



# ***IEP NEWSLETTER***

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## Fish Salvage at the State Water Project’s and Central Valley Project’s Fish Facilities during the 2016 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 (Delta) located in Byron, California (Aasen 2013). Both facilities use louver-bypass systems to divert fish from the exported water. The salvaged 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 2016 water year (WY) salvage information from the TFCF and the SDFPF, and examines data from water years (WYs) 1981 to 2016 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<sup>1</sup> (*Morone saxatilis*), Delta Smelt<sup>1</sup> (*Hypomesus transpacificus*), Longfin Smelt<sup>1</sup> (*Spirinchus thaleichthys*), Splittail (*Pogonichthys macrolepidotus*), and Threadfin Shad<sup>11</sup> (*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 30 minutes (= 24.75 minutes, standard deviation [sd] = 9.85) at the SDFPF and generally once every 2 hours for 10 to

1 Pelagic Organism Decline (POD) species

60 minutes (= 29.99, sd = 0.72) at the TFCF. Fish 20-mm fork length (FL) or larger were identified, counted, 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, 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 is the estimated number of juvenile Chinook Salmon entrained by the facility minus the number of Chinook Salmon that survive salvage operations (California Department 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 classification 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 Department of Fish and Wildlife 2014). This table was created by the U.S. Fish and Wildlife Service, who 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 (Matt Dekar, personal communication<sup>2</sup>). Nevertheless, 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 less than 20 mm FL. Larval sampling at the SDFPF ran from March 1 through June 8 and from March 1 through June 7 at the TFCF. Larval samples were collected once for every six 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 Department of Fish and Wildlife personnel.

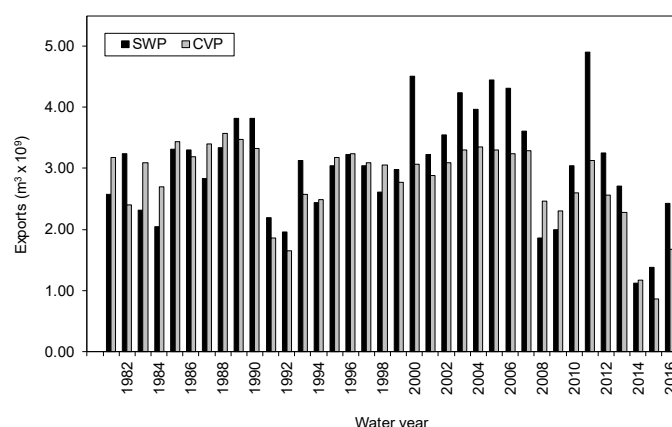
<sup>2</sup> Dekar, M. 2015. U.S. Fish and Wildlife Service.

## Water Exports

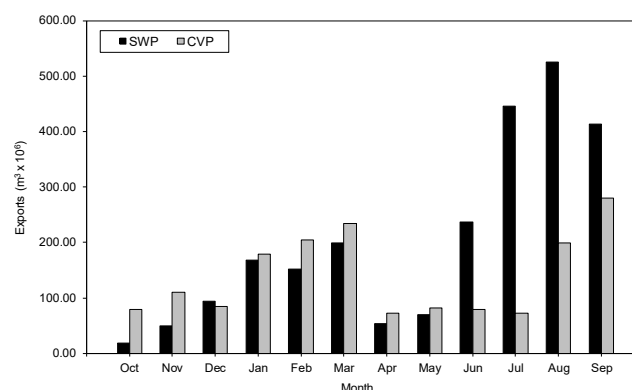
The SWP exported 2.43 billion cubic meters (m<sup>3</sup>) of water, an increase from WY 2015 (1.38 billion m<sup>3</sup>) and the record low exports in WY 2014 (1.12 billion m<sup>3</sup>), but a decrease from the record high in WY 2011 (4.91 billion m<sup>3</sup>) (Figure 1). The CVP exported 1.68 billion m<sup>3</sup> of water, an increase from the record low in WY 2015 (0.86 billion m<sup>3</sup>) and WY 2014 (1.17 billion m<sup>3</sup>), but lower than WY 2011 (3.13 billion m<sup>3</sup>). The increased exports at both facilities coincided with increased rainfall compared to WYs 2014 and 2015. Both of which were critical water years occurring at the end of a 4-year drought. Exports in WY 2016 at both facilities were below the WYs 1981–2015 average (3.07 billion m<sup>3</sup> at SWP and 2.82 billion m<sup>3</sup> at CVP).

