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# Status and Trends

## Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities during the 2014 Water Year

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### Introduction

Two facilities mitigate fish losses associated with water export by the federal Central Valley Project (CVP) and California's State Water Project (SWP). The CVP's Tracy Fish Collection Facility (TFCF) and the SWP's Skinner Delta Fish Protective Facility (SDFPF) divert (salvage) fish from water exported from the southern end of the Sacramento-San Joaquin Delta. Both facilities use louver-bypass systems to divert fish from the exported water. The diverted fish are periodically loaded into tanker trucks and transported to fixed release sites in the western Delta. Operations began in 1957 at the TFCF and in 1968 at the SDFPF.

### Methods

This report summarizes the 2014 water year (10/1/2013–9/30/2014) salvage information from the TFCF and the SDFPF, and examines data from water years (WY) 1981 to 2014 for possible relevance to salvage trends in recent years. The following species were given individual consideration: Chinook Salmon (*Oncorhynchus tshawytscha*), Steelhead (*O. mykiss*), Striped Bass[1] (*Morone saxatilis*), Delta Smelt[1] (*Hypomesus transpacificus*), Longfin Smelt[1] (*Spirinchus thaleichthys*), Splittail (*Pogonichthys macrolepidotus*), and Threadfin Shad[1] (*Dorosoma petenense*).

Systematic sampling was used to estimate the numbers and species of fish salvaged at both facilities. Bypass flows into the fish-collection buildings were sub-sampled generally once every 1 or 2 hours for 1 to 60 minutes ($\bar{x}$ = 28.68, sd = 5.10) at the SDFPF, and once every 2 hours for 10 to 120 minutes ($\bar{x}$ = 29.39, sd = 4.27) at the TFCF. Fish 20 mm fork length (FL) or larger were identified, numerated, and measured. These fish counts were expanded to estimate the total number of fish salvaged in each 1- to 2-hour period of water export. For example, a subsample duration of 30 minutes over a 120-minute export period equals an expansion factor of 4, which was multiplied by the number of fish per species collected from the fish count. These incremental salvage estimates were then summed across time to develop monthly and annual species-salvage totals for each facility.

Chinook Salmon loss estimates were presented because the loss model has been widely accepted by regulatory agencies and has undergone extensive review. *Loss* is the estimated number of Chinook Salmon entrained by the facility minus the number of Chinook Salmon that survive salvage operations (California Dept.

[1] Pelagic Organism Decline (POD) species

of Fish and Game 2006). Salmon salvage and loss were summarized by origin (i.e., hatchery fish defined as adipose fin clipped or wild fish defined as non-adipose fin clipped) and race (fall, late-fall, winter, or spring). Race of wild and hatchery Chinook Salmon was determined solely by the Delta Model length-at-date table which is based on length at date of salvage (California Dept. of Fish and Wildlife 2014). It was created by the U.S. Fish and Wildlife Service, which further modified the California Department of Water Resources modified version of the Fisher Model by changing the upper and lower boundaries for winter-run Chinook Salmon. However, apparent growth rates and size ranges among races are variable, leading to potential misclassification with the Delta Model (Harvey and Stroble 2013).

Larval fish were also collected and examined to determine the presence of Delta Smelt and Longfin Smelt < 20 mm FL. Larval sampling at the SDFPF ran from February 24 through June 30 and from March 13 through June 7 at the TFCF. Larval samples were collected once for every 6 hours of water export. Duration of larval samples was the same as the duration for counts. To retain these smaller fish, the fish screen used in the routine counts was lined with a 0.5 mm Nitex net. Larval fish from the TFCF were identified to species by TFCF personnel, and larval fish from the SDFPF were identified to the lowest taxa possible by California Dept. of Fish and Wildlife personnel.

## Water Exports

The SWP exported 1.12 billion $m^3$ of water which was a record low and a marked decrease from exports in WY 2013 (2.70 billion $m^3$), WY 2012 (3.25 billion $m^3$), and the record high in WY 2011 (4.90 billion $m^3$) (Figure 1). The CVP exported 1.17 billion $m^3$ of water which was a record low and well below exports in WY 2013 (2.27 billion $m^3$), WY 2012 (2.56 billion $m^3$), and substantially lower than the near record high in WY 2011 (3.13 billion $m^3$). The record low exports at both facilities coincided with 2014 being a critical water year and the third straight year of drought conditions in California. Exports in WY 2013–2014 at both facilities were below the WY 1981–2014 average (3.11 billion $m^3$ at SWP and 2.87 billion $m^3$ at CVP) while WY 2012 exports were near average at SWP and below average at CVP.

