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Status and Trends

Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities during the 2017 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 2017 water year (WY) salvage information from the TFCF and the SDFPF and examines data from water years (WYs) 1981 to 2017 for salvage trends over time, with emphasis on comparing 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 one to 30 minutes (= 26.14 minutes, standard deviation = 8.09) at the SDFPF and generally once every two hours for 10 to 60 minutes (= 30.01, standard deviation = 0.78) 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 one- to two-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 of Chinook Salmon was initially determined by the Delta criteria based on length at date of salvage (California Department of Fish and Wildlife 2014). If Coded Wire Tag (CWT) information was available, the race of hatchery Chinook Salmon was updated. The Delta criteria 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"). Nevertheless, apparent growth rates and size ranges among races are variable, leading to potential misclassification with the Delta criteria (Harvey and Stroble 2013), so a change was made to use CWT tag race in WY 2017.

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 February 27 through June 26 and from February 20 through June 25 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.

1 Pelagic Organism Decline (POD) species

Water Exports

The SWP exported 4.44 billion m^3 of water, which was a marked increase from WY 2016 (2.43 billion m^3), WY 2015 (1.38 billion m^3), and the record low exports in WY 2014 (1.12 billion m^3), but a small decrease from the record high exports in WY 2011 (4.91 billion m^3) (Figure 1). The CVP exported 3.31 billion m^3 of water, which was also a marked increase from WY 2016 (1.68 billion m^3), WY 2014 (1.17 billion m^3), and the record low in WY 2015 (0.86 billion m^3), but similar to WY 2011 (3.13 billion m^3). The increased exports at both facilities coincided with increased rainfall and the end of a five-year drought. Exports in WY 2017 at both facilities were above the WYs 1981–2016 average (3.05 billion m^3 at SWP and 2.78 billion m^3 at CVP).

Exports at the SWP peaked in January–February and June–August (Figure 2). During these periods, the SWP exported 2.61 billion m^3, which represented 58.79 percent of annual export. Exports at the CVP peaked in June–August. The cumulative water export for those months was 947.41 million m^3, which represented 28.67 percent of the annual export. SWP monthly exports ranged from 67.55 to 587.17 million m^3. CVP monthly exports ranged from 183.85 to 330.23 million m^3.

Figure 1 Annual water exports in billions of cubic meters for the SWP and the CVP, WYs 1981 to 2017.

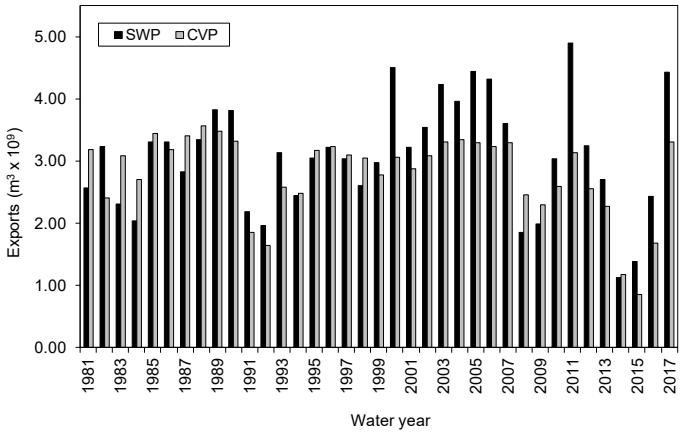
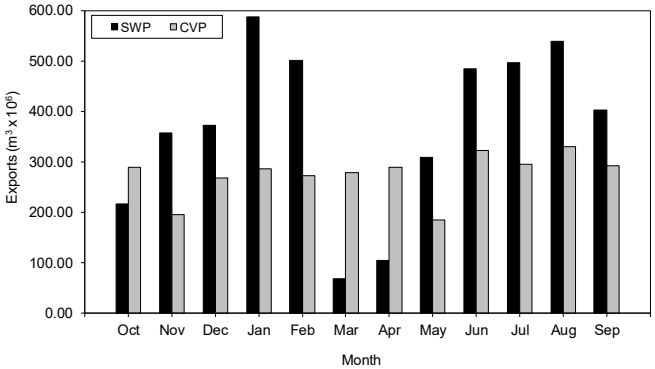


Figure 2 Monthly water exports in millions of cubic meters for the SWP and the CVP, WY 2017.

