Interagency Ecological Program for the San Francisco Estuary

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Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities during the 2015 Water Year

Geir Aasen (CDFW), Geir.Aasen@wildlife.ca.gov

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). 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 2015 water year (WY) (WY 2015 was 10/1/2014–9/30/2015) salvage information from the TFCF and the SDFPF, and examines data from water years 1981–2015 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 one or two hours for 5–60 minutes ($\bar{x}$ = 29.05 minutes, standard deviation (sd) = 4.48) at the SDFPF and once every two hours for 10–45 minutes ($\bar{x}$ = 27.47, sd = 6.65) at the TFCF. Fish with 20 millimeter (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 one- to two-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 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). It 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, see "Notes"). 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 March 2–June 26 and from February 24–June 12 at the TFCF. Larval samples were collected once for every six hours of water export. The 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.

[1] Pelagic Organism Decline (POD) species

Water Exports

The SWP exported 1.38 billion cubic meters (m^3) of water, which was a small increase from the record low exports in WY 2014 (1.12 billion m^3), but a marked decrease from WY 2013 (2.70 billion m^3) and the record high in WY 2011 (4.90 billion m^3) (Figure 1). The CVP exported 0.86 billion m^3 of water, which was a record low and a small decrease in exports from the previous record low in WY 2014 (1.17 billion m^3), and substantially lower than WY 2013 (2.27 billion m^3). The low exports at both facilities coincided with 2015 being a critical water year and the 4th straight year of drought conditions in California. Exports in WY 2015 at both facilities were well below the WYs 1981–2013 average (3.18 billion m^3 at SWP and 2.92 billion m^3 at CVP).

Exports at the SWP peaked from December 2014 through February 2015 (Figure 2). During this period, the SWP exported 887.03 million m^3, which represented 64.2 percent of annual export. Exports at the CVP were markedly higher in the months of December, 2014; March, 2015; and September, 2015. The cumulative water export for those months was 397.37 million m^3, which represented 46.3 percent of the annual export. CVP monthly exports ranged from 23.19 to 168.00 million m^3. SWP monthly exports ranged from 20.90 to 320.58 million m^3.

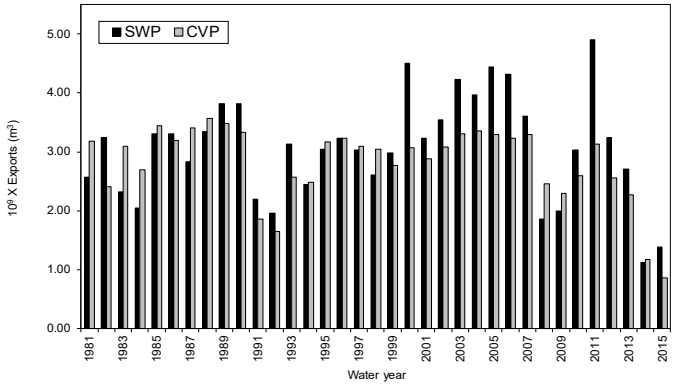

Figure 1 Annual water exports in billions of cubic meters for the SWP and the CVP, WYs 1981 to 2015.

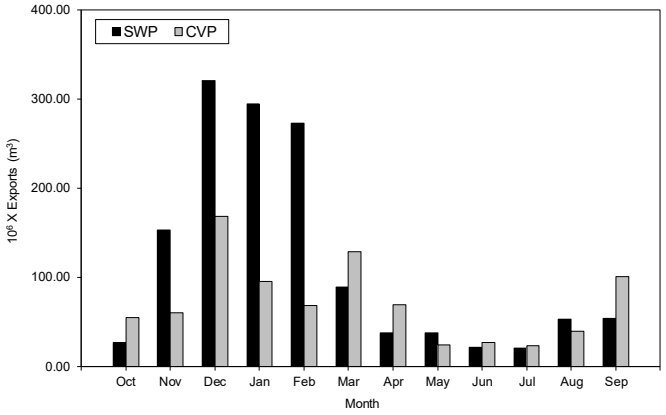

Figure 2 Monthly water exports in millions of cubic meters for the SWP and the CVP, WY 2015.