The exports of the two water projects generally followed a similar seasonal pattern. Exports at the SWP peaked in November–December 2013, March 2014, and again in August–September 2014 (Figure 2). During these periods, the SWP exported 684.45 million $m^3$, which represented 61.0% of annual export. Exports at the CVP peaked in October–November 2013, March–April 2014, and again in September 2014 (Figure 2). During this period, the CVP exported 790.38 million $m^3$, which represented 67.6% of annual export. CVP monthly exports ranged from 18.28 to 222.39 million $m^3$. SWP monthly exports ranged from 19.79 to million 152.52 $m^3$.

## Total Salvage and Prevalent Species

Total fish salvage (all fish species combined) at the TFCF was a record low at 160,681 (Figure 3). This was

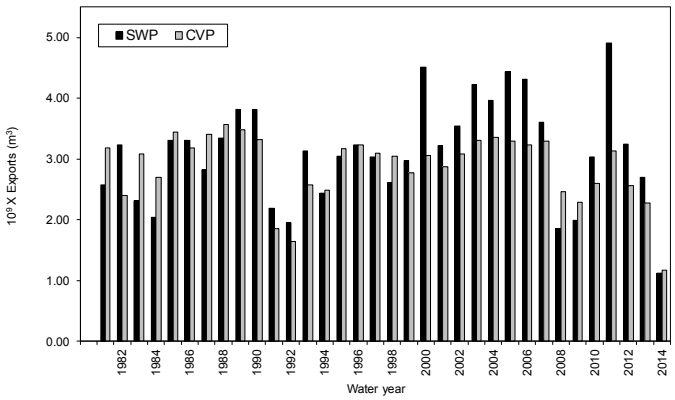


**Figure 1 Annual water exports in billions of cubic meters for the SWP and the CVP, water years 1981 to 2014.**

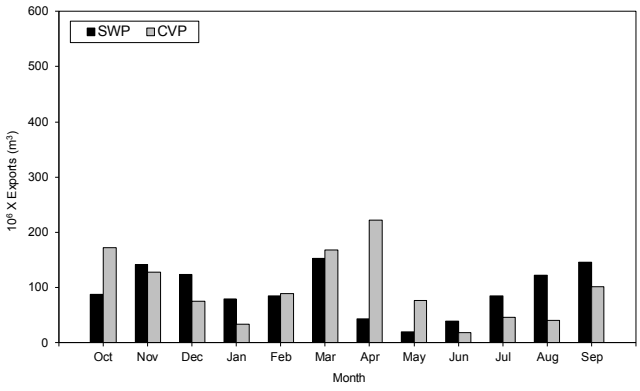


**Figure 2 Monthly water exports in millions of cubic meters for the SWP and the CVP, WY 2014.**

a marked decrease from WY 2013 (2,828,514) and the previous record low in WY 2012 (475,082) (Figure 3). Total fish salvage at the SDFPF was also a record low at 236,846. This was a marked decrease from WY 2013 (3,042,176) and WY 2012 (1,607,286). The record low total fish salvage at both facilities in WY 2014 was most likely affected by record low exports since salvage in recent years has been influenced by exports (i.e. lower salvage at low exports).

Threadfin Shad was the most salvaged species at SDFPF and Bluegill (*Lepomis macrochirus*) was the most salvaged species at TFCF (Figure 4 and Table 1). Bluegill and Inland Silverside (*Menidia beryllina*) were the 2nd and 3rd most salvaged fish at SDFPF, respectively. Threadfin Shad and Largemouth Bass (*Micropterus salmoides*) were the 2nd and 3rd most salvaged fish at TFCF, respectively. Native species comprised 3.2% of total fish salvage at SDFPF and 2.9% of total fish salvage at TFCF. Relatively few Chinook Salmon, Steelhead, Delta Smelt, and Longfin Smelt were salvaged at the SDFPF (< 0.2% combined of total fish salvage) and at the TFCF (< 1.0% combined of total fish salvage).

