, development of a shared conceptual framework has begun. Once this has been completed, restoration and management efforts can be focused on the identification of key factors that can be effectively manipulated and compared with an expected outcome. Performance measures for the EWA must be based upon the application of substantive criteria that are measurable, precise, consistent and sensitive, as well as feasible, cost-effective and appropriate (Margoluis and Salafsky, 1998). The evaluation of the EWA should become part of an adaptive management strategy that feeds back into improved decision-making and results in more effective conservation (Figures 1.a and 1.b).

Environmental Conditions/Delta Smelt Situation in WY 2003

While a mild-to-moderate *El Nino* brought drought relief to the Gulf and East Coast states, dry conditions persisted across much of the continental United States, and much of California experienced above-normal temperatures with below-normal precipitation until well into spring. December was wet, with near-normal average temperatures, but January and February brought below-normal precipitation and above-normal temperatures, and snow totals only about 25% of normal. Near-normal temperatures and precipitation improved snow totals by the end of March, but relief from the apparent drought did not come until April. Above-normal precipitation in April and into early May increased snow totals to above-normal in parts of the northern Sierra Nevada, and runoff combined with below-normal temperatures kept the Delta cool through the bulk of the delta smelt spawning period (NOAA 2003). Cool temperatures are correlated with an extended spawning period, potentially improving delta smelt recruitment (Nobriga et al., 2000).

The South Delta export facilities began reporting delta smelt incidental take in December of 2002. The monthly salvage for water years 2001 through 2003 is summarized in Table 1. A summary of EWA expenditures for water years 2001 through 2003 is presented in Table 2.

December

Following a period of heavy precipitation, the Project Agencies declared excess conditions in the Delta on December 18, and concurrent with increased export pumping, delta smelt salvage was reported at the CVP pumps. Although smelt salvage was moderate, concern was expressed during the DAT call on December 23 that winter-run Chinook salvage could exceed export-reduction criteria. The Water Operations

Management Team (WOMT) approved the DAT recommendation to reduce exports if necessary, should the Chinook decision process criteria be met during the holiday break. Delta smelt salvage continued at both export facilities over the next few days, but remained moderate (Fig. 2). Reduction of exports to a combined 6,000 cfs began on December 27, and although undertaken to protect juvenile salmonids, was expected to benefit adult delta smelt. As losses of older Chinook began to taper off, the DAT recommended increasing exports to a combined 9,000 cfs, beginning on January 1. Export curtailments were lifted on January 2.

EWA Costs. The Department of Water Resources estimated that SWP exports were reduced by approximately 32,000 acre-feet in December as a result of this action (Fish Action #4-03, December 27-31). Future settlements of EWA costs and credits will reflect the actual cost of water, energy, storage and conveyance incurred.

January

Benefits that were expected to accrue to adult delta smelt as a result of actions taken to benefit Chinook salmon failed to become apparent, as the 14-day average salvage estimate climbed steadily after December 18 to reach the heightened-concern level (14-day average salvage of 400, or "yellow light") on January 12 (Fig. 3). The male-to-female ratio was approximately even; males were significantly ahead of females with regard to gonadal maturity. Females were observed to carry ova of approximately 0.7mm (0.9mm is the size at maturity). Because the recovery index for delta smelt for 2002 was very low (33 as compared to 322, 265 and 314 in 1999, 2000 and 2001, respectively), concern for these pre-spawn adults was high. On January 13, the DAT team recommended reducing exports at the SWP, where approximately 75% of the salvage was occurring, to 6,000 cfs for at least three days. Meeting again on January 16, the DAT recommended continuing the curtailment through the long weekend, with resumption of normal operations on January 21. Delta smelt salvage at the SWP decreased markedly, the 14-day average dropping below 400 by January 18 and salvage densities ranging from 9 to 12 per thousand acre-feet of export during the six-day curtailment period. Salvaged delta smelt were comparatively larger this year, increasing from an average 60mm mid-month to 70mm by the end of the month.

EWA Costs. The Department of Water Resources estimated that SWP exports were reduced by approximately 9,500 acre-feet as a result of Fish Action #4-03 (January 1-2), 60,000 acre-feet as a result of Fish Action #5-03 (January 15-20), and 20,000 acre-feet as a result of Fish Action #6-03 (January 25-28). Future settlements of EWA costs and credits will reflect the actual cost of water, energy, storage and conveyance incurred.

February

After one of the driest Januaries on record, the Delta returned to balanced conditions on February 14, and the export-to-inflow (E/I) ratio dropped to 35%, in accordance with the

1995 Water Quality Control Plan. The 14-day average delta smelt salvage continued to decline through February, and salvage of delta smelt at the export pumps never became a concern. The spring Kodiak trawl, initiated on February 18, indicated that delta smelt were distributed in a typical dry-year pattern, with most found in the northwestern sloughs and channels in and around Cache and Montezuma Sloughs, sampling very few fish in the South Delta. Water temperatures were still cool; gonadal development ranged from essentially undeveloped to pre-spawning, indicating that the onset of spawning was imminent. The weather continued in a dry pattern, prompting the Project Agencies to inform the Management Agencies that, as in 2002, they did not anticipate sufficient storage to both maintain the Vernalis flow and ensure adequate flows for the Vernalis Adaptive Management Plan (VAMP) period. Dry weather also drove concerns for water quality, as by mid-month it had become apparent that the Projects would have to decrease exports and increase releases from upstream storage reservoirs to meet X2 standards (25 days at Roe Island). The Project Agencies achieved compliance through February 12, failed to achieve compliance February 13-15, and resumed compliance February 15 using increased reservoir releases to meet the X2 criterion. No EWA actions were taken in February.

March

Despite remaining dry overall, upstream reservoir releases to support water quality prompted the Project Agencies to declare excess conditions in the Delta on March first. During the weekly DAT conference call on March 4, the Project Agencies advised the Management Agencies that the E/I ratio would likely begin controlling exports on March 8. During the March 11 conference call, the DAT discussed the potential for a relaxation of the E/I ratio to 45%, to obtain assets for the EWA. Delta smelt salvage was not a concern; however, there was concern that salvage of juvenile salmonids, while currently low, could increase if an expected storm event caused increases in emigration. Relaxation of the E/I ratio was authorized. Numeric salvage thresholds were developed to determine when incidental take concerns would stop excess exports allowed under the relaxation. During the March 11 call, export pump salvage thresholds were set at 150 older juvenile Chinook for two successive days, and at 400 delta smelt for two successive days. Operators indicated that they would be able to reduce exports within one day, if either take threshold were exceeded. The E/I relaxation began on March 12 and ran until March 28, securing 41,000 acre-feet of debt reduction for the EWA. Delta smelt salvage remained low, as the spring Kodiak trawl (March 4 and March 17) indicated that the bulk of the adult population appeared to be distributed north and west of the export pumps. The 20-mm survey, beginning on March 24, indicated that larvae in the 5-10 mm range were found predominantly in the main channel of the Sacramento River above the confluence with the San Joaquin (Fig. 7.a.). However, the 20-mm survey did indicate that larvae were present in the South Delta, and salvage at the CVP included a few female delta smelt with ova sizes in the 0.2 to 0.4 mm range, suggesting the possibility of a second spawn, if temperatures remained appropriate. Concern for these fish, as well as for juvenile Chinook, informed the decision to discontinue the relaxation of the E/I ratio on March 28.

April

The U.S. Bureau of Reclamation increased releases from New Melones Dam on the Stanislaus River, to meet water quality standards in the Delta. Construction of the South Delta agricultural barriers began on April 2 at the Grant Line Canal and Old River-Tracy sites and at Middle River on April 9. Construction of the Head of Old River barrier (HORB) began on April 1. With the beginning of the VAMP on April 15, exports dropped to a combined rate of 1,500 cfs, and San Joaquin River flows increased to 3,200 cfs (Fig. 4). The purpose of the VAMP is to evaluate the relative effects of exports, inflow and the HORB on juvenile San Joaquin basin Chinook salmon survival and assist in providing protection for both anadromous and estuarine species. Three of the HORB's six culverts were left open and three were closed, allowing San Joaquin River water to enter Old River to support South Delta water levels. Except for the Grant Line Canal barrier, the agricultural barriers began operating tidally on April 15. The final week of the Kodiak trawl indicated that most of the adult delta smelt population was in the Sacramento River area. Most of the fish sampled were spawned females. A few of the adult smelt salvaged at the CVP exhibited advanced stages of gonadal maturation, an indication of an extended spawning season. Water temperatures reached approximately 18.5^0C in early April, then declined to approximately 14^0C for several weeks with increased inflow from precipitation, potentially prolonging the smelt spawning season and out-migration of juvenile salmonids. Although salvage at the export pumps remained low, Management Agency biologists worked under the assumption that, since the 20-mm survey sampled larvae in the South Delta (Fig. 7.b & c), delta smelt were being taken at the pumps but were too small to be detected or counted (a mean length of about 11 mm). Delta smelt detection resumed in salvage operations at the CVP on April 22, but salvage of larvae greater than 20 mm did not exceed the heightened-concern level.