Total Salvage and Prevalent Species

Total fish salvage (all fish species combined) at the SDFPF was a near-record low at 347,882 (Figure 3). This was a marked increase from the record low in WY 2014 (236,846), but well below WY 2013 (3,042,176) and WY 2012 (1,607,286). Total fish salvage at the TFCF was low at 295,854. This was an increase from the record low in WY 2014 (160,681), but well below WY 2013 (2,828,514) and WY 2012 (475,082) (Figure 3). The low and near-record low total fish salvage at both facilities in WY 2014–2015 were most likely affected by low or near-record low exports, as salvage in recent years has been influenced by exports (i.e., lower salvage at low exports).

Threadfin Shad was the most-salvaged species at both the SDFPF and TFCF (Figure 4 and Table 1). Bluegill (*Lepomis macrochirus*) and Striped Bass were the 2nd and 3rd most-salvaged fish at SDFPF, respectively. Bluegill and Striped Bass were also the 2nd and 3rd most-salvaged fish at TFCF, respectively. Native species comprised 1.1 percent of total fish salvage at SDFPF and 1.3 percent of total fish salvage at TFCF. Relatively few Chinook Salmon, Steelhead, Delta Smelt, and Longfin Smelt were

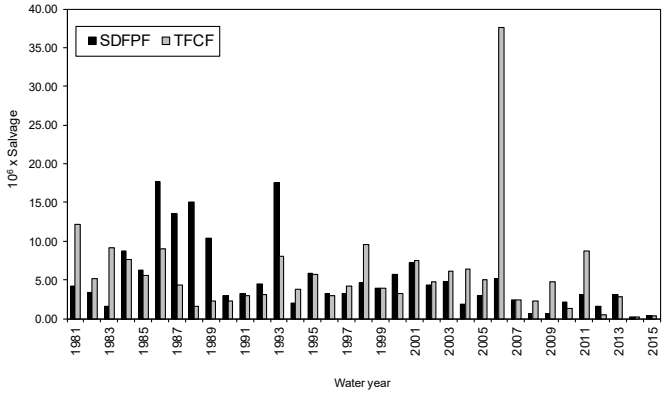

Figure 3 Annual salvage of all fish taxa combined at the SDFPF and the TFCF, WYs 1981 to 2015.

Table 1 Annual fish salvage and percentage of annual fish salvage (%) collected from the SDFPF and TFCF in WY 2015.

SDFPF			TFCF		
Species	***Salvage***	***%***	***Species***	***Salvage***	***%***
Threadfin Shad	186,368	53.6	Threadfin Shad	114,804	38.8
Bluegill	78,532	22.6	Bluegill	107,883	36.5
Striped Bass	35,070	10.1	Striped Bass	21,398	7.2
Inland Silverside	18,349	5.3	Shimofuri Goby	11,467	3.9
American Shad	15,299	4.4	Largemouth Bass	11,278	3.8
Largemouth Bass	2,953	0.8	White Catfish	7,979	2.7
Shimofuri Goby	2,371	0.7	Inland Silverside	4,187	1.4
Prickly Sculpin	2,298	0.7	American Shad	3,384	1.1
Rainwater Killifish	1,773	0.5	Prickly Sculpin	2,836	1
Bigscale Logperch	937	0.3	Rainwater Killifish	2,240	0.8
Black Crappie	777	0.2	Yellowfin Goby	1,545	0.5
Yellowfin Goby	674	0.2	Channel Catfish	1,276	0.4
Splittail	656	0.2	Golden Shiner	1,232	0.4
Steelhead	442	0.1	Redear Sunfish	949	0.3
White Catfish	298	<0.1	Western Mosquitofish	837	0.3
Golden Shiner	286	<0.1	Black Crappie	808	0.3
Chinook Salmon	221	<0.1	Black Bullhead	324	0.1
Western Mosquitofish	151	<0.1	Pacific Lamprey	265	<0.1
Longfin Smelt	102	<0.1	Chinook Salmon	187	<0.1
Channel Catfish	84	<0.1	Brown Bullhead	172	<0.1
Lamprey Unknown	82	<0.1	Threespine Stickleback	164	<0.1
Common Carp	77	<0.1	Bigscale Logperch	148	<0.1
Redear Sunfish	34	<0.1	Steelhead	124	<0.1
Green Sunfish	15	<0.1	Striped Mullet	88	<0.1
Sacramento Blackfish	15	<0.1	Delta Smelt	68	<0.1
Threespine Stickleback	7	<0.1	Warmouth	48	<0.1
Shokihaze Goby	4	<0.1	Green Sunfish	32	<0.1
Delta Smelt	4	<0.1	Lamprey Unknown	31	<0.1
Tule Perch	2	<0.1	Longfin Smelt	28	<0.1
Riffle Sculpin	1	<0.1	Red Shiner	24	<0.1
			Pacific Staghorn Sculpin	12	<0.1
			Splittail	12	<0.1
			Starry Flounder	12	<0.1
			River Lamprey	4	<0.1
			Tule Perch	4	<0.1
			White Crappie	4	<0.1