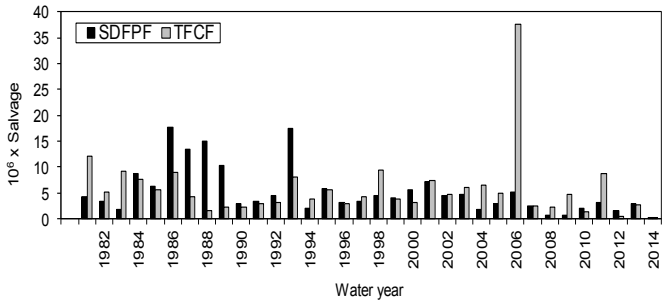


**Figure 3 Annual salvage of all fish taxa combined at the SDFPF and the TFCF, water years 1981 to 2014.**

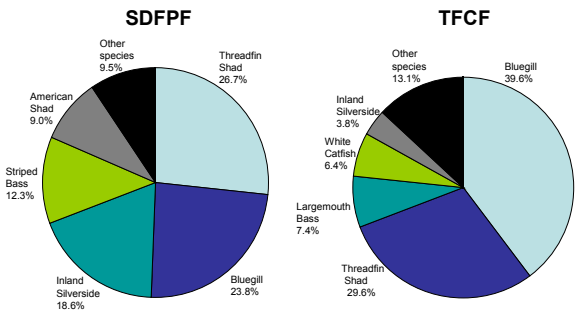


**Figure 4 Percentages of annual salvage for the five most prevalent fish species and other fish species combined at the SDFPF and TFCF, WY 2014.**

**Table 1 Annual fish salvage and percentage of annual fish salvage (%) collected from the SDFPF and TFCF in WY 2014.**

| SDFPF | | | TFCF | | |
|---|---|---|---|---|---|
| ***Species*** | ***Salvage*** | ***%*** | ***Species*** | ***Salvage*** | ***%*** |
| Threadfin Shad | 63,237 | 26.7 | Bluegill | 63,667 | 39.6 |
| Bluegill | 56,458 | 23.8 | Threadfin Shad | 47,603 | 29.6 |
| Inland Silverside | 44,169 | 18.6 | Largemouth Bass | 11,961 | 7.4 |
| Striped Bass | 29,057 | 12.3 | White Catfish | 10,261 | 6.4 |
| American Shad | 21,423 | 9.0 | Inland Silverside | 6,163 | 3.8 |
| Prickly Sculpin | 5,425 | 2.3 | Striped Bass | 5,933 | 3.7 |
| Largemouth Bass | 5,278 | 2.2 | Shimofuri Goby | 4,382 | 2.7 |
| Shimofuri Goby | 5,080 | 2.1 | Prickly Sculpin | 2,494 | 1.6 |
| Pacific Herring | 1,604 | 0.7 | Golden Shiner | 1,367 | 0.9 |
| Common Carp | 1,325 | 0.6 | Chinook Salmon | 1,177 | 0.7 |
| Rainwater Killifish | 974 | 0.4 | American Shad | 1,080 | 0.7 |
| Yellowfin Goby | 873 | 0.4 | Channel Catfish | 972 | 0.6 |
| White Catfish | 533 | 0.2 | Rainwater Killifish | 835 | 0.5 |
| Black Crappie | 482 | 0.2 | Black Crappie | 667 | 0.4 |
| Channel Catfish | 176 | <0.1 | Western Mosquitofish | 389 | 0.2 |
| Western Mosquitofish | 118 | <0.1 | Yellowfin Goby | 352 | 0.2 |
| Golden Shiner | 101 | <0.1 | Rainbow / Steelhead Trout | 330 | 0.2 |
| Rainbow / Steelhead Trout | 84 | <0.1 | Redear Sunfish | 268 | 0.2 |
| Lamprey Unknown | 81 | <0.1 | Pacific Herring | 204 | 0.1 |
| Chinook Salmon | 64 | <0.1 | Threespine Stickleback | 154 | 0.1 |
| Delta Smelt | 62 | <0.1 | Pacific Lamprey | 144 | <0.1 |
| Warmouth | 60 | <0.1 | Black Bullhead | 47 | <0.1 |
| Splittail | 55 | <0.1 | Bigscale Logperch | 35 | <0.1 |
| Threespine Stickleback | 52 | <0.1 | Tule Perch | 35 | <0.1 |
| Longfin Smelt | 32 | <0.1 | Warmouth | 32 | <0.1 |
| Bigscale Logperch | 28 | <0.1 | Brown Bullhead | 30 | <0.1 |
| Redear Sunfish | 6 | <0.1 | Lamprey Unknown | 24 | <0.1 |
| Tule Perch | 4 | <0.1 | Delta Smelt | 16 | <0.1 |
| Sacramento Blackfish | 2 | <0.1 | Splittail | 12 | <0.1 |
| California Roach | 2 | <0.1 | Wakasagi | 12 | <0.1 |
| Starry Flounder | 1 | <0.1 | Longfin Smelt | 8 | <0.1 |
| | | | Pacific Brook Lamprey | 8 | <0.1 |
| | | | Green Sunfish | 7 | <0.1 |
| | | | Sacramento Blackfish | 4 | <0.1 |
| | | | White Crappie | 4 | <0.1 |
| | | | Blue Catfish | 4 | <0.1 |

## Chinook Salmon

Salvages of Chinook Salmon (all races and origins combined) at both facilities continued the low salvage trend since WY 2001 (Figure 5). SDFPF salvage (64) was a record low, which decreased substantially from WY 2013 (3,184) and WY 2012 (1,579). Mean WY 2001–2014 SDFPF salvage was about 9% of the mean salvages in the 1980s and the 1990s. Salvage of Chinook Salmon was also a record low at the TFCF (1,177) and decreased from WY 2013 (4,032) and WY 2012 (1,965). Mean WY 2001–2014 TFCF salvage was about 12% of the mean salvages in the 1980s and the 1990s.