EWA Costs. The Department of Water Resources estimated that SWP exports were reduced by approximately 19,000 acre-feet as a result of Fish Action #7-03 (April 15-30). Future settlements of EWA costs and credits will reflect the actual cost of water, energy, storage and conveyance incurred.

May

The Service convened the Delta Smelt Working Group on May 12 to discuss the potential to extend exports cuts beyond the conclusion of the VAMP, an action often referred to as the "post-VAMP shoulder." Analysis has shown that positive Central Delta flows may benefit delta smelt larvae hatched in the Central Delta by helping them to move away from the pumps (Nobriga et al, 2000). It was acknowledged that any action taken would consume more EWA assets than previously estimated, due to recent rains. Although the fourth week of the 20-mm survey indicated an improvement in distribution of larval fish over previous weeks (Fig. 7.d.), overall numbers sampled were very low, resulting in a heightened level of concern. Noting that the expectation of

benefits resulting from export curtailments would be expected to fall off sharply after May 31 as the South Delta continued to warm, the Working Group recommended that most of the remaining EWA assets be applied to a VAMP shoulder, saving very little for potential fish actions in June. Based on the Mossdale trawl data indicating that the migration of juvenile salmon past the HORB was not yet complete, salmon biologists requested that the HORB remain in place for at least a portion of the VAMP shoulder; however, after consideration of the presumed benefits to fall-run San Joaquin Chinook against the presumed detriment to delta smelt, the Working Group recommended (1) breaching the HORB immediately following the conclusion of the VAMP and tying open the flap gates on the agricultural barriers, (2) restricting Project exports to a combined 1,500 cfs through May 18, and (3) ramping up exports beginning May 19 to a rate at which combined exports matched the San Joaquin River flow at Vernalis. This action was intended to support South Delta habitat, promote western migration of young delta smelt and improve the overall survival of young delta smelt.

Delta smelt salvage rose steadily in May, with the 14-day average increasing from 39 on the first to exceed the heightened-concern level of 400 on May 22 (Fig. 5). Most salvage occurred at the CVP; however, salvage occurred at the SWP on May 11-12 and May 18 in response to increased pumping at the SWP's Banks Pumping Plant for a predation experiment in Clifton Court Forebay. This experiment, proposed in conjunction with the VAMP, was an attempt to quantify the extent of delta smelt predation by fish resident in Clifton Court Forebay[2]. The fifth week of 20-mm sampling completed on May 24 indicated that a substantial fraction of juveniles were still migrating toward rearing habitat in Suisun Bay, and most were north and west of Franks Tract, where they were generally regarded as being beyond the influence of the export facilities (Fig. 7.e.). As South Delta water temperatures climbed toward the lethal limit for delta smelt (exceeding 24^0C), and EWA debt began to accumulate, the Management Agency biologists recommended that export pumping begin ramping up to full capacity beginning on May 28.

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 #7-03 (May 1-15) and 169,000 acre-feet as a result of Fish Action #8-03 (May 16-31). Insufficient availability of Central Valley Project Improvement Act (CVPIA) 3406 (b)(2) water necessitated that export reduction at the CVP of approximately 26,000 acre-feet also be reimbursed by the EWA under Fish Action #8-03. Future settlements of EWA costs and credits will reflect the actual cost of water, energy, storage and conveyance incurred.

June

The 14-day average of combined salvage of delta smelt peaked on June 6 and declined steadily through the rest of the month. Sampling performed during this period by the 20-mm survey indicated that fewer delta smelt were located in the vicinity of the South Delta, with the bulk of individuals found in the Sacramento River and in the area of the

[2] These results are not yet available.

confluence west of Franks Tract (Fig. 7.f). By mid-month no delta smelt were sampled in the South Delta; by the end of June no delta smelt were sampled south of Frank's Tract (Fig. 7.g & h.). As salvage decreased, the EWA agencies began discussing the potential to relax the E/I ratio to decrease EWA debt, within criteria designed to minimize salvage of delta smelt. The E/I would not be relaxed until delta smelt salvage dropped below 400 for three consecutive days, and would be suspended if salvage exceeded 400 for three consecutive days. Relaxation began on June 16 and continued through June 30, accruing approximately 22,000 acre-feet of debt reduction for the EWA.

July

On July 1 the Project Agencies declared balanced conditions in the Delta, and the E/I ratio rose to 65%. The EWA could no longer relax the E/I to reduce debt, but instead planned to share its 500 cfs of additional pumping capacity with the SWP to move debt from San Luis Reservoir to Oroville Reservoir. The same criterion, salvage of 400 or more delta smelt for three consecutive days, was specified for suspension of pumping. EWA debt was successfully transferred through September, allowing for it to be reduced or eliminated should Oroville fill, or to be repaid using water acquired north of the Delta. Delta smelt salvage never became a concern.

Discussion

EWA 2002 Science Technical Review Panel. In its annual report, the EWA Science Technical Review Panel made the following recommendations with regard to delta smelt: (1) clarification of the criteria and underlying information used to develop the decision trees, (2) clarification of the ecological significance of take at the pumps, (3) formal definition of measures of performance appropriate for evaluating the biological benefits of EWA, (4) determine the combinations of physical conditions in the Delta (flow, transports, temperature) that give rise to "entrainment events" of delta smelt, (5) develop a quantitative synthesis of the life cycle of delta smelt, and (6) determine the magnitude of predation mortality in Clifton Court Forebay. The Panel requested that the CALFED Chief Scientist respond to their recommendations in writing. The Delta Smelt Working Group provided a memo to the CALFED Chief Scientist that was anticipated to be of use in the compilation of such a report, the contents of which are summarized below:

The IEP's Delta Smelt Team proposed a Study Plan for Delta Smelt (included as Attachment 2) that addresses many of the recommendations presented by the Science Review Panel. The Team agreed that the decision tree needs to be updated, and volunteers were identified. The ecological significance of incidental take at the pumps is considered by many to be a critical question for species recovery and management. While not yet definitively determined, an IEP study is currently underway that may provide valuable insight by the end of 2004. Draft performance measures have been

included in this report (Figures 1.a and 1.b). There has been general discussion of how to make performance measures relevant to managers and policymakers. Lacking more specific protocols, the monitoring of take at the export pumps is the only surrogate measure currently available. The agenda of the 2003 EWA Delta Smelt Workshop in August focused exclusively on the development of a model that integrated life stage and environmental conditions to assist in population assessment and the interpretation of take at the export facilities. An individual-based model may provide initial results on a one-year time line, but likely will require another year or two for further refinement. Such a model would not be appropriate for use during real-time operations. More information is available in the workshop summary, prepared and distributed by the EWA Science Advisors. Finally, after discussion during weekly DAT calls, limited experimental pumping was conducted in Clifton Court Forebay in an attempt to determine the impact of residence time on fish abundance, providing an insight into predation and pre-screen mortality. Results have not yet been released.

Performance. Because the available amount of environmental water is limited, actions taken must be carefully coordinated and targeted if they are to be effective. The CALFED goals for the EWA are to (1) protect the at-risk fish species affected by SWP and CVP operations and facilities, (2) contribute to the recovery of those species, (3) allow timely water-management responses to changing environmental conditions and changing fish protection needs, (4) provide reliable water supplies to water users in the export areas, and (5) not result in uncompensated costs to water users (CALFED 2000). The last two goals, while successfully accomplished, lie beyond the scope of this paper; discussion here is confined to an analysis of whether or not EWA fish actions were protective, timely and contributed to the recovery of delta smelt.

Protection of at-risk native species can be viewed as a short-term goal of EWA, designed to provide immediate responses to situations in which incidental take at the export pumps may become an issue. EWA fish actions likely contributed to the avoidance of reconsultation; as delta smelt salvage rose toward the 14-day average of 400 (the heightened-concern level), fish actions were identified and implemented that resulted in the decrease of overall salvage. Review of delta smelt distribution data from the 20 mm survey subsequent to EWA fish actions indicated decreased densities in the areas in which delta smelt were most vulnerable to entrainment. It is important to note that the incidental take statement from the Service's 1995 Biological Opinion (1995 BO) (U.S. Fish and Wildlife Service, 1995) was developed based upon water year classification at the 90% exceedence level. Water years 2001-2002 were dry throughout; however, during water year 2003 the Delta experienced a dry winter followed by a wet spring. Under the 90% exceedence hydrology, authorized take at the pumps remained at the below-normal level; however, by spring, hydrologic conditions were in the above-normal range, prompting the Projects to increase their projected allocations to their contractors. If water managers had adopted a 50% exceedence hydrology, the Projects would have reached the reconsultation level in May.