Exports at the SWP peaked July through September 2016 (Figure 2). During this period, the SWP exported

**Figure 1 Annual water exports in billions of cubic meters for the SWP and the CVP, WYs 1981 to 2016.**



**Figure 2 Monthly water exports in millions of cubic meters for the SWP and the CVP, WY 2016.**



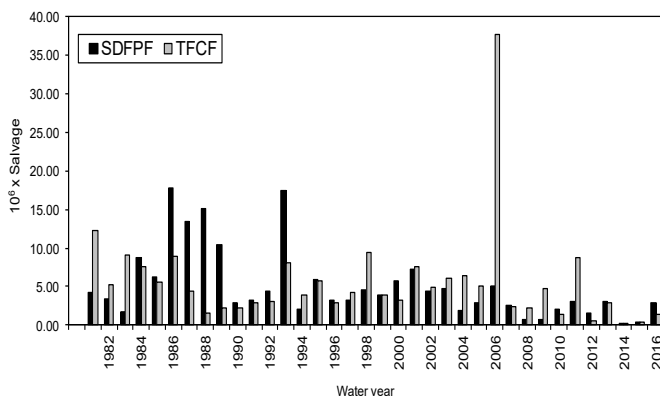
1.39 billion m<sup>3</sup>, which represented 57.1 percent of annual export. Exports at the CVP were higher in the months of January through March and August through September 2016. The cumulative water export for those months was 1.10 billion m<sup>3</sup>, which represented 65.4 percent of the annual export. SWP monthly exports ranged from 18.67 to 526.12 million m<sup>3</sup>. CVP monthly exports ranged from 72.99 to 280.40 million m<sup>3</sup>.

### Total Salvage and Prevalent Species

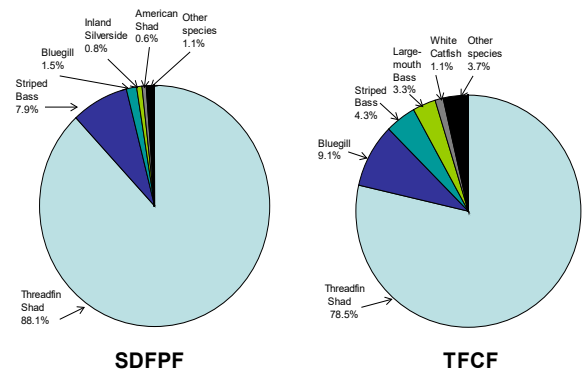
Total fish salvage (all fish species combined) at the SDFPF was 2,832,631 (Figure 3). This was a large increase from WY 2015 (347,882) and the record low in WY 2014 (236,846), but below WY 2013 (3,042,176). Total fish salvage at the TFCF was 1,437,551. This was a large increase from WY 2015 (295,854) and the record low in WY 2014 (160,681), but below WY 2013 (2,828,514). The marked increase in total fish salvage at both facilities in WY 2016 was most likely affected by an increase in exports since salvage in recent years has been influenced by exports (i.e., higher salvage at higher exports).

Threadfin Shad was the most-salvaged species at both the SDFPF and TFCF (Figure 4 and Table 1). Striped Bass and Bluegill (*Lepomis macrochirus*) were the 2nd and 3rd most-salvaged fish at SDFPF, respectively. Bluegill and Striped Bass were the 2nd and 3rd most-salvaged fish at TFCF, respectively. Native species comprised 0.2 percent of total fish salvage at SDFPF and 0.7 percent of total fish salvage at TFCF. Relatively few Chinook Salmon, Steelhead, Delta Smelt, and Longfin Smelt were salvaged at the SDFPF (0.04 percent combined of

**Figure 3 Annual salvage of all fish taxa combined at the SDFPF and the TFCF, WYs 1981 to 2016.**



**Figure 4 Percentages of annual salvage for the five most prevalent fish species and other fish species combined at the SDFPF and TFCF, WY 2016.**



total fish salvage) and at the TFCF (0.11 percent). These percentages represent a decrease for both facilities from WY 2015 (0.22 percent) and WY 2014 (0.10 percent) at the SDFPF and WY 2015 (0.14 percent) and WY 2014 (0.95 percent) at the TFCF.