salvaged at the SDFPF (0.22 percent of combined total fish salvage), which was an increase from WY 2014 (0.10 percent) and approximately equal to WY 2013 (0.21 percent). Relatively few Chinook Salmon, Steelhead, Delta Smelt, and Longfin Smelt were salvaged at the TFCF (0.14 percent of combined total fish salvage), which was a decrease from WY 2014 (0.95 percent) and WY 2013 (0.18 percent).

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 sub-adult Chinook Salmon (221) increased considerably from the record low in WY 2014 (64), but was a marked decrease from WY 2013 (3,184). Mean salvage for Chinook Salmon in WYs 2001–2015 at SDFPF was only 8.7 percent of the mean salvage in WYs 1981–2000. Salvage of juvenile Chinook Salmon was a record low at the TFCF (187) and markedly decreased from the previous record low in WY 2014 (1,177) and WY 2013 (4,032). Mean WYs 2001–2015 TFCF salvage was only 11.0 percent of the mean salvage in WYs 1981–2000.

Salvaged Chinook Salmon at the SDFPF were primarily hatchery late-fall-run sized fish, which comprised 39.3 percent of hatchery fish. Salvaged Chinook Salmon at the TFCF were also primarily hatchery late-fall-run sized fish, which comprised 75.0 percent of hatchery fish (Table 2). The majority of hatchery late-fall-run fish at the SDFPF and the TFCF were salvaged in December (Figure 6).

Annual loss of Chinook Salmon (all origins and races) was higher at the SDFPF (822) than at the TFCF (148) (Table 2). Greater entrainment loss at the SDFPF than at the TFCF was attributable to greater pre-screen loss.

Steelhead

Salvage of juvenile and sub-adult Steelhead (wild and hatchery origins combined) continued the pattern of low salvage observed since WY 2005 (Figure 7). WY 2015 salvage at the SDFPF (442)

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 2015.

Facility	Origin	Race	Salvage	Percentage	Loss
SDFPF					
	Wild				
		Fall	4	6.9	17
		Late-fall	6	10.3	27
		Spring	7	12.1	34
		Winter	17	29.3	75
		Unknown race	24	41.4	*
	Total Wild		58		153
	Hatchery				
		Fall	41	25.2	181
		Late-fall	64	39.3	285
		Spring	0	0.0	0
		Winter	46	28.2	203
		Unknown race	12	7.4	*
	Total Hatchery		163		669
	Grand Total		221		822
TFCF					
	Wild	Fall	12	13.2	9
		Late-fall	0	0.0	0
		Spring	43	47.3	36
		Winter	36	39.6	31
	Total Wild		91		76
	Hatchery				
		Fall	0	0.0	0
		Late-fall	72	75.0	54
		Spring	8	8.3	7
		Winter	16	16.7	11
	Total Hatchery		96		72
	Grand Total		187		148

*No loss was calculated for sub-adult unknown run Chinook Salmon (n=3), since they were too large to fit the loss calculation.

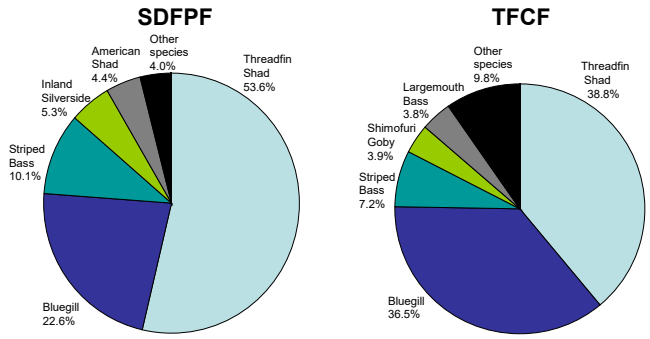

Figure 4 Percentages of annual salvage for the five most prevalent fish species and other fish species combined at the SDFPF and TFCF, WY 2015.