In this water year, when delta smelt abundance indicators were very low and concern for incidental take at the pumps was high, the Management Agencies, Project Agencies and stakeholders were able to discuss available real-time data on Delta conditions, take at the pumps and distribution and abundance of delta smelt in an open forum and work together to achieve consensus and implement protective actions in a timely manner. The ability to modify exports in real time, rather than relying solely on prescriptive standards, provided protective intervention before take levels required reconsultation. The ability to analyze trends *as they were developing* enabled the EWA agencies to identify situations in which incidental take could become important and to tailor a specific response, which in turn allowed the Projects to modify exports, generally with a three-day lead time.

Contributions to the recovery of delta smelt can be seen as a long-term goal of EWA, and thus may not focus so much on take as on real-time operations and broad strategies designed to improve habitat conditions. In its 1995 BO, the Service assumed an overall benefit from the institution of flows placing X2 near the confluence, as this would provide for improved distribution of delta smelt away from the influence of the export pumps. Achieving this condition would make it less likely that delta smelt would be entrained, therefore reducing take. Three years of operation are insufficient to determine whether or not EWA has had a positive impact on delta smelt; even if abundance indices were to indicate increases, they represent too limited a timeframe to overcome natural variance.

Accomplishments During EWA Implementation in Water Year 2003. Staff of the Management and Project Agencies and stakeholders communicated, cooperated, and coordinated effectively to implement the EWA. This professional interdisciplinary team approach was evidence of a solid commitment to the EWA effort. The Delta Smelt Working Group and the Data Assessment Team continued to use a structured process for evaluating data (the delta smelt decision tree) and to assess conditions and formulate recommendations for EWA actions to benefit fish in water year 2003. 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, including 25,000 acre-feet of EWA assets at the CVP to support the post-VAMP shoulder. Environmental water was used to maintain a net positive flow in the South Delta, to provide an environment wherein spawning, rearing and migration conditions were more suitable, and to minimize incidental take of at-risk native species.

The five EWA implementing agencies (U.S. Fish and Wildlife Service, NOAA Fisheries, California Department of Fish and Game (CDFG), U.S. Bureau of Reclamation and California Department of Water Resources) drafted an environmental impact report/statement and an action-specific implementation plan. Public review concluded

September 15, and the agencies are in the process of responding to comments, finalizing the EIR/EIS and drafting the Record of Decision. The Services are conducting formal consultation under Section 7 of the Endangered Species Act, and CDFG will consult under the Natural Communities Conservation Planning Act.

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. This served to focus the awareness of policy makers, managers and stakeholders to the challenge of balancing the use of Central Valley water resources. Again in 2003, CALFED Science sponsored an EWA Delta Smelt Workshop, held August 18 and 19 in Santa Cruz. Breaking with past formats, the meeting was a technical working session, built around the development of a simulation model of the life cycle of delta smelt, for use in the assessment of benefits of the expenditure of EWA assets to protect and recover delta smelt. This individual-based model may be available for hypothesis testing, evaluation of the performance of the EWA, and the development and testing of management scenarios in two to three years. The third annual EWA Science Review Workshop, for which this paper has been prepared, will take place in October.

Limitations Encountered During EWA Implementation in Water Year 2003. While making recommendations to decision-makers on beneficial actions for delta smelt in real-time, staff occasionally found themselves in a reactive rather than a proactive mode. Tools to combat this situation include up-front use of the Particle Tracking Model and improved understanding of delta smelt needs at varied life-stages, as well as of estuarine and hydraulic processes. EWA agency staff also were somewhat constrained by a lack of information concerning the impact of take at the export pumps on the delta smelt population as a whole.

Science Needs for Improved EWA Implementation and Evaluation. The Interagency Ecological Program (IEP) has proposed a study plan for delta smelt that includes (1) the development of a statistically valid model for predicting delta smelt abundance, (2) examination of the existing data on egg and larval distribution to identify the conditions associated with spawning, (3) analyses to redefine delta smelt habitat, and (4) comprehensive field testing of the statistical model, including egg and larval surveys, entrainment monitoring, particle tracking, temperature monitoring and other factors. This proposal integrates many of the science needs that have been identified in the past. In addition, work is still needed on the impacts of the South Delta barriers, predation and indirect mortality, restoration of shallow-water habitat and the hydraulic "zone of influence" of the export pumps. There is a need to evaluate the potential ecosystem benefits and subsequent population benefits of EWA implementation. There is also a need for improved determination of the amount of water that EWA would likely need to provide optimal protection for at-risk species in each year-type, and to develop adequate EWA placeholders in each month.

Proposed Changes in the Methods of EWA Implementation. Evaluation of EWA performance will likely suggest new directions and strategies for implementation. The EWA agencies and stakeholders must be prepared for an open and honest evaluation of the EWA, and be willing to direct changes, both in the field and at the policy level, that are necessary to improve efficiency and effectiveness. Although there was agreement among the Delta Smelt Working Group on the need to review and potentially revise the decision tree, this review has not yet been done. There is a need for evaluation of the DAT and Delta Smelt Working Group conference calls, to improve efficiency and facilitate a management-level review of their effectiveness. Current Delta and upstream monitoring should be reviewed and, if needed, additional sampling or other efforts should be instituted. Strategies need to be developed which guide decision-making when EWA assets are limited and/or at-risk species have conflicting needs. Clear criteria are needed for the identification of circumstances under which Tier 3 assets may be needed, and a procedure established for activating those assets when needed. More discussion is needed on the prioritization and implementation of key scientific studies important to the EWA and to the use of environmental water for the benefit of at-risk species.

Questions for Further Consideration

Several questions pertinent to the protection and recovery of delta smelt have not been addressed in this report. The following questions may contribute to a framework for 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?

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Table 1. Salvage of delta smelt at State and Federal export facilities for water years 2001-2003.

Month	WY '01 Salvage* (Below Normal)	WY '02 Salvage* (Below Normal)	WY '03 Salvage* (Below Normal)	Reconsultation Level+	
				↑ Normal	↓ Normal
December	192	1,129	2,776	733	8,052
January	181	5,231	9,561	5,379	13,354
February	3,870	280	1,494	7,188	10,910
March	3,772	225	483	6,979	5,386
April	520	372	492	2,378	12,354
May	13,170	47,361	16,309	9,769	55,277
June	2,418	11,926	10,096	10,709	47,245
Total	26,124	66,526	41,211		

* source: USBR Central Valley Operations website, www.mp.usbr.gov/cvo/html/fishrpt.html
+ source: 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 2001-2003, in thousands of acre-feet.

Month	WY 2001	Species Benefited	WY 2002	Species Benefited	WY 2003	Species Benefited
October			5*	Salmonids	13**	Salmonids
November			15*	Salmonids		
December					32	Salmonids
January	69	Salmonids	66	Salmonids/Smelt	89	Salmonids/Smelt

Month	WY 2001	Species Benefited	WY 2002	Species Benefited	WY 2003	Species Benefited
February	69	Salmonids/Smelt				
March	65	Salmonids/Smelt				
April	29	Salmonids/Smelt	28	Salmonids/Smelt	19	Salmonids/Smelt
May	49	Salmonids/Smelt	149	Salmonids/Smelt	208	Salmonids/Smelt
June	9	Salmonids/Smelt	5	Salmonids/Smelt		
Total	290		248		348	

*release of PCWA purchase from Folsom Reservoir, timed for flow and temperature benefits

**power generation bypass at Folsom Dam

source: EWA *Fish Action* summaries for water years 2001, 2002 and 2003

The model begins with the assumption that the biological diversity of the Delta has intrinsic value and therefore is worth protecting. The model then develops the concept of the EWA as a tool for the protection of the diversity that we value:

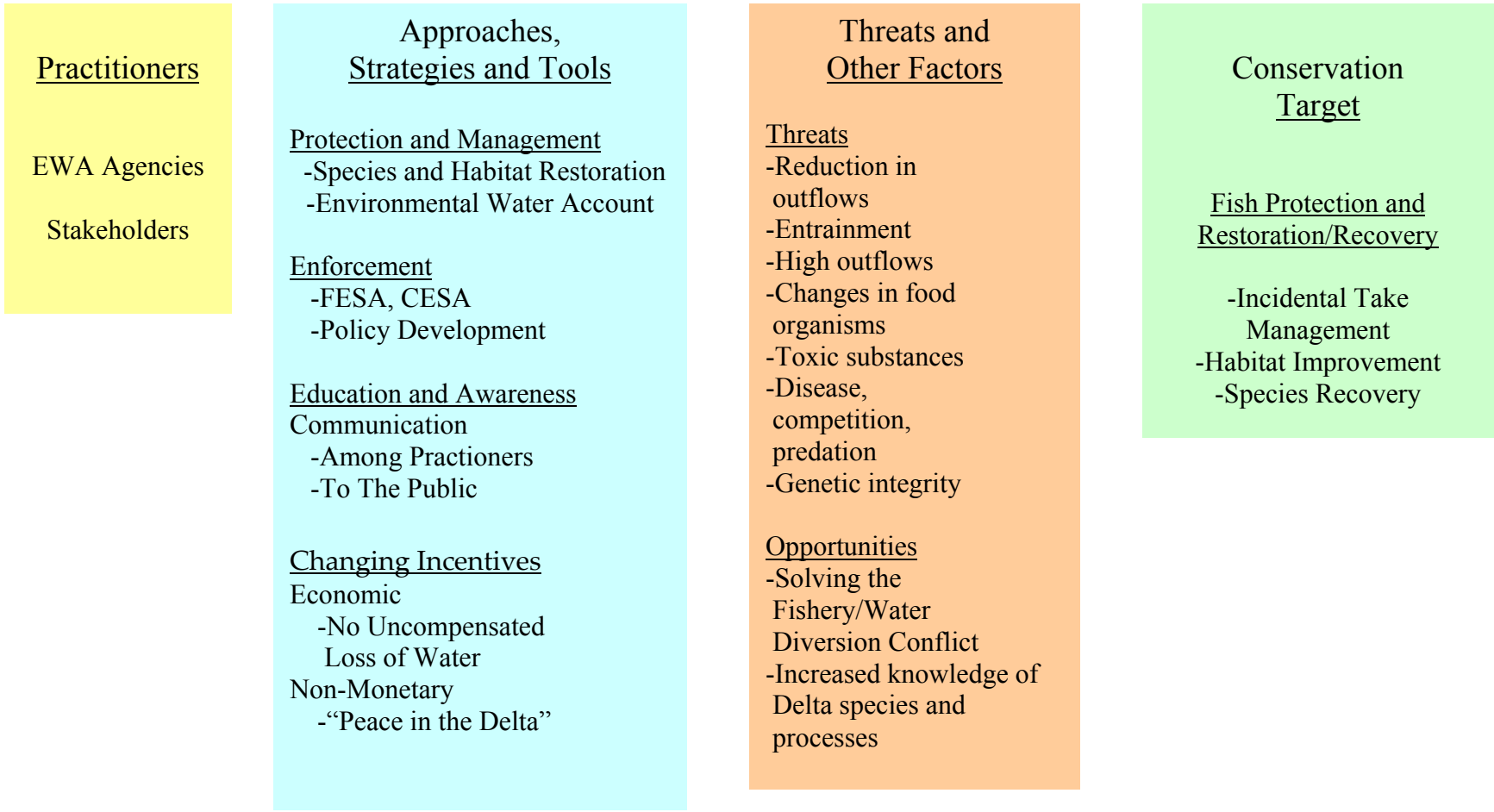


Figure 1.a. Proposed Draft Conceptual Model for the Environmental Water Account.

Criteria must be measurable, precise, consistent and sensitive to the phenomena being tracked, as well as feasible, cost-effective and appropriate:

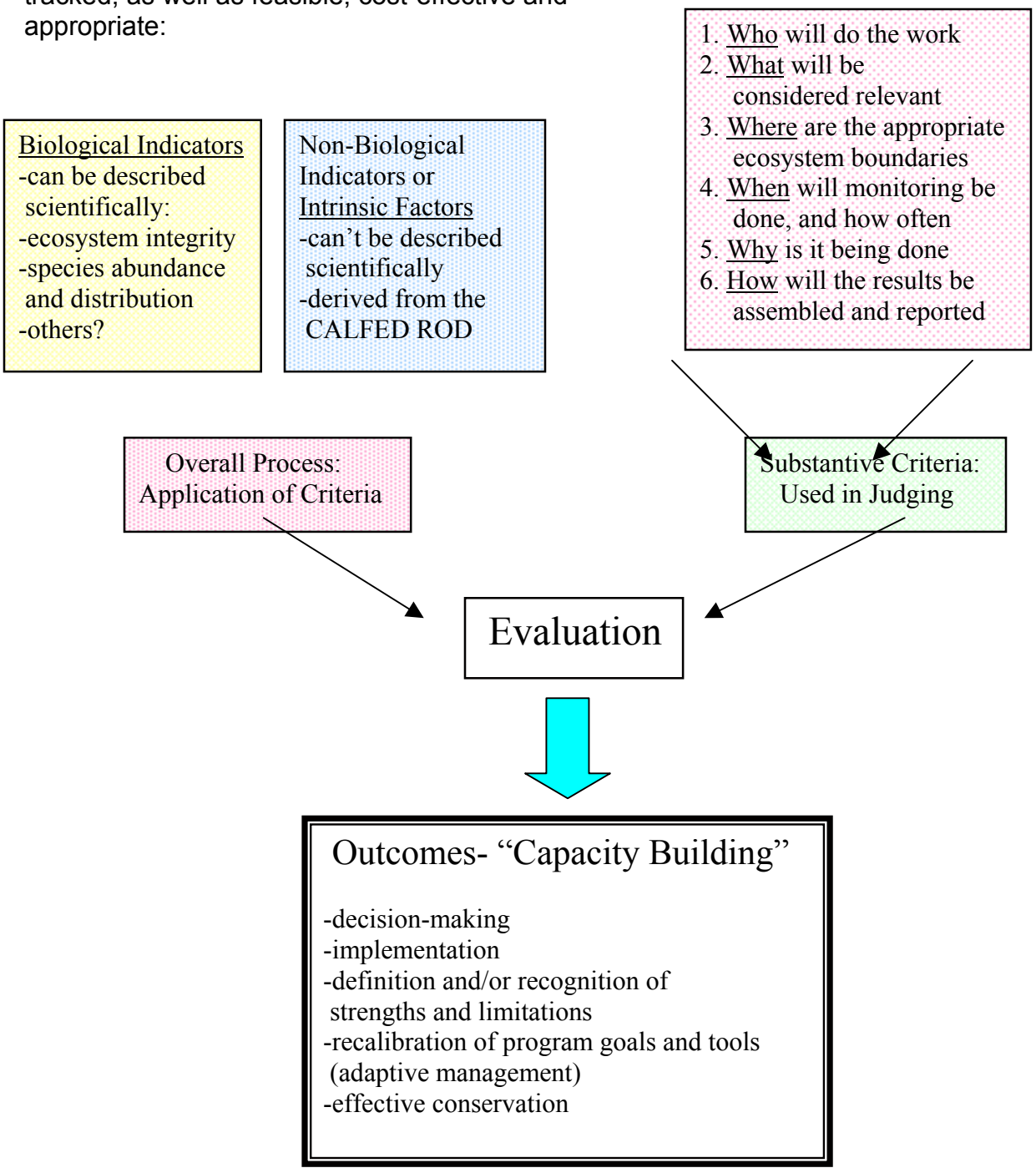


Figure 1.b. Proposed Draft Performance Measures for the Environmental Water Account.