Salvaged Chinook Salmon at the SDFPF were primarily wild winter-run–sized fish, which comprised 80.6% of wild fish. Salvaged Chinook Salmon at the TFCF were primarily wild fall-run–sized fish, which comprised 46.5% of wild fish (Table 2). The majority of wild winter-run fish at the SDFPF were salvaged in March and the majority of wild fall-run fish at the TFCF were salvaged in April (Figure 6).

Loss of Chinook Salmon (all origins and races) was higher at the TFCF (827) than at the SDFPF (278) (Table 2). Normally, greater entrainment loss occurs at the SDFPF than at the TFCF due to greater pre-screen loss (California Dept. of Fish and Game 2006). However, greater loss in WY 2014 at the TFCF was attributable to low numbers of fall-run fish and no spring-run fish salvaged at SDFPF. The low numbers of fall-run fish and no spring-run fish salvaged at SDFPF may have been influenced by low exports at SWP in April and May, whereas exports peaked in April at CVP when the majority of wild fall-run fish were salvaged (Figure 2).

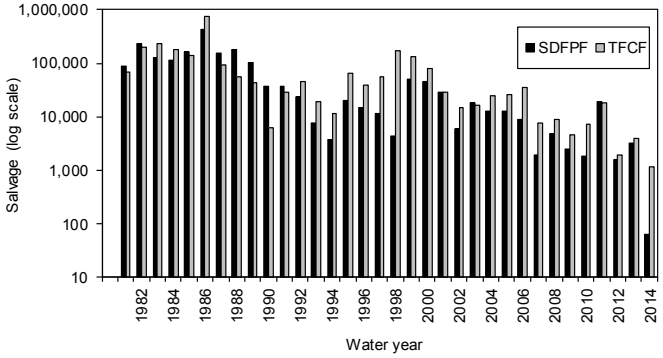


**Figure 5 Annual salvage of Chinook Salmon (all races and wild and hatchery origins combined) at the SDFPF and the TFCF, water years 1981 to 2014. The logarithmic scale is $log_{10}$.**

**Table 2 Chinook Salmon annual salvage, percentage of annual salvage, race and origin (wild or hatchery), and loss at the SDFPF and the TFCF, WY 2014.**

| Facility | Origin | Race | Salvage | Percentage | Loss |
|---|---|---|---|---|---|
| ***SDFPF*** | | | | | |
| | ***Wild*** | | | | |
| | | Fall | 4 | 6.5 | 16 |
| | | Late-fall | 0 | 0.0 | 0 |
| | | Spring | 8 | 12.9 | 33 |
| | | Winter | 50 | 80.6 | 220 |
| | ***Total Wild*** | | ***62*** | | ***269*** |
| | ***Hatchery*** | | | | |
| | | Fall | 0 | 0.0 | 0 |
| | | Late-fall | 0 | 0.0 | 0 |
| | | Spring | 0 | 0.0 | 0 |
| | | Winter | 2 | 100.0 | 9 |
| | ***Total Hatchery*** | | ***2*** | | ***9*** |
| | ***Grand Total*** | | ***64*** | | ***278*** |
| ***TFCF*** | | | | | |
| | ***Wild*** | Fall | 540 | 46.5 | 385 |
| | | Late-fall | 0 | 0.0 | 0 |
| | | Spring | 476 | 41.0 | 313 |
| | | Winter | 141 | 12.2 | 118 |
| | | Unknown Race | 4 | 0.3 | * |
| | ***Total Wild*** | | ***1,161*** | | ***816*** |
| | ***Hatchery*** | | | | |
| | | Fall | 0 | 0.0 | 0 |
| | | Late-fall | 0 | 0.0 | 0 |
| | | Spring | 12 | 75.0 | 8 |
| | | Winter | 4 | 25.0 | 3 |
| | ***Total Hatchery*** | | ***16*** | | ***11*** |
| | ***Grand Total*** | | ***1,177*** | | ***827*** |

* No length was taken for Chinook Salmon and consequently race and loss could not be determined.