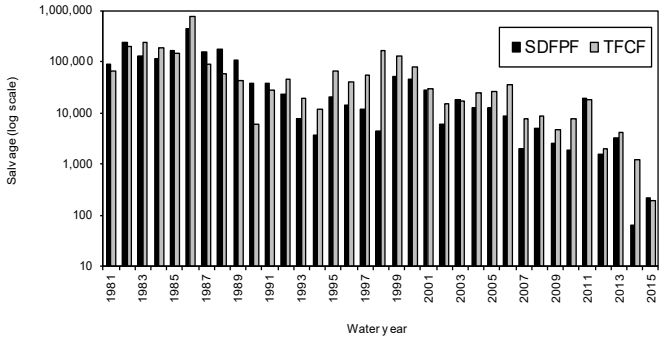

Figure 5 Annual salvage of Chinook Salmon (all races and wild and hatchery origins combined) at the SDFPF and the TFCF, WYs 1981 to 2015. The logarithmic scale is log_{10}.

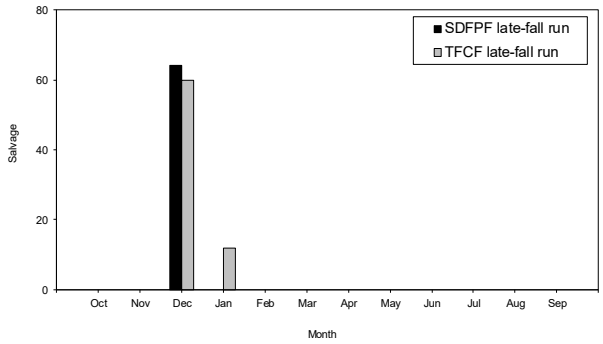

Figure 6 Monthly salvage of hatchery late fall-run Chinook Salmon at the SDFPF and the TFCF, WY 2015.

was a five-fold increase from the record low in WY 2014 (84), but substantially lower than in WY 2013 (861). Salvage at the TFCF (124) was a record low and a marked decrease from WY 2014 (330) and 2013 (646).

The SDFPF salvaged 407 hatchery Steelhead and 35 wild Steelhead. The TFCF salvaged 116 hatchery Steelhead and eight 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 February at the SDFPF and in April–May at the TFCF.

Striped Bass

Salvage of juvenile and sub-adult Striped Bass at the SDFPF (35,070) was a record low, while salvage at the TFCF (21,398) was a near-record low. Salvage at the SDFPF and the TFCF continued a declining trend observed since the mid-1990s (Figure 9). Prior to WY 1995, annual Striped Bass salvage estimates were generally above 1,000,000 fish.

Most Striped Bass salvage at the SDFPF occurred in December, February, and May–June (Figure 10). Most Striped Bass salvage at the TFCF occurred in December and May–June. Salvage at the SDFPF in December (11,105), February (11,024), May (6,482), and June (3,007) accounted for 90.2 percent of total WY salvage. At the TFCF, salvage in December (3,286), May (9,265), and June (5,443) accounted for 84.1 percent of total WY salvage. Striped Bass were salvaged every month except for October at the SDFPF. Striped Bass were salvaged every month at the TFCF, with the lowest monthly salvage occurring in October (2).

Delta Smelt

Salvage of Delta Smelt continued the pattern of mostly low salvage observed since WY 2005 (Figure 11). Salvage at the TFCF (68) was a four-fold increase from

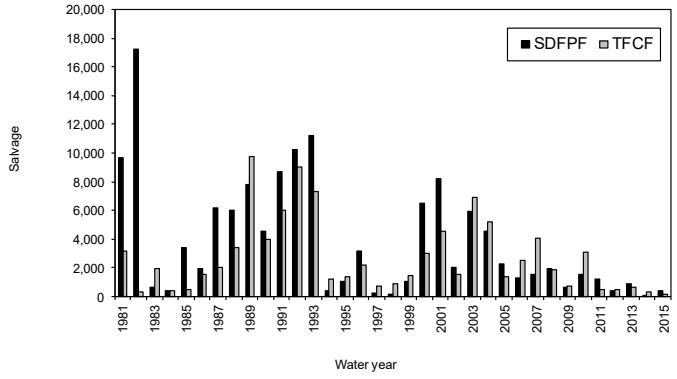

Figure 7 Annual salvage of Steelhead (wild and hatchery origins combined) at the SDFPF and the TFCF, WYs 1981 to 2015.