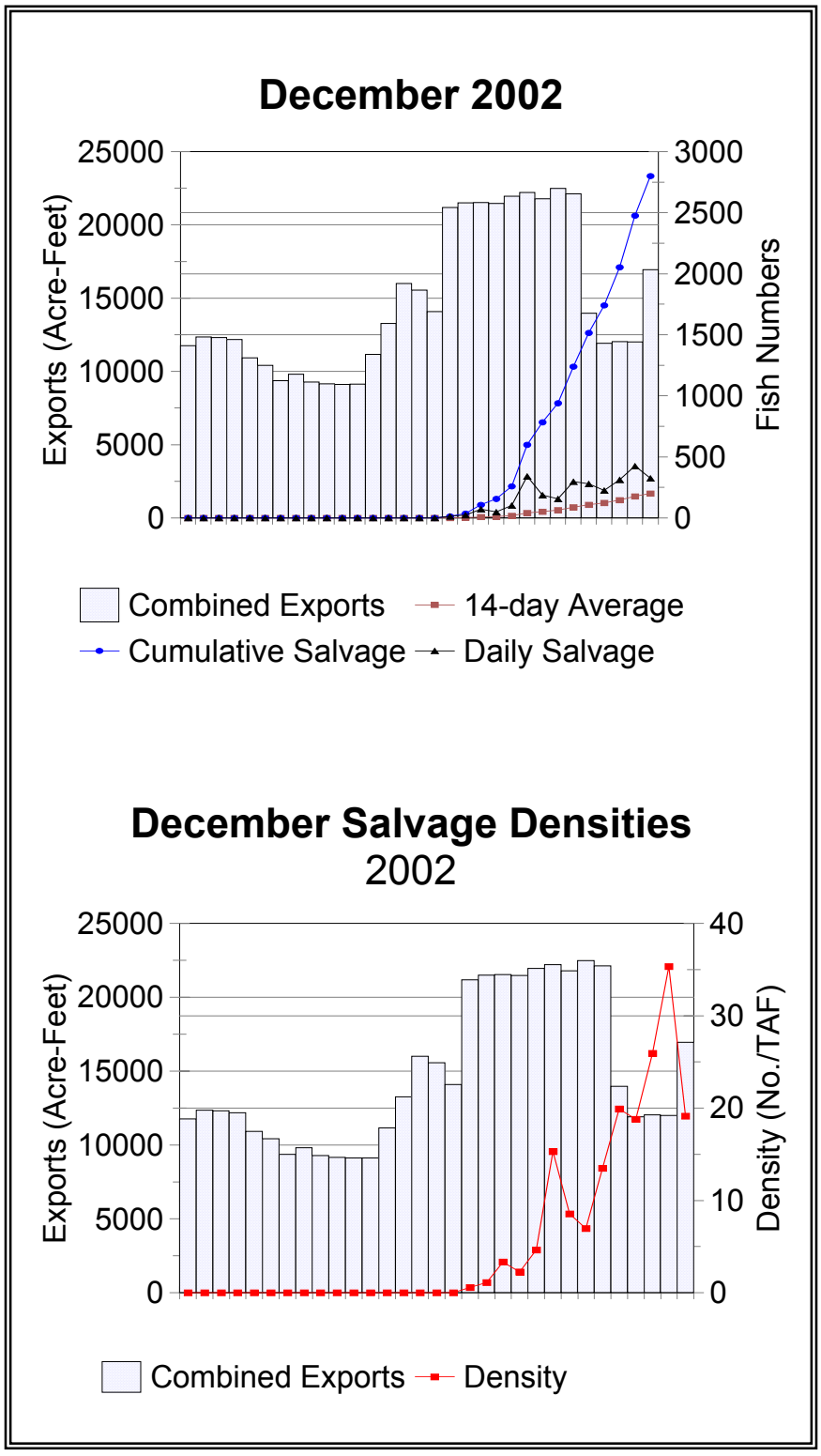


Figure 2. Summary of EWA actions in December 2002.

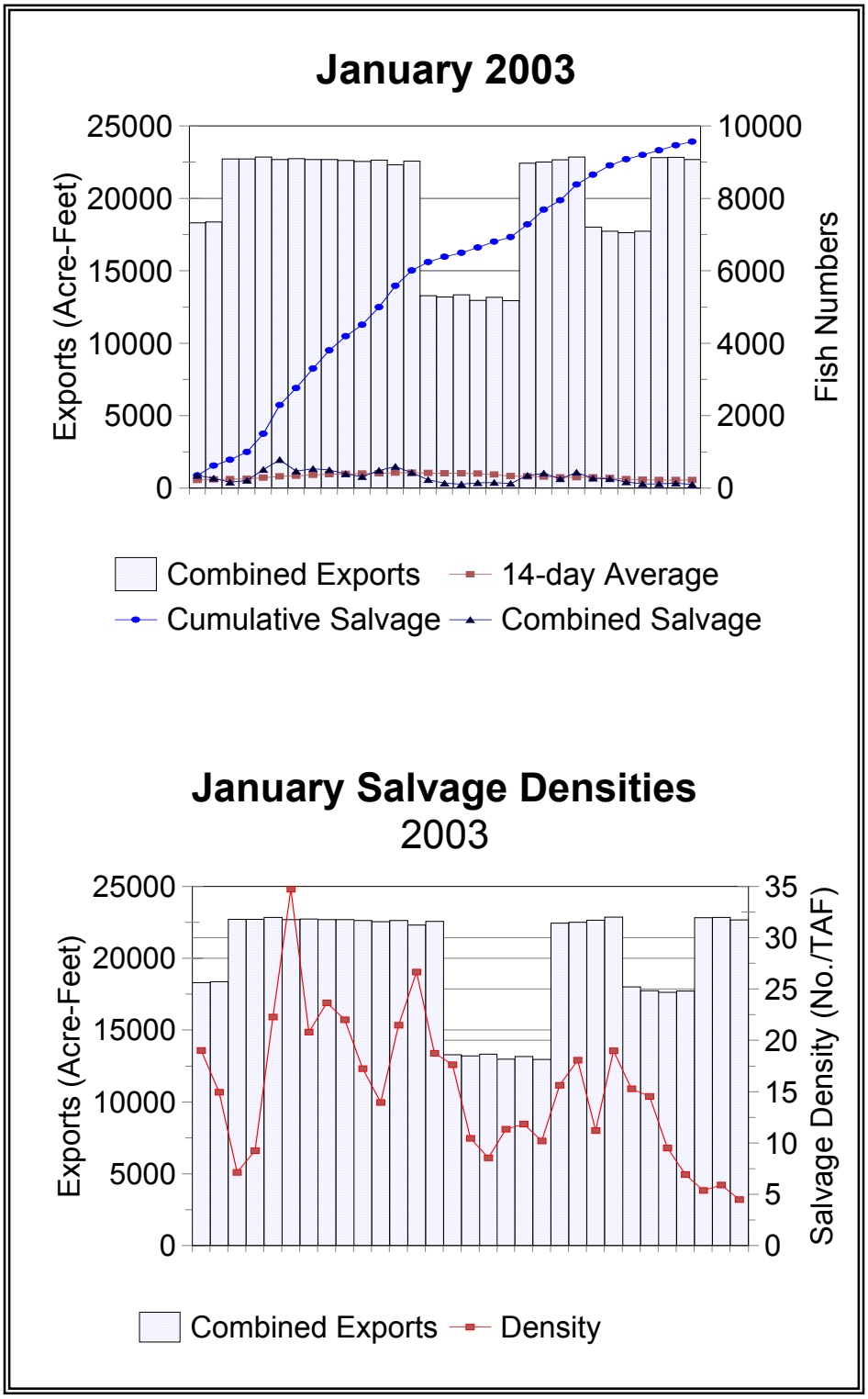


Figure 3. Summary of EWA actions in January 2003.

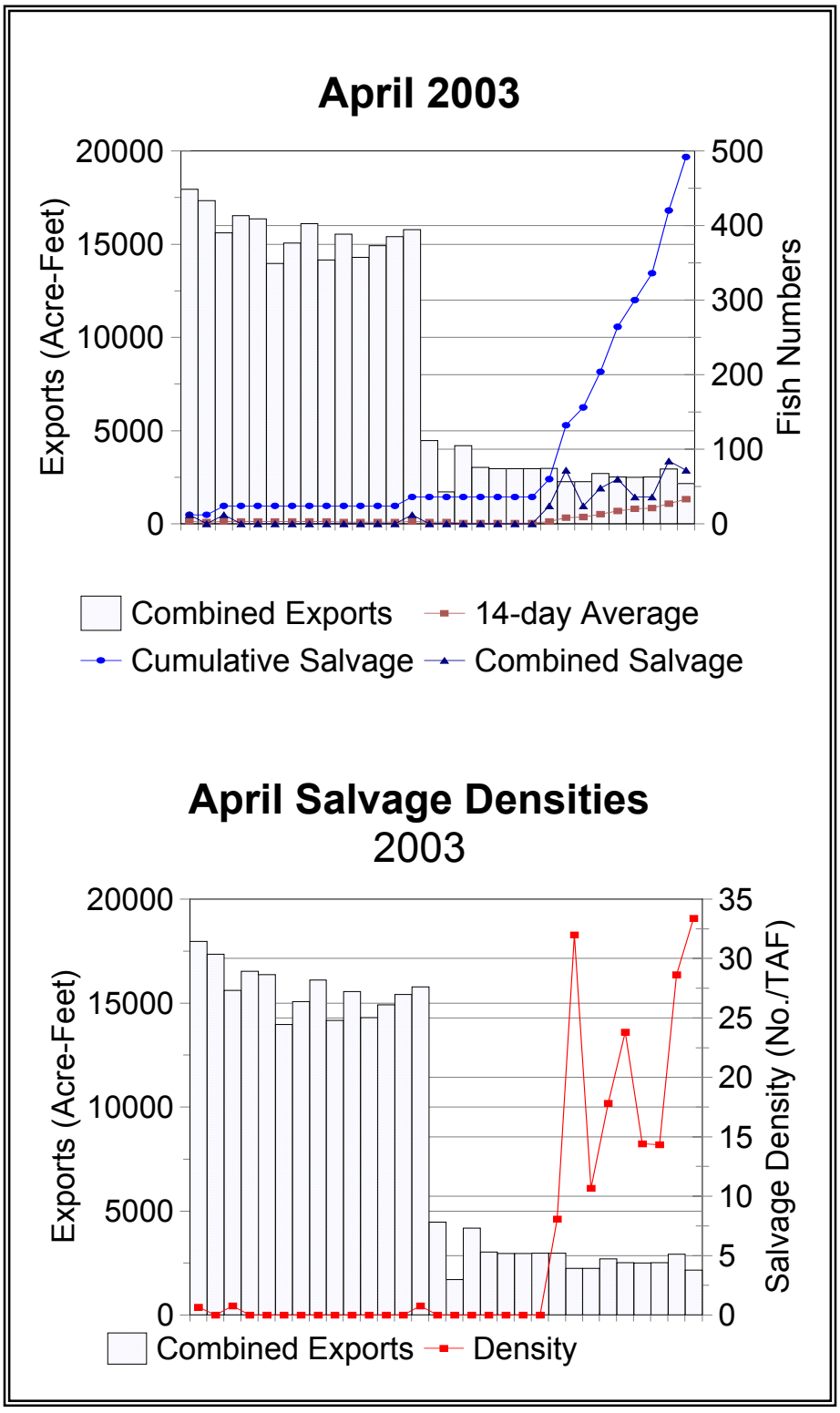


Figure 4. Summary of EWA actions in April 2003.