## Steelhead

Salvage of Steelhead (wild and hatchery origins combined) continued the pattern of low salvage observed since WY 2005 (Figure 7). Salvage at the SDFPF (84) was a record low and substantially lower than in WY 2013 (861). Salvage at the TFCF (330) was also lower than in WY 2013 (646).

The SDFPF salvaged 47 hatchery Steelhead and 37 wild Steelhead. The TFCF salvaged 183 hatchery Steelhead and 147 wild Steelhead. Salvage of wild Steelhead at both facilities peaked around the middle of the water year (Figure 8). Wild Steelhead were salvaged most frequently in March at the SDFPF and in April at the TFCF.

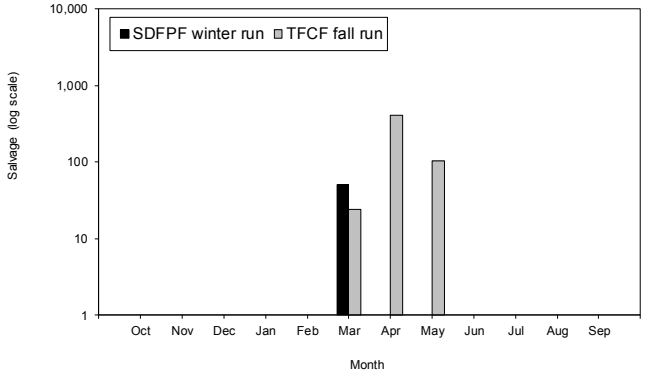


**Figure 6 Monthly salvage of wild, winter-run Chinook Salmon at the SDFPF and wild, fall-run Chinook Salmon at the TFCF, WY 2014. The logarithmic scale is $\log_{10}$.**

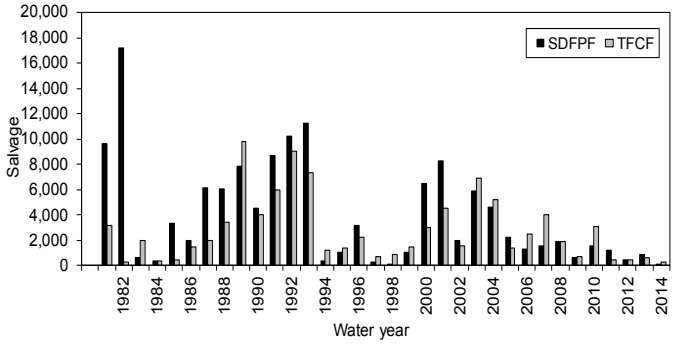


**Figure 7 Annual salvage of Steelhead (wild and hatchery origins combined) at the SDFPF and the TFCF, water years 1981 to 2014.**

## Striped Bass

Salvage at the SDFPF (29,057) and the TFCF (5,933) were both record lows. Salvage at the SDFPF and the TFCF continued the generally-low trend observed since the mid-1990s (Figure 9). Prior to WY 1995, annual Striped Bass salvages were generally above 1,000,000 fish.

Most Striped Bass salvage at the SDFPF occurred in October–November and in June (Figure 10). Most Striped Bass salvage at the TFCF occurred from May–July. Salvage at the SDFPF in October (9,490), November (7,993), and June (4,166) accounted for 74.5% of annual salvage. At the TFCF, salvage in May (3,082), June (1,543), and July (550) accounted for 87.2% of annual salvage. Striped Bass was salvaged every month at both facilities, with the lowest monthly salvage occurring in September at the SDFPF (46) and in December at the TFCF (9).