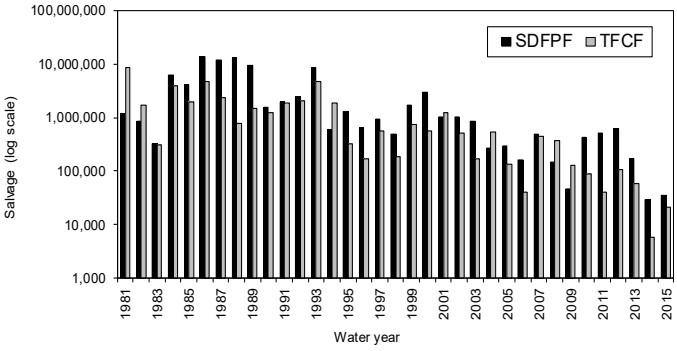

Figure 9 Annual salvage of Striped Bass at the SDFPF and the TFCF, WYs 1981 to 2015. The logarithmic scale is $\log_{10}$.

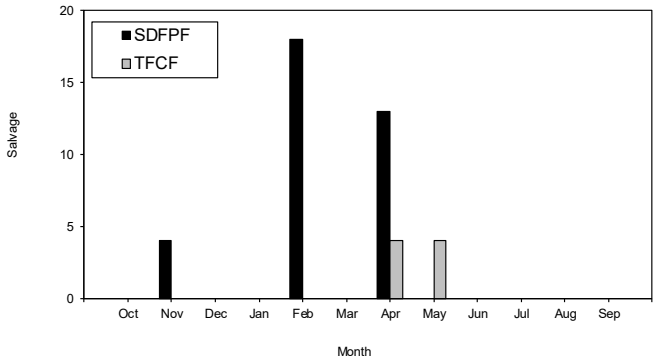

Figure 8 Monthly salvage of wild Steelhead at the SDFPF and the TFCF, WY 2015.

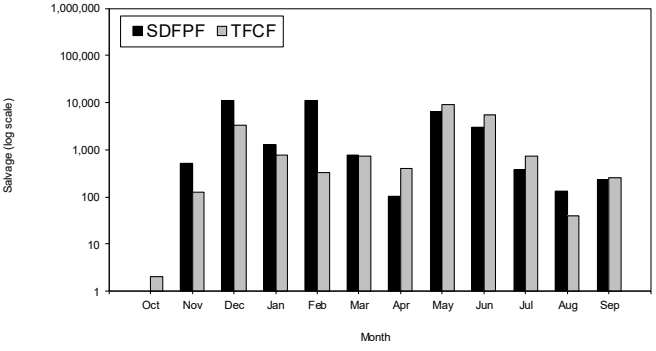

Figure 10 Monthly salvage of Striped Bass at the SDFPF and the TFCF, WY 2015. The logarithmic scale is $\log_{10}$.

the record low in WY 2014 (16), but a marked decrease from WY 2013 (300). Salvage at the SDFPF (4) decreased markedly from WY 2014 (62) and WY 2013 (1,701), but increased from the record low in WY 2011 (0).

Salvage of Delta Smelt at both facilities occurred predominantly in the winter (Figure 12). Adult Delta Smelt at SDFPF were only salvaged in January. No juvenile Delta Smelt was salvaged at SDFPF. Adult Delta Smelt at TFCF were salvaged in January–February, where January salvage (52) accounted for 76.0 percent of the total WY salvage. Juvenile Delta Smelt at TFCF were only salvaged in May (4).

Delta Smelt less than 20 mm FL were only detected at the SDFPF on April 23 (Table 3).

No Delta Smelt less than 20 mm FL were detected at the TFCF in WY 2015, which was a decrease from WY 2014 (6) and WY 2013 (9).

Longfin Smelt

Salvage of juvenile Longfin Smelt at the SDFPF in WY 2015 (102) increased from WY 2014 (32), but markedly decreased from WY 2013 (659) (Figure 13). The record low salvage of Longfin Smelt occurred in WY 2011 (0). Salvage at the TFCF (28) also increased from WY 2014 (8), but markedly decreased from WY 2013 (241). Salvage in WY 2015 increased slightly from WY 2011 (4).