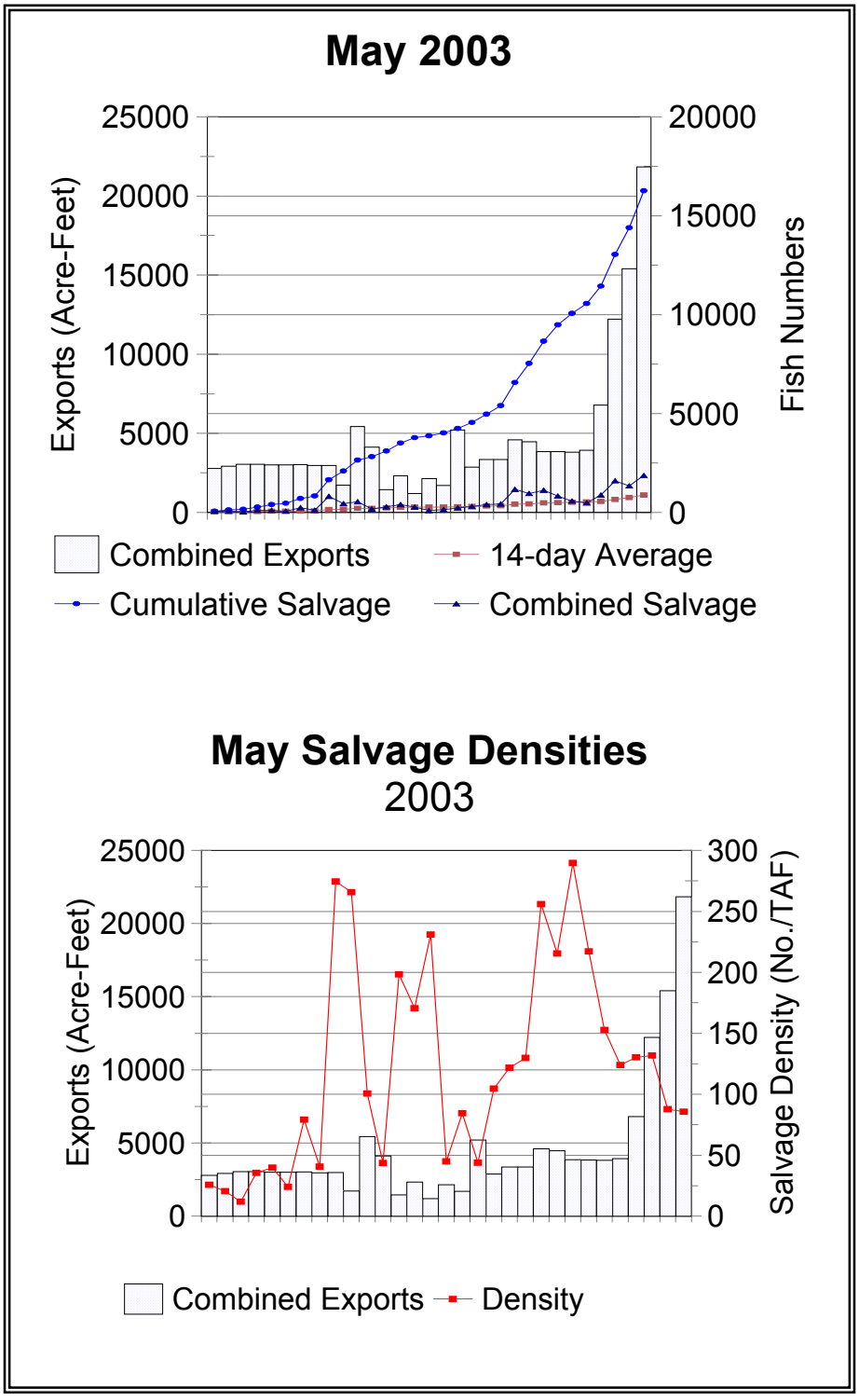


Figure 5. Summary of EWA actions in May 2003.

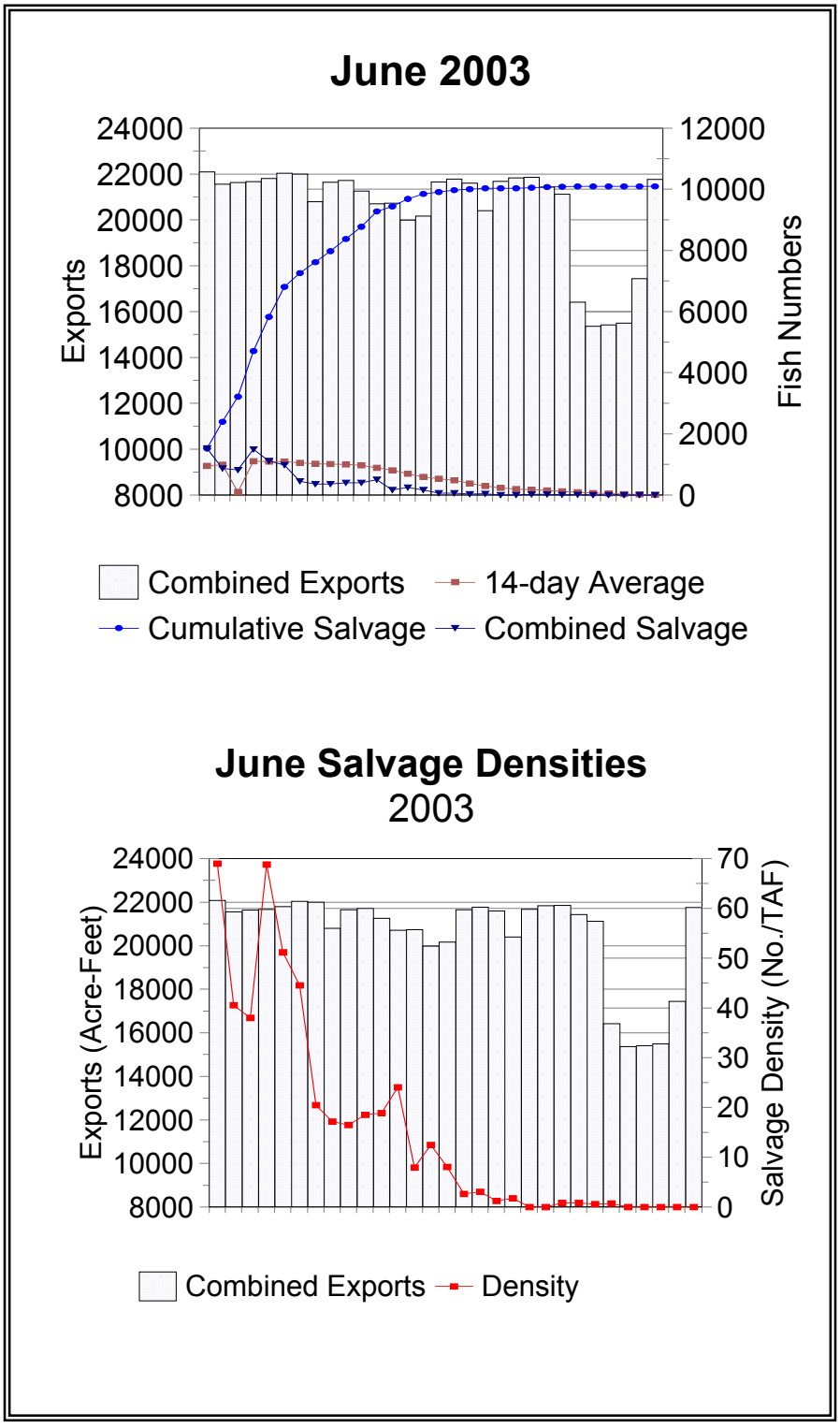
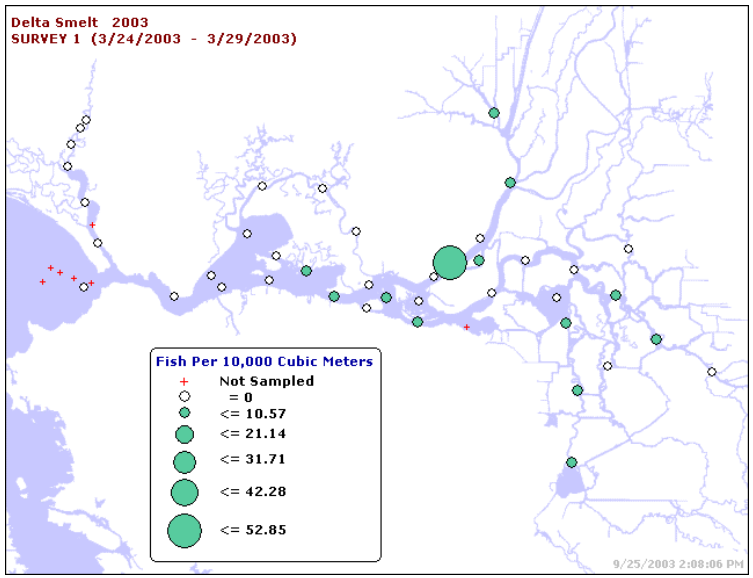
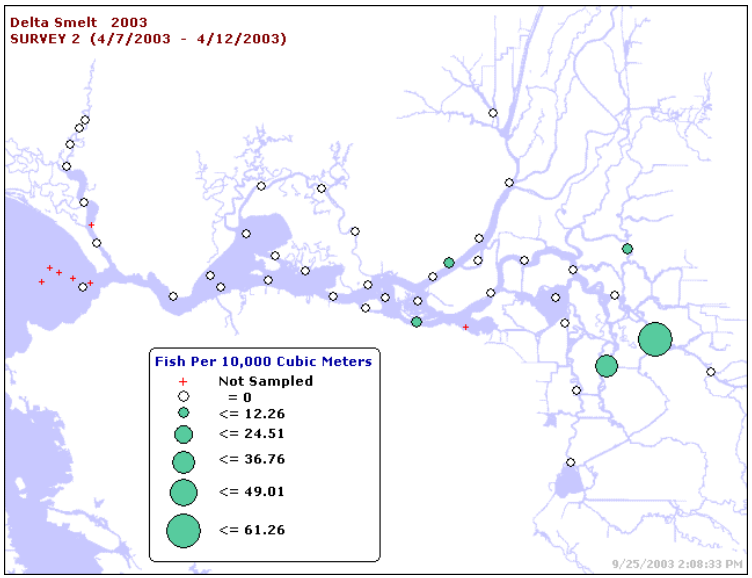