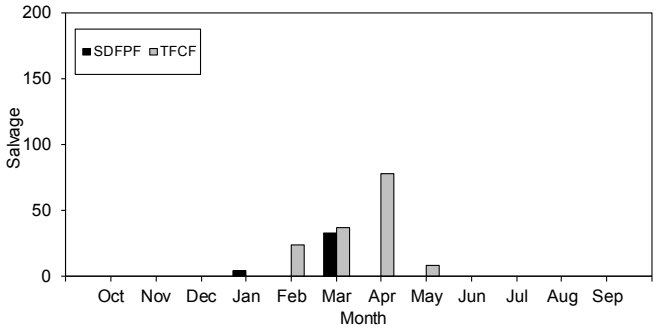


**Figure 8 Monthly salvage of wild Steelhead at the SDFPF and the TFCF, WY 2014.**

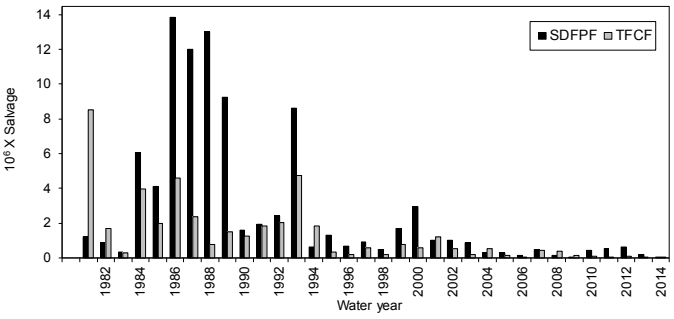


**Figure 9 Annual salvage of Striped Bass at the SDFPF and the TFCF, water years 1981 to 2014.**

## Delta Smelt

Salvage of Delta Smelt continued the pattern of mostly low salvage observed since WY 2005 (Figure 11). Salvage at the TFCF (16) was a record low and decreased from WY 2013 (300) and the previous record low from WY 2011 (51). Salvage at the SDFPF (62) decreased markedly from WY 2013 (1,701) and increased slightly from the record low in WY 2011 (0).

No adult Delta Smelt were salvaged at either facility. Juvenile Delta Smelt at SDFPF were salvaged in April–May, where May salvage (42) accounted for 67.7% of the total WY salvage (Figure 12). Juvenile Delta Smelt at TFCF were also salvaged in April–May, where May salvage (12) accounted for 75.0% of the total WY salvage.

Delta Smelt less than 20 mm FL were first detected at the SDFPF on April 2 and were observed on 10 days of monitoring (Table 3). The longest periods of consecutive daily detections were April 18–19 and April 21–22. April was also the only month with < 20 mm FL detections.

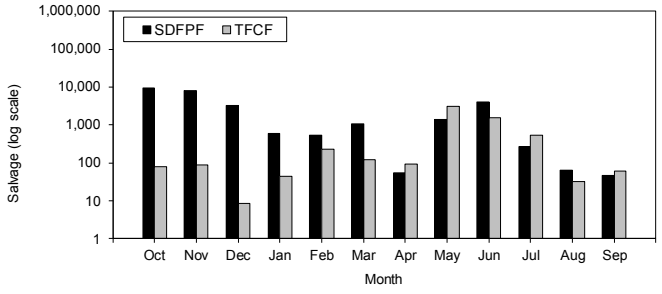


**Figure 10 Monthly salvage of Striped Bass at the SDFPF and the TFCF, WY 2014. The logarithmic scale is $log_{10}$.**

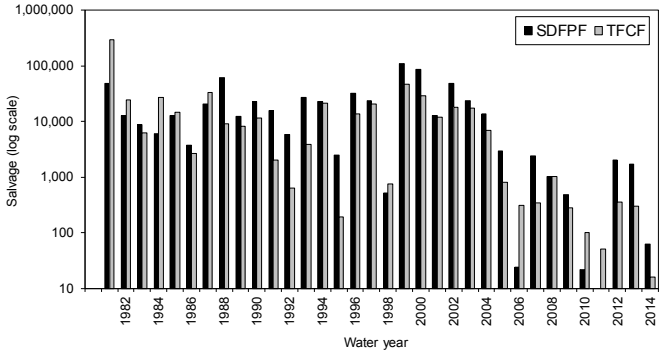


**Figure 11 Annual salvage of Delta Smelt at the SDFPF and the TFCF, water years 1981 to 2014. The logarithmic scale is $log_{10}$.**

Delta Smelt less than 20 mm FL were first detected at the TFCF on April 19 and were observed on 5 days of monitoring (Table 3). The longest periods of consecutive daily detections were April 24–25 and May 2–3. April recorded the most daily detections (3 days).

## Longfin Smelt

Salvage at the SDFPF (32) decreased from WY 2013 (659) but increased from the record low in WY 2011 (0) (Figure 13). Salvage at the TFCF (8) also decreased from WY 2013 (241) but increased slightly from WY 2011 (4).

Longfin Smelt was salvaged in February–March at the SDFPF (Figure 14). March salvage (28) accounted for 87.5% of the total WY salvage. Longfin Smelt was only salvaged in April at the TFCF which accounted for 100.0% of the total WY salvage.

Longfin Smelt less than 20 mm FL were first detected at the SDFPF on February 24 and were observed on 13 days of monitoring (Table 3). The longest period of consecutive daily detections was from February 24–March 1. March recorded the most daily detections (8 days).