Juvenile Longfin Smelt were salvaged in April–May at the SDFPF (Figure 14). April salvage (60) accounted for 59.0 percent of the total WY salvage. Longfin Smelt were salvaged in March–May at the TFCF. April salvage (12) accounted for 43.0 percent of the total WY salvage.

Table 3 Delta Smelt and Longfin Smelt less than 20 mm fork length (FL) observed in larval samples collected from the SDFPF and the TFCF in WY 2015. Daily numbers of 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***
2/27/2015	NS	NS	N	1
3/3/2015	N	1	N	N
3/30/2015	N	N	N	1
4/5/2015	N	1	N	N
4/8/2015	N	N	N	1
4/13/2015	N	1	N	N
4/14/2015	N	2	N	1
4/15/2015	N	1	N	N
4/19/2015	N	1	N	N
4/21/2015	N	5	N	N
4/23/2015	1	1	N	1

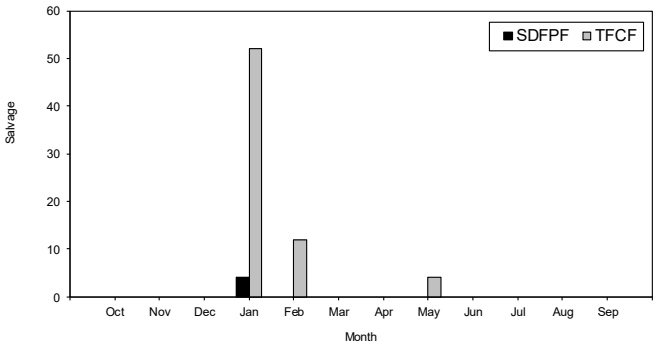

Figure 12 Monthly salvage of Delta Smelt at the SDFPF and the TFCF, WY 2015.

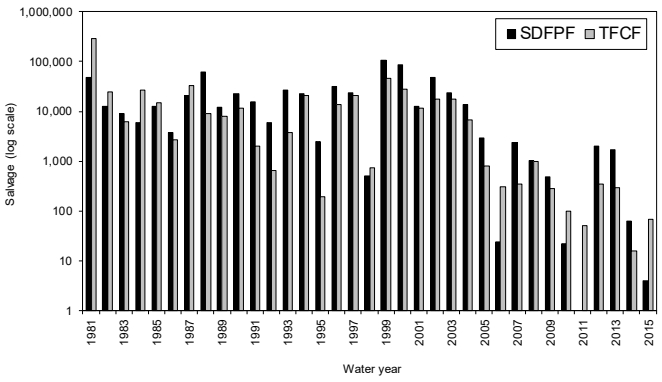

Figure 11 Annual salvage of Delta Smelt at the SDFPF and the TFCF, WYs 1981 to 2015. The logarithmic scale is log_{10}.

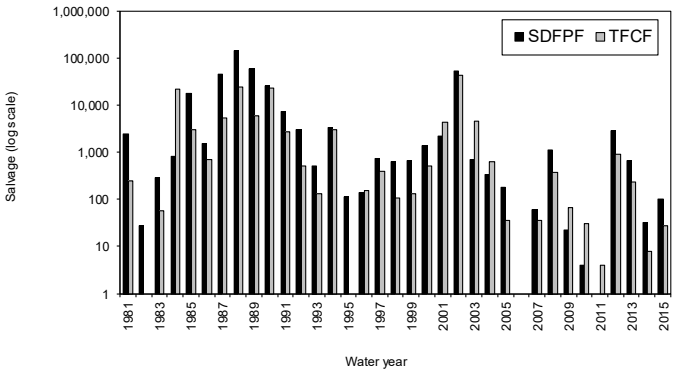

Figure 13 Annual salvage of Longfin Smelt at the SDFPF and the TFCF, WYs 1981 to 2015. The logarithmic scale is log_{10}.

Longfin Smelt less than 20 mm FL were first detected at the SDFPF on March 3, and were observed on eight days of monitoring (Table 3). The longest period of consecutive daily detections was April 13–15. April recorded the most daily detections (7 days).