Figure 6. Summary of EWA actions in June 2003.



7.a.



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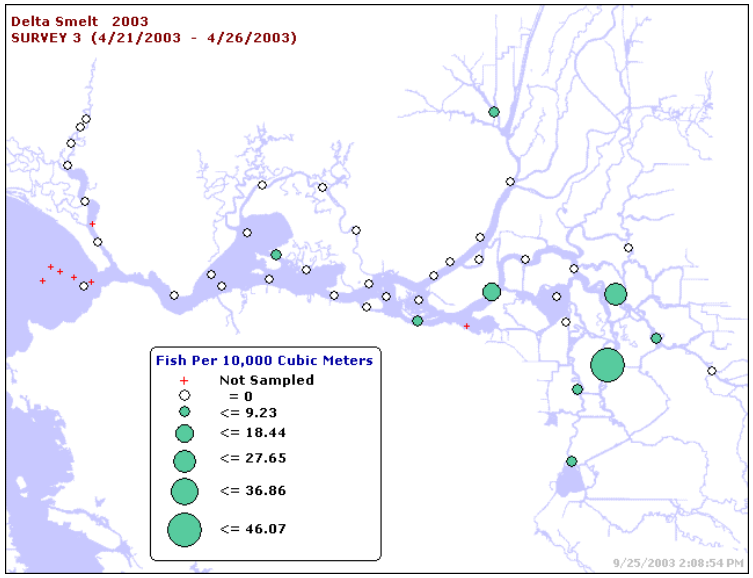

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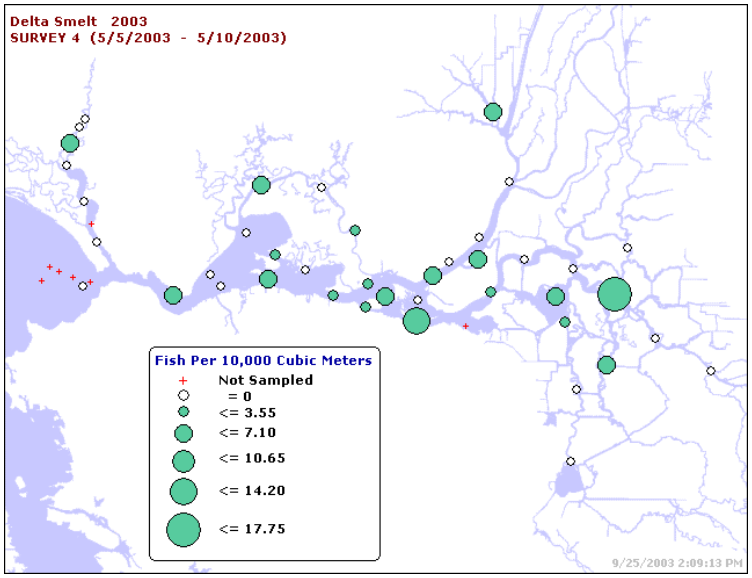
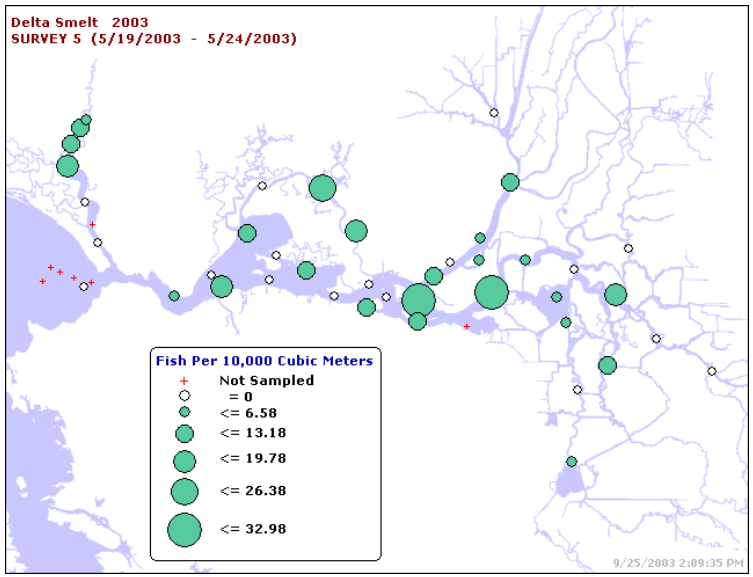


7.d.

Figure 7. Delta smelt distributions as sampled by the 20-millimeter survey. Source: California Department of Fish and Game



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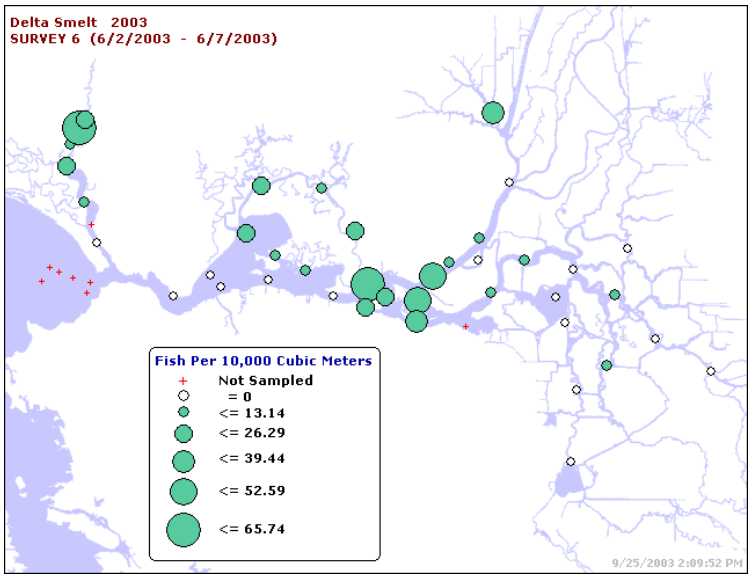