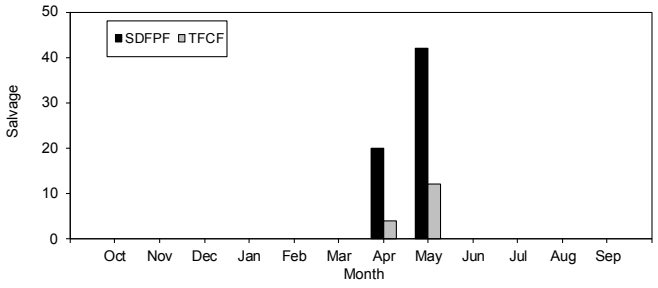


**Figure 12 Monthly salvage of Delta Smelt at the SDFPF and the TFCF, WY 2014.**

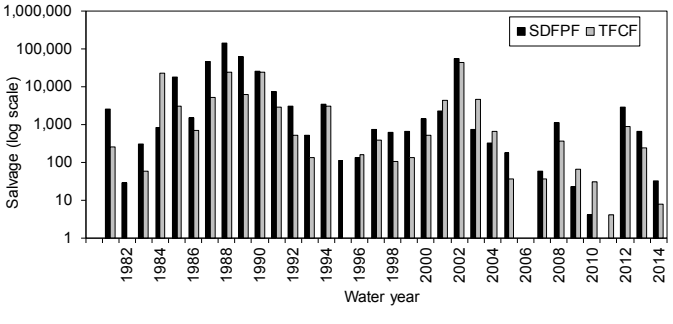


**Figure 13 Annual salvage of Longfin Smelt at the SDFPF and the TFCF, water years 1981 to 2014. The logarithmic scale is $log_{10}$.**

**Table 3 Smelt less than 20 mm fork length (FL) observed in larval samples collected from the SDFPF and the TFCF in WY 2014. Daily numbers of Delta Smelt and Longfin Smelt < 20 mm FL are recorded while an "N" indicates no detection. An "NS" indicates no sampling.**

| | *SDFPF* | | *TFCF* | |
|---|---|---|---|---|
| *DATE* | *Delta Smelt larvae* | *Longfin Smelt larvae* | *Delta Smelt larvae* | *Longfin Smelt larvae* |
| 2/24/2014 | N | 7 | NS | NS |
| 2/25/2014 | N | 2 | NS | NS |
| 2/26/2014 | N | 3 | NS | NS |
| 2/27/2014 | N | 1 | NS | NS |
| 2/28/2014 | N | 4 | NS | NS |
| 3/1/2014 | N | 3 | NS | NS |
| 3/3/2014 | N | 1 | NS | NS |
| 3/5/2014 | N | 1 | NS | NS |
| 3/7/2014 | N | 3 | NS | NS |
| 3/10/2014 | N | 1 | NS | NS |
| 3/19/2014 | N | 1 | N | N |
| 3/20/2014 | N | 1 | N | N |
| 3/25/2014 | N | 2 | N | N |
| 4/2/2014 | 1 | N | N | N |
| 4/12/2014 | 5 | N | N | N |
| 4/13/2014 | N | N | N | 1 |
| 4/14/2014 | 1 | N | N | N |
| 4/16/2014 | 2 | N | N | N |
| 4/18/2014 | 2 | N | N | N |
| 4/19/2014 | 1 | N | 1 | N |
| 4/21/2014 | 1 | N | N | 1 |
| 4/22/2014 | 2 | N | N | N |
| 4/24/2014 | N | N | 1 | N |
| 4/25/2014 | N | N | 1 | N |
| 4/28/2014 | 1 | N | N | N |
| 4/30/2014 | 4 | N | N | N |
| 5/2/2014 | N | N | 1 | N |
| 5/3/2014 | N | N | 2 | N |

Longfin Smelt less than 20 mm FL were first detected at the TFCF on April 13 and were observed on 2 days of monitoring (Table 3). April was also the only month with < 20 mm FL detections.

## Splittail

Annual salvages of Splittail at both facilities were lower than in WY 2013 (Figure 15). Salvage at the TFCF was a record low (12), which was substantially lower than the previous record-low in WY 2013 (125) and the record high in WY 2011 (7,660,024). Salvage at the SDFPF was a record low (55), which was substantially lower than the previous record-low in WY 2013 (329) and the near record high in WY 2011 (1,326,065). Annual Splittail salvages have followed a boom-or-bust pattern, often varying year to year by several orders of magnitude.

## Threadfin Shad

Annual salvage at the SDFPF (63,237) was slightly higher than at the TFCF (47,603) and both were record low salvages (Figure 16). Salvage at the SDFPF was much lower than in WY 2013 (2,535,117). Similarly, TFCF salvage was much lower than in WY 2013 (2,463,695). Similar to Splittail, annual salvages of Threadfin Shad have varied greatly through time.