### Chinook Salmon

Annual salvage estimates of Chinook Salmon (all races and origins combined) at both facilities continued the low salvage trend since WY 2001 (Figure 5). SDFPF salvage of juvenile and large (> 300 mm FL) Chinook Salmon (362) increased from WY 2015 (221) and increased from the record low in WY 2014 (64). Mean salvage for Chinook Salmon in WYs 2001–2016 at SDFPF was only 8.2 percent of the mean salvage in WYs 1981–2000. Salvage of juvenile and large Chinook Salmon at the TFCF (970) was a large increase from the record low in WY 2015 (187), but decreased slightly from WY 2014 (1,177). Mean WYs 2001–2016 TFCF salvage was only 10.3 percent of the mean salvage in WYs 1981–2000.

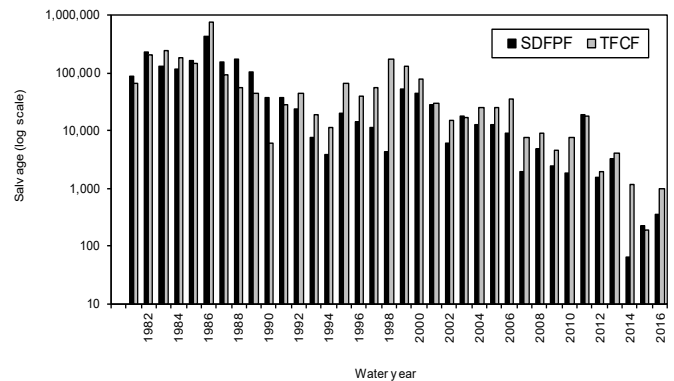
Salvaged Chinook Salmon at the SDFPF were primarily hatchery winter-run sized fish, which comprised 56.2 percent of hatchery fish, but only 33.3 percent of all salmon salvaged (Table 2). Salvaged Chinook Salmon at the TFCF were primarily hatchery spring-run sized fish, which comprised 83.0 percent of hatchery fish. The majority of hatchery winter-run fish at the SDFPF were salvaged in January while the majority of hatchery spring-run fish at the TFCF were salvaged in March.

Wild Chinook Salmon at both facilities were primarily spring-run sized fish, which comprised 34.9 percent of wild