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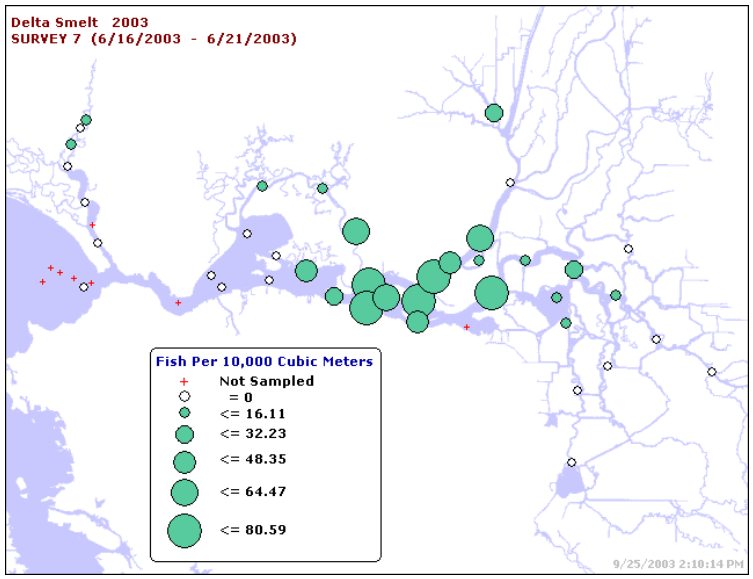

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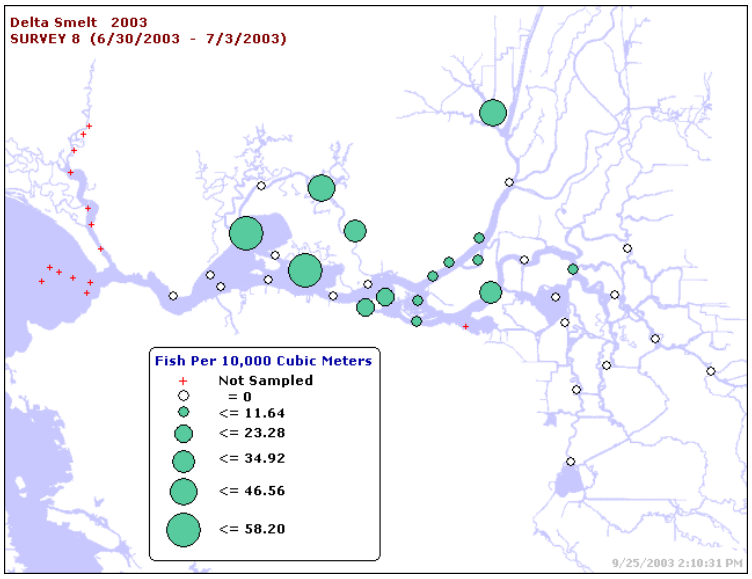

7.h.

Figure 7. Delta smelt distributions as sampled by the 20-millimeter survey. Source: California Department of Fish and Ga

Attachment 1. 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 of 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 couth 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 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 the distribution of spawning broad or restricted? 2) Is larval distribution broad or restricted? 3) When does spawning occur? 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 of the zone of influence (e.g., east 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? 2) Do we consider changing the agricultural barrier/HOB 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.

Source: Nobriga et al, 2001

[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 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.

Attachment 2

IEP Study Plan for Delta Smelt

1. Development of statistical model
    - FMWT index = temperature window * entrainment * Distribution
        - FMWT index = temperature window * relative entrainment
            - Particle tracking modeling

Goal: Develop a simple, reliable model for predicting delta smelt abundance.
The model proposed is based upon the linear relationship between the number of days of temperatures suitable for spawning or "temperature window" and the FMWT index of juvenile smelt. Nearly 70% of the abundance index variation is explained by the length of temperature window. It should be possible to improve the relationship by including a variable to explain the relative loss of fish to operations. Thus the equation can be expanded to include the variables of entrainment and distribution (the first model above), the idea being that the smelt's geographic distribution can provide some measure of entrainment "risk." Alternatively, the distribution and entrainment variables may be combined into a single variable, referred to as "relative entrainment" (the second model above), which uses the geographic distributions based upon monitoring surveys to determine the relative percentage of fish that may be susceptible to entrainment, as determined by particle tracking modeling.
The first approximation of relative entrainment is a product of the relative distribution of delta smelt and the estuary flow patterns. Relative distribution data is already available from surveys such as the 20MM and the TNS. Investigation of the particle tracking model and the possible outcomes of particles injected. Other refinements to the model may include better measures of abundances and more precise measures of the spawning window.
The particle tracking model has been used by the Delta Smelt Working Group (DSWG) to assess possible outcomes of various water management options, e.g. delta barriers and changes in pumping. Relative distribution data from surveys such as the 20MM and TNS are coupled with the Particle Tracking Model. Preliminary analysis of relative entrainment has estimates averaging ~25% of the population lost to operations. This significant source of mortality needs to be verified and, if true, included in the model.

2. Existing egg and larva data analysis

- 1991-1995 data
- 1995 E&L data concomitant with 20mm data
- Filtering of 1970-90 E&L data

Goal: of the exploration is to examine the distribution of spawning and identify the in situ conditions associated with spawning.

Existing data will be used to refine the temperature window variable in the predictive model. The E&L survey ran from 1970 to 1995; however, the prior-to-1991 osmerids were not identified to the species level for delta smelt and longfin smelt, leaving only the four years of delta smelt-specific survey data, including extremely wet and dry water-years. The first analysis will focus on the 1991-1995 E&L data, looking at the spatial and temporal distribution of delta smelt at various sizes and the associated environmental variables, with particular attention being given to the smallest (most recently hatched) fish.

The following efforts will attempt to increase the length of the data series to enhance the E&L analysis: The first will examine the applicability of the 20mm Survey data to substitute for the E&L data for the years after 1995; and the second test the usefulness of the 91-95 E&L data as a "filter" for the 1970-90 data, separating out delta smelt from longfin smelt *based* upon temporal and environmental data, thereby increasing the delta smelt data set to cover many more years and hydrological conditions. With this last exercise come major caveats regarding the data analysis. Obviously the filtered data should not be used to generate summary statistics; and with the filtered data we expect some amount of error, *i.e.* the inclusion of some longfin smelt as well as the exclusion of some delta smelt. Despite these caveats, if the efforts are successful, they will prove useful in the exploration of the temporal and spatial variability of spawning. The success or failure of the last two efforts will determine the need for a renewed E&L Survey.

3. Analyses to redefine delta smelt habitat

- Comprehensive review and analysis of all recent data sets
- Specific assessment of Moyle et al original SW and X2 theories

Goal: To redefine delta smelt habitat.
The paradigms of shallow water as delta smelt habitat and X2/mixing zone as nursery area have become dogma in the literature and are often used as the basis for restoration goals and objectives. Nonetheless, when the salinity distribution of delta smelt from the FMWT is plotted, over 95% of the catch is in waters <1ppt. When near shore sampling is compared to offshore sampling, it is clear that the delta smelt is almost entirely found in the offshore areas. In short, the picture that arises is of a pelagic near-freshwater species.
This analysis involves re-examination of the delta smelt habitat model using the available data sources, including FMWT, Chipps Island, Bay Study, Suisun Marsh, TNS, 20MM, E&L and Salvage. Analysis will track the shifts in "habitat" associated with ontogenetic and life-cycle shifts in the delta smelt. The first approach will be to examine the distributions of delta smelt along environmental gradients at various life stages.

4. Comprehensive field test of the statistical model, including focused E&L surveys, entrainment monitoring, PT modeling, temperature modeling, etc.

Goal: To test the assumptions of the models relative entrainment variable and develop new assumptions to refine the model.
Delta smelt movements through the estuary and the factors that influence that movement are of critical importance. While changes in barriers, cross channel operations, exports and outflows have obvious and measurable influences on the flow patterns within the delta, it is not clear what effect they have on smelt distribution. Of special import is the question of whether or not smelt movements can be influenced by water management.
The delta smelt hatch as small (~5 mm TL) larvae with poor fin development. Swimming capability at the early stage is fairly poor. As the smelt develop, swimming performance increases. Early analysis of fish movements within the delta treated delta smelt as though they were particles, and the DSWG have used the Particle Tracking Model (PTM) to evaluate water management decisions. Although delta smelt larvae bear little resemblance to particles in their size and abilities, early attempts to bestow the modeled particles with behavior (i.e. surface or bottom orientation, and/or tidal vertical migration) were not successful. In these early attempts, the position of particles at T_1 was given as the distribution of smelt larvae from a single 20MM Survey. The distribution of the modeled particles did not correspond with the measured distribution of larvae at T_2, two weeks later, which may have been due to the scale of the sampling, the behavior of the fish, or the assumptions of the PTM.
Problems of scale and PTM adequacy need to be addressed if we are to get a handle on relative entrainment, the zone of influence and the second variable of the delta smelt abundance model. These problems may best be addressed in an intensive, multi-disciplined field study. Where PTM assumptions and results can be verified against

actual conditions, more intensive larval sampling may provide the necessary resolution to track smelt movements relative to abiotic conditions.