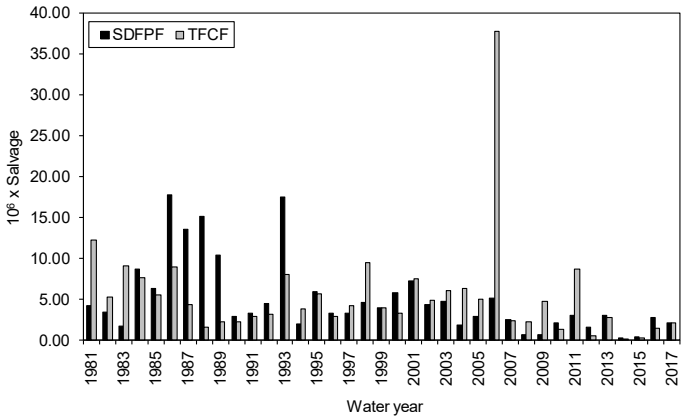


Total Salvage and Prevalent Species

Total fish salvage (all fish species combined) at the SDFPF was 2,104,742 (Figure 3). This was a small decrease from WY 2016 (2,832,631), but a large increase from WY 2015 (347,882) and the record low in WY 2014 (236,846). Total fish salvage at the TFCF was 2,061,133. This was a large increase from WY 2016 (1,437,551), WY 2015 (295,854), and the record low in WY 2014 (160,681). The marked increase in total fish salvage at TFCF in WY 2017 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). This trend was not found at SDFPF, where total fish salvage was higher in WY 2016 than WY 2017.

Threadfin Shad was the most salvaged species at both the SDFPF and TFCF (Figure 4 and Table 1). American Shad (*Alosa sapidissima*) and Striped Bass were the second- and third-most salvaged fish at SDFPF, respectively. Splittail and American Shad were the second- and third-most salvaged fish at TFCF, respectively. Native species comprised 19.5 percent of total fish salvage at SDFPF and 22.1 percent of total fish salvage at TFCF. This was a large increase from WY 2016 at SDFPF (0.2 percent) and TFCF (0.7 percent), and attributable to increased Splittail salvage in WY 2017. Relatively few Chinook Salmon, Steelhead, Delta Smelt, and Longfin Smelt were salvaged at the SDFPF (1.1 percent combined of total fish salvage) and at the TFCF (1.1 percent). These percentages represent an increase for both facilities from WY 2016

Figure 3 Annual salvage of all fish taxa combined at the SDFPF and the TFCF, WYs 1981 to 2017.



(0.04 percent) and WY 2015 (0.22 percent) at the SDFPF and WY 2016 (0.11 percent) and WY 2015 (0.14 percent) at the TFCF.

Chinook Salmon

Annual salvage estimates of Chinook Salmon (all races and origins combined) at both facilities markedly increased from the low salvage trend seen since WY 2001 (Figure 5). SDFPF salvage of juvenile and large (> 300-mm FL) Chinook Salmon (23,118) increased dramatically from WY 2016 (362) and WY 2015 (221). Mean salvage for Chinook Salmon in WYs 2001–2017 at SDFPF was only 9.2 percent of the mean salvage in WYs 1981–2000. Salvage of juvenile Chinook Salmon at the TFCF (23,633) was a large increase from WY 2016 (970) and the record low in WY 2015 (187). Mean WYs 2001–2017 TFCF salvage was only 10.9 percent of the mean salvage in WYs 1981–2000.

Salvaged Chinook Salmon at the SDFPF were primarily wild spring-run-sized fish, which comprised 64.6 percent of wild fish (Table 2). Salvaged Chinook Salmon at the TFCF were also primarily wild spring-run-sized fish, which comprised 56.0 percent of wild fish. Wild spring-run fish at the SDFPF were salvaged in February–June, with the majority salvaged in May (10,489), while wild spring-run-fish at the TFCF were salvaged in March–June, with the majority salvaged in April (6,246).

Annual loss of Chinook Salmon (all origins and races) was higher at the SDFPF (100,811) than at the TFCF (15,867) (Table 2). Greater entrainment loss at the SDFPF than at the TFCF was attributable to greater pre-screen loss.

Figure 4 Percentages of annual salvage for the 5 most prevalent fish species and other fish species combined at the SDFPF and TFCF, WY 2017.