**Table 1 Annual fish salvage and percentage of annual fish salvage (%) collected from the SDFPF and TFCF in WY 2016.**

<i>SDFPF</i>			<i>TFCF</i>		
<i>Species</i>	<i>Salvage</i>	<i>%</i>	<i>Species</i>	<i>Salvage</i>	<i>%</i>
Threadfin Shad	2,494,795	88.1	Threadfin Shad	1,127,956	78.5
Striped Bass	224,967	7.9	Bluegill	131,079	9.1
Bluegill	41,665	1.5	Striped Bass	61,787	4.3
Inland Silverside	22,297	0.8	Largemouth Bass	47,736	3.3
American Shad	16,878	0.6	White Catfish	15,165	1.1
Shimofuri Goby	12,052	0.4	Inland Silverside	11,223	0.8
Largemouth Bass	6,889	0.2	Shimofuri Goby	8,443	0.6
White Catfish	3,710	0.1	Rainwater Killifish	6,869	0.5
Prickly Sculpin	2,665	<0.1	Golden Shiner	4,985	0.3
Splittail	1,951	<0.1	American Shad	4,553	0.3
Bigscale	1,555	<0.1	Pacific Lamprey	2,418	0.2
Logperch			Lamprey Unknown	2,356	0.2
Black Crappie	1,268	<0.1	Prickly Sculpin	2,069	0.1
Steelhead	789	<0.1	Channel Catfish	1,859	0.1
Chinook Salmon	362	<0.1	Western Mosquitofish	1,776	0.1
Lamprey Unknown	196	<0.1	Redear Sunfish	1,381	0.1
Channel Catfish	191	<0.1	Black Crappie	1,208	<0.1
Yellowfin Goby	123	<0.1	Chinook Salmon	970	<0.1
Golden Shiner	115	<0.1	Red Shiner	886	<0.1
Western Mosquitofish	36	<0.1	Sacramento Sucker	661	<0.1
Rainwater Killifish	34	<0.1	Steelhead	652	<0.1
Redear Sunfish	16	<0.1	Yellowfin Goby	532	<0.1
Common Carp	12	<0.1	Bigscale Logperch	277	<0.1
Black Bullhead	11	<0.1	Threespine Stickleback	217	<0.1
Delta Smelt	8	<0.1	Splittail	109	<0.1
Green Sunfish	6	<0.1	Warmouth	96	<0.1
Starry Flounder	6	<0.1	Black Bullhead	58	<0.1
Goldfish	4	<0.1	Brown Bullhead	36	<0.1
Green Sturgeon	4	<0.1	Green Sunfish	36	<0.1
Spotted Bass	4	<0.1	Striped Mullet	28	<0.1
Striped Mullet	4	<0.1	Spotted Bass	20	<0.1
White Crappie	4	<0.1	River Lamprey	16	<0.1
Shokihaze Goby	3	<0.1	Shokihaze Goby	16	<0.1
Brown Bullhead	2	<0.1	Smallmouth Bass	16	<0.1
Hitch	2	<0.1	Delta Smelt	12	<0.1
Longfin Smelt	2	<0.1	Common Carp	8	<0.1
Threespine Stickleback	2	<0.1	Fathead Minnow	8	<0.1
Wakasagi	2	<0.1	Longfin Smelt	8	<0.1
Tule Perch	1	<0.1	Sacramento Blackfish	8	<0.1
			Starry Flounder	8	<0.1
			Pacific Staghorn Sculpin	4	<0.1
			Tule Perch	4	<0.1
			White Crappie	2	<0.1

**Figure 5 Annual salvage of Chinook Salmon (all races and wild and hatchery origins combined) at the SDFPF and the TFCF, WYs 1981 to 2016.**



Note: The logarithmic scale is  $\log_{10}$ .

fish at SDFPF and 47.3 percent at the TFCF (Table 2). The majority of wild spring run fish at both the SDFPF and the TFCF were salvaged in March.

Annual loss of Chinook Salmon (all origins and races) was higher at the SDFPF (1,557) than at the TFCF (680) (Table 2). Greater entrainment loss at the SDFPF than at the TFCF was attributable to greater pre-screen loss.

## Steelhead

Salvage of Steelhead (wild and hatchery origins combined) continued the pattern of low salvage observed since WY 2005 (Figure 6). SDFPF salvage of juvenile and large (> 350 mm FL) Steelhead (789) increased from both WY 2015 (442) and the record low in WY 2014 (84). Juvenile salvage at the TFCF (652) increased from the record low in WY 2015 (124) and WY 2014 (330).

The SDFPF salvaged 731 hatchery Steelhead and 58 wild Steelhead. The TFCF salvaged 591 hatchery Steelhead and 61 wild Steelhead. Salvage of wild Steelhead at both facilities peaked around the middle of the water year (Figure 7). Wild Steelhead were salvaged most frequently in March at both the SDFPF and the TFCF.

## Striped Bass

Salvage of juvenile and sub-adult Striped Bass at the SDFPF (224,967) was a large increase from the record low in WY 2015 (35,070). Salvage at the TFCF (61,787) was also an increase from the near record low in WY 2015 (21,398). Salvage at the SDFPF and the TFCF continued a

**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 2016.**

<i>Facility</i>	<i>Origin</i>	<i>Race</i>	<i>Salvage</i>	<i>%</i>	<i>Loss</i>
<b>SDFPF</b>					
	Wild	Fall	39	27.3	168
		Late-fall	36	25.2	159
		Spring	50	34.9	214
		Winter	8	5.6	35
		Unknown race	10	7.0	*
	Total Wild		143		576
	Hatchery				
		Fall	1	0.5	4
		Late-fall	61	27.8	272
		Spring	34	15.5	147
		Winter	123	56.2	558
	Total Hatchery		219		981
	Grand Total		362		1,557
<b>TFCF</b>					
	Wild	Fall	80	35.1	57
		Late-fall	8	3.6	7
		Spring	108	47.3	83
		Winter	28	12.3	21
		Unknown race	4	1.7	**
	Total Wild		228		168
	Hatchery				
		Fall	4	0.6	3
		Late-fall	32	4.3	26
		Spring	616	83.0	413
		Winter	90	12.1	70
	Total Hatchery		742		512
	Grand Total		970		680