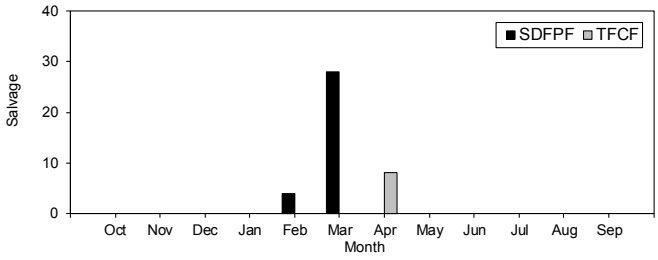


**Figure 14 Monthly salvage of Longfin Smelt at the SDFPF and the TFCF, WY 2014.**

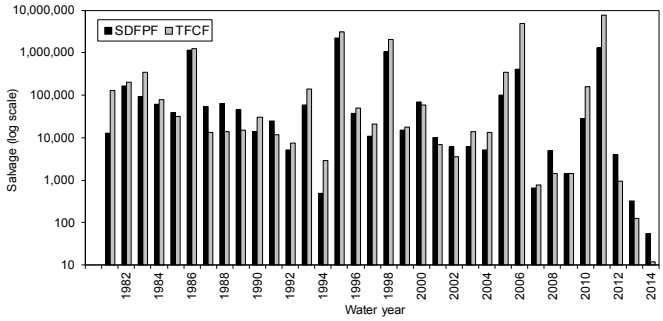


**Figure 15 Annual salvage of Splittail at the SDFPF and the TFCF, water years 1981 to 2014. The logarithmic scale is $log_{10}$.**

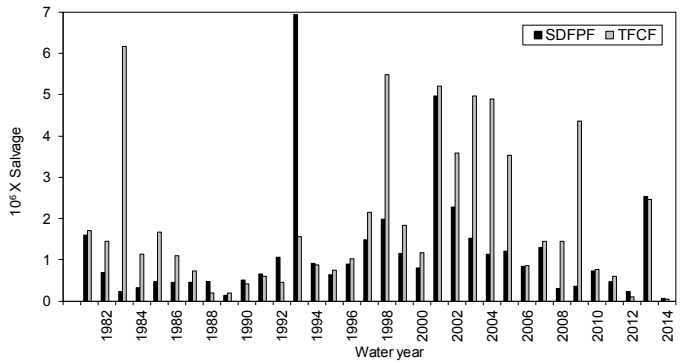


**Figure 16 Annual salvage of Threadfin Shad at the SDFPF and the TFCF, water years 1981 to 2014.**

### References

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# Delta Smelt refuge population: 2014 update and five-year trends in phenotypic traits

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### Background

The University of California, Davis (UC Davis) Fish Conservation & Culture Laboratory (FCCL), in collaboration with the Genomic Variation Laboratory (GVL) of UC Davis, has maintained a refuge population of Delta Smelt (*Hypomesus transpacificus*) for seven generations (Fisch et al. 2009, 2010; Nagel et al. 2013; Lindberg et al. 2013; Ghebremariam et al. 2013). The refuge population was created in 2008 in response to the rapid decline of Delta Smelt abundance estimates. The main goals of the breeding program are to maintain a viable population of Delta Smelt, in captivity, that is phenotypically and genetically identical to the wild population, and to provide Delta Smelt for state and federal research programs and grants. These goals are attained, in part, with intensive genetic monitoring and management (Fisch et al. 2009). In addition, the FCCL collects phenotype information during spawning to detect and monitor any phenotypic changes in the refuge population over time. This article highlights the Delta Smelt breeding program in 2014 and discusses phenotypic (body weight, fork length, and egg number) and genotypic differences between and within the cultured and wild (wild caught and subsequently hatchery reared) Delta Smelt populations.

### Spawning and larval survival 2010–2013

The FCCL has developed rearing methods and techniques for the cultured and wild Delta Smelt (Fisch et al. 2009, 2010; Nagel et al. 2013; Lindberg et al. 2013; and Ghebremariam et al. 2013). To maintain the refuge population, approximately 260 pair crosses are made each year between individual males and females. The progeny of one pair cross are full-siblings (FSG). Eggs from approximately eight FSGs are combined in equal numbers to form a "multi-family group" (MFG), which will be hatched and raised together until the following spawning season. In previous years, FSGs consisted of 750 eggs. However in 2014, due to improvements in larval survival over years (Figure 1), the number of eggs was reduced to 700/FSG. With good larval survival, the juvenile thinning introduced in the last two years has resulted in better fish growth and survival.

### Tagging fin-clipping the adult fish

Starting two weeks before and continuing throughout the spawning season, tanks are sorted to find adults that are "ripe" (ready or nearly-ready to spawn). The refuge population becomes mature roughly in the order