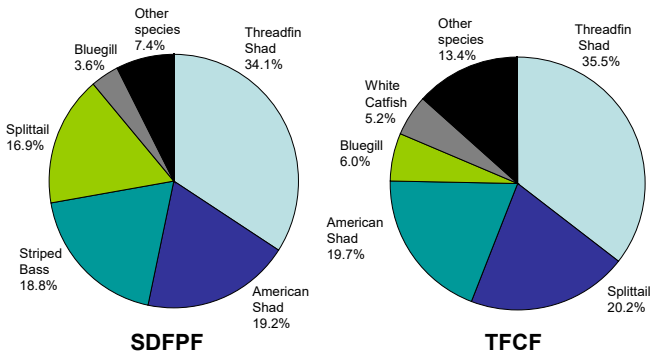


Table 1 Annual fish salvage and percentage of annual fish salvage (%) collected from the SDFPF and TFCF in WY 2017.

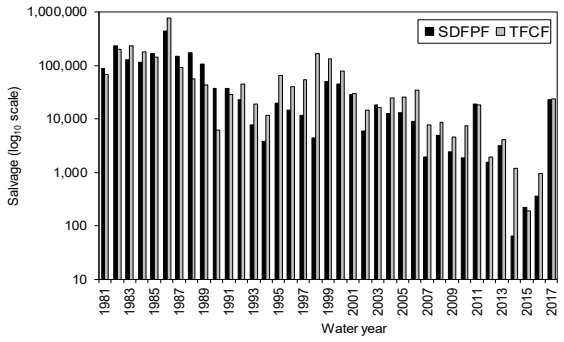
SDFPF			TFCF		
Species	***Salvage***	***%***	***Species***	***Salvage***	***%***
Threadfin Shad	717,753	34.1	Threadfin Shad	731,760	35.5
American Shad	405,135	19.2	Splittail	415,517	20.2
Striped Bass	396,161	18.8	American Shad	405,336	19.7
Splittail	355,538	16.9	Bluegill	123,970	6.0
Bluegill	76,476	3.6	White Catfish	107,330	5.2
Largemouth Bass	38,909	1.8	Striped Bass	94,467	4.6
Prickly Sculpin	28,895	1.4	Largemouth Bass	47,643	2.3
Chinook Salmon	23,118	1.1	Chinook Salmon	23,633	1.1
Inland Silverside	17,249	0.8	Common Carp	21,952	1.1
White Catfish	14,065	0.7	Channel Catfish	21,350	1.0
Common Carp	12,018	0.6	Shimofuri Goby	17,114	0.8
Shimofuri Goby	9,620	0.5	Lamprey	13,559	0.7
Lamprey Unknown	2,468	0.1	Unknown Inland Silverside	11,181	0.5
Black Crappie	2,046	<0.1	Golden Shiner	7,013	0.3
Channel Catfish	1,678	<0.1	Rainwater Killifish	4,151	0.2
Yellowfin Goby	1,235	<0.1	Redear Sunfish	3,496	0.2
Goldfish	612	<0.1	Black Crappie	2,981	0.1
Bigscale Logperch	608	<0.1	Yellowfin Goby	2,468	0.1
Golden Shiner	550	<0.1	Western Mosquitofish	1,711	<0.1
Rainwater Killifish	203	<0.1	Prickly Sculpin	1,189	<0.1
Steelhead	78	<0.1	Sacramento Sucker	836	<0.1
Starry Flounder	65	<0.1	Goldfish	596	<0.1
Western Mosquitofish	59	<0.1	Threespine Stickleback	475	<0.1
Shokihaze Goby	40	<0.1	Black Bullhead	452	<0.1
White Sturgeon	35	<0.1	Pacific Lamprey	164	<0.1
Black Bullhead	30	<0.1	Bigscale Logperch	162	<0.1
Wakasagi	29	<0.1	Warmouth	113	<0.1
Delta Smelt	25	<0.1	Brown Bullhead	88	<0.1
Smallmouth Bass	12	<0.1	Red Shiner	76	<0.1
Brown Bullhead	8	<0.1	White Sturgeon	68	<0.1
Redear Sunfish	8	<0.1	Sacramento Pikeminnow	40	<0.1
Threespine Stickleback	4	<0.1	Green Sunfish	32	<0.1
Green Sunfish	4	<0.1	Delta Smelt	32	<0.1
Warmouth	4	<0.1	Steelhead	30	<0.1
Freshwater Eel	4	<0.1	Shokihaze Goby	28	<0.1
			Starry Flounder	24	<0.1
			White Crappie	20	<0.1
			Sacramento Blackfish	16	<0.1
			Tule Perch	12	<0.1
			Fathead Minnow	12	<0.1
			Large-Scale Loach	12	<0.1
			Spotted Bass	8	<0.1
			Hitch	4	<0.1
			Green Sturgeon	4	<0.1
			Wakasagi	4	<0.1
			River Lamprey	4	<0.1