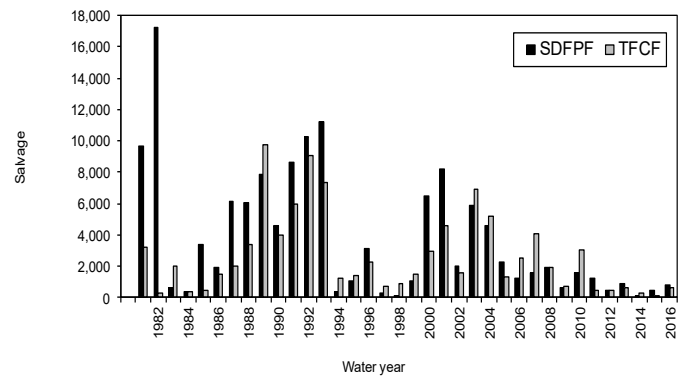
\* No loss was calculated for SDFPF large unknown run Chinook Salmon (n = 2) since they were too large to fit the loss calculation

\*\* No loss was calculated for TFCF large unknown run Chinook Salmon (n = 1) since they were too large to fit the loss calculation

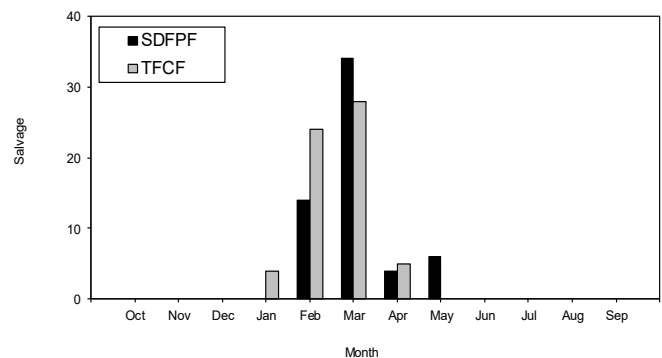
declining trend observed since the mid-1990s (Figure 8). Prior to WY 1995, annual Striped Bass salvage estimates were generally above 1,000,000 fish.

Most Striped Bass salvage at the SDFPF and TFCF occurred in May, June, and July (Figure 9). Salvage at the SDFPF in May (35,773), June (122,761), and July

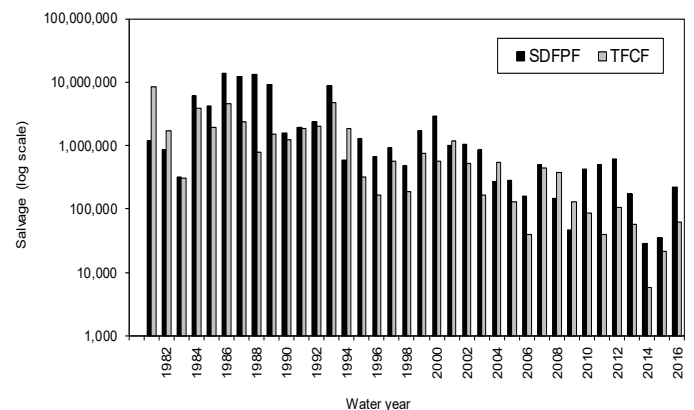
**Figure 6 Annual salvage of Steelhead (wild and hatchery origins combined) at the SDFPF and the TFCF, WYs 1981 to 2016.**



**Figure 7 Monthly salvage of wild Steelhead at the SDFPF and the TFCF, WY 2016.**



**Figure 8 Annual salvage of Striped Bass at the SDFPF and the TFCF, WYs 1981 to 2016.**



Note: The logarithmic scale is log<sub>10</sub>.