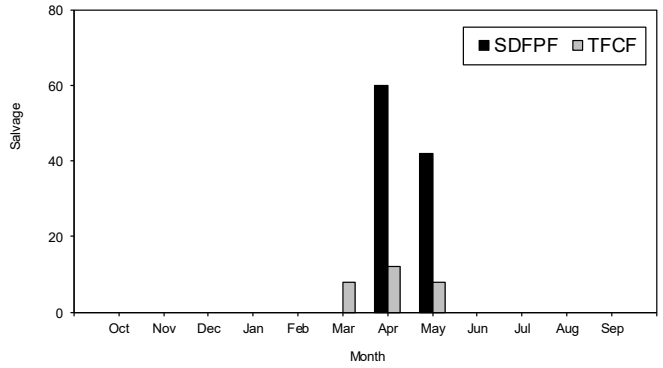

Figure 14 Monthly salvage of Longfin Smelt at the SDFPF and the TFCF, WY 2015.

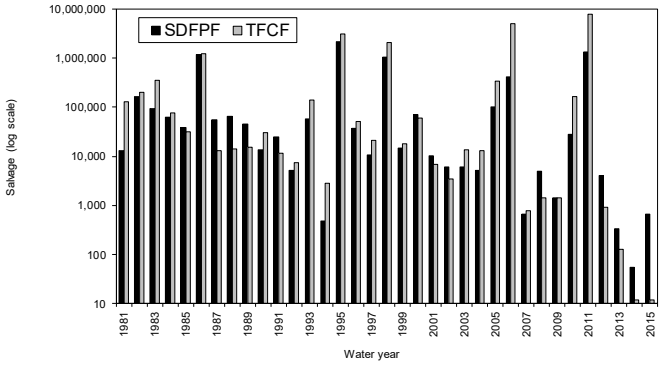

Figure 15 Annual salvage of Splittail at the SDFPF and the TFCF, WYs 1981 to 2015. The logarithmic scale is $\log_{10}$.

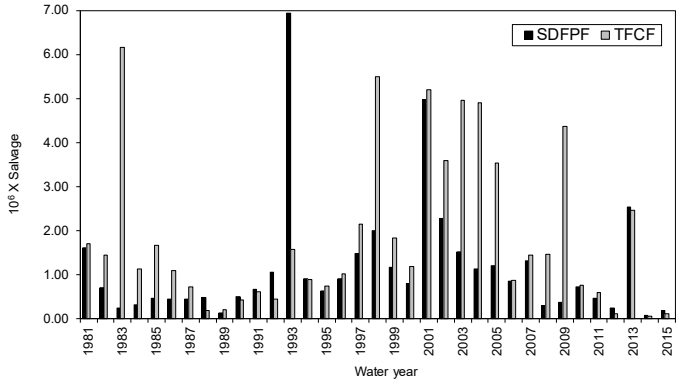

Figure 16 Annual salvage of Threadfin Shad at the SDFPF and the TFCF, WYs 1981 to 2015.

Longfin Smelt less than 20 mm FL were first detected at the TFCF on February 27 and were observed on five days of monitoring (Table 3). April recorded the most daily detections (3 days).

Splittail

Annual salvage estimates of Splittail at both facilities were markedly different from each other (Figure 15). Salvage at the TFCF was a record tying low (12), which was equal to the record low in WY 2014 (12). Conversely, salvage at the SDFPF was 12 times higher (656) than the record-low in WY 2014 (55). 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 (186,368) than at the TFCF (114,804), and both were near record lows (Figure 16). Salvage at the SDFPF was higher than the record low in WY 2014 (63,237) but substantially lower than WY 2013 (2,535,117). Similarly, TFCF salvage was higher than the record low in WY 2014 (47,603) but substantially lower than WY 2013 (2,463,695). Similar to Splittail, annual salvage estimates of Threadfin Shad have varied greatly through time.

Notes

Dekar, M. 2015. U.S. Fish and Wildlife Service. 850 South Guild Ave, Suite 105 Lodi, CA 95240.

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The Interagency Ecological Program for the San Francisco Estuary
is a cooperative effort of the following agencies:

California Department of Water Resources
State Water Resources Control Board
U.S. Bureau of Reclamation
U.S. Army Corps of Engineers

California Department of Fish and Wildlife
U.S. Fish and Wildlife Service
U.S. Geological Survey
U.S. Environmental Protection Agency
National Marine Fisheries Service

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