(31,635) accounted for 84.5 percent of total WY salvage. At the TFCF, salvage in May (9,463), June (29,894), and July (4,940) accounted for 71.7 percent of total WY salvage. Striped Bass were salvaged every month at both the SDFPF and the TFCF, with the lowest monthly salvages occurring both in October at the SDFPF (51) and at the TFCF (48).

## Delta Smelt

Salvage of Delta Smelt continued the pattern of mostly low salvage observed since WY 2005 (Figure 10). Salvage was a record low at the TFCF (12), which was a decrease from WY 2015 (68), similar to WY 2014 (16), and a large decrease from WY 2013 (300). Salvage at

the SDFPF (8) increased slightly from WY 2015 (4), but decreased from WY 2014 (62) and WY 2013 (1,701).

Salvage of Delta Smelt at both facilities occurred predominantly in winter and spring. Adult Delta Smelt at SDFPF were only salvaged in February (4). Juvenile Delta Smelt at SDFPF were only salvaged in April (4). Adult Delta Smelt at TFCF were salvaged equally in January (4) and February (4). Juvenile Delta Smelt at TFCF were only salvaged in April (4).

No Delta Smelt less than 20 mm FL were detected at the SDFPF in WY 2016, which was a decrease from WY 2015 (1) and WY 2014 (14). No Delta Smelt less than 20 mm FL were detected at the TFCF in WY 2016, as in WY 2015, which was a decrease from WY 2014 (6).

## Longfin Smelt

Salvage of Longfin Smelt at the SDFPF in WY 2016 (2) decreased from WY 2015 (102), WY 2014 (32) and WY 2013 (659) while salvage at the TFCF (8) was equal to WY 2014 (8), but decreased from WY 2015 (28) and WY 2013 (241) (Figure 11). No adult Longfin Smelt were salvaged at either facility, and juvenile Longfin Smelt were only salvaged in March at the SDFPF (2) and at the TFCF (8).

No Longfin Smelt less than 20 mm FL were detected at the SDFPF in WY 2016 which was a decrease from WY 2015 (13) and WY 2014 (37). Only one Longfin Smelt less than 20 mm FL was detected at the TFCF on March 16th which was a decrease from WY 2015 (5) and WY 2014 (2).

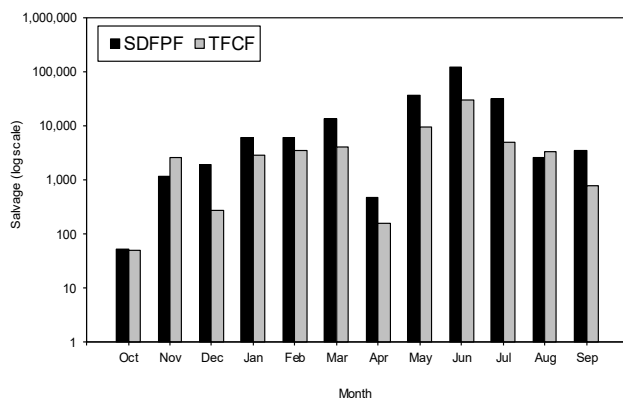
## Splittail

Annual salvage estimates of juvenile and adult Splittail at both facilities were markedly different from each other (Figure 12). Salvage at the TFCF was low (109), but an increase from the record lows in WY 2015 (12) and WY 2014 (12). Salvage at the SDFPF (1,951) was an increase from WY 2015 (656). Annual Splittail salvage estimates have followed a boom-or-bust pattern, often varying year to year by several orders of magnitude.

## Threadfin Shad

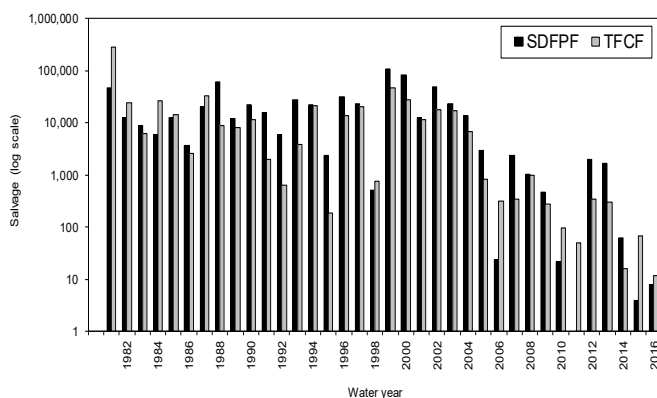
Annual salvage of juvenile and adult Threadfin Shad was higher at the SDFPF (2,494,795) than at the TFCF

**Figure 9 Monthly salvage of Striped Bass at the SDFPF and the TFCF, WY 2016.**



Note: The logarithmic scale is  $\log_{10}$ .

**Figure 10 Annual salvage of Delta Smelt at the SDFPF and the TFCF, WYs 1981 to 2016.**



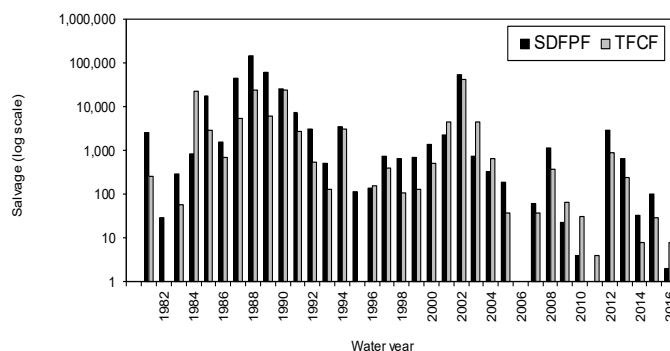
Note: The logarithmic scale is  $\log_{10}$ .

(1,127,956) (Figure 13). Salvage at the SDFPF was substantially higher than WY 2015 (186,368) and the record low in WY 2014 (63,237). Similarly, TFCF salvage was substantially higher than in WY 2015 (114,804) and the record low in WY 2014 (47,603). Similar to Splittail, annual salvage estimates of Threadfin Shad have varied greatly through time.

## References

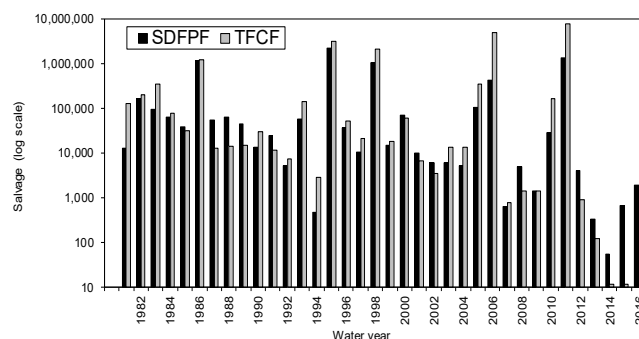
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**Figure 11 Annual salvage of Longfin Smelt at the SDFPF and the TFCF, WYs 1981 to 2016.**



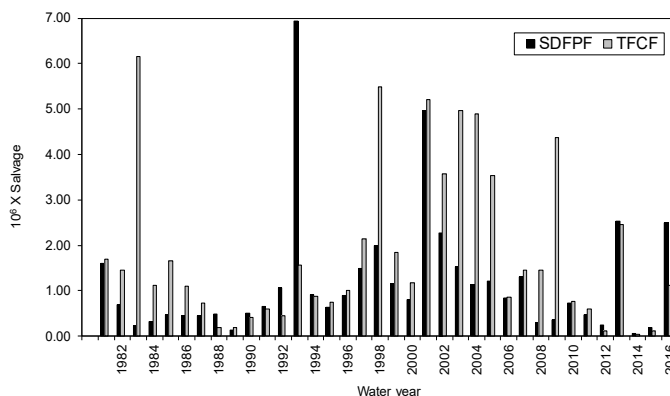
Note: The logarithmic scale is  $\log_{10}$ .

**Figure 12 Annual salvage of Splittail at the SDFPF and the TFCF, WYs 1981 to 2016.**



Note: The logarithmic scale is  $\log_{10}$ .

**Figure 13 Annual salvage of Threadfin Shad at the SDFPF and the TFCF, WYs 1981 to 2016.**



Did you know that quarterly highlights about current IEP science can be found on the IEP webpage along with a new calendar that displays IEP Project Work Team and other IEP-related public meetings? To view these features see the links below:

<http://www.water.ca.gov/iep/activities/calendar.cfm>

<http://www.water.ca.gov/iep/highlights/index.cfm>