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 (78) was a record low and a marked decrease from WY 2016 (789) and WY 2015 (442). Juvenile salvage at the TFCF (30) was also a record low and marked decrease from WY 2016 (652) and the previous record low in WY 2015 (124).

The SDFPF salvaged 37 hatchery Steelhead and 41 wild Steelhead. The TFCF salvaged 6 hatchery Steelhead and 24 wild Steelhead. Wild Steelhead were salvaged most frequently in May at the SDFPF and in June at the TFCF (Figure 7).

Figure 5 Annual salvage of Chinook Salmon (all races and wild and hatchery origins combined) at the SDFPF and the TFCF, WYs 1981 to 2017.



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

Figure 6 Annual salvage of Steelhead (wild and hatchery origins combined) at the SDFPF and the TFCF, WYs 1981 to 2017.

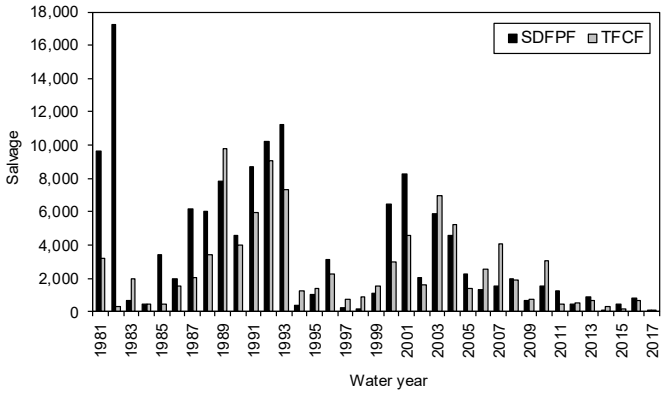


Table 2 Chinook Salmon annual salvage, percentage of annual salvage, race and origin (wild or hatchery), and loss at the SDFPF and the TFCF, WY 2017.

Facility	*Origin*	*Race*	*Salvage*	*Percentage*	*Loss*
SDFPF					
	Wild	Fall	7,763	34.8	33,578
		Late-fall	16	0.1	70
		Spring	14,388	64.6	63,415
		Winter	22	0.1	94
	Large unknown race		96	0.4	*
	Total Wild		22,285		97,157
	Hatchery				
		Fall	123	14.8	548
		Late-fall	422	50.7	1,868
		Spring	262	31.4	1,151
		Winter	20	2.4	87
	Large unknown race		6	0.7	*
	Total Hatchery		833		3,654
	Grand Total		23,118		100,811
TFCF					
	Wild	Fall	9,648	43.9	6,107
		Late-fall	4	<0.1	3
		Spring	12,325	56.0	8,598
		Winter	24	0.1	17
	Total Wild		22,001		14,725
	Hatchery				
		Fall	436	26.7	301
		Late-fall	544	33.3	379
		Spring	648	39.7	459
		Winter	4	0.3	3
	Total Hatchery		1,632		1,142
	Grand Total		23,633		15,867

*No loss was calculated for SDFPF large unknown race Chinook Salmon since they were too large to fit the loss calculation

Striped Bass

Salvage of juvenile, sub-adult, and adult Striped Bass at the SDFPF (396,161) was an increase from WY 2016 (224,967) and a large increase from the record low in WY 2015 (35,070). Salvage at the TFCF (94,467) was an increase from WY 2016 (61,787) and was also a large increase from the near-record low in WY 2015 (21,398). Salvage at the SDFPF and the TFCF continued a 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 occurred in June–July and in July–August at the TFCF (Figure 9). Salvage at the SDFPF in June (71,677) and July (191,626) accounted for 66.5 percent of total WY salvage. At the TFCF, salvage in July (24,744) and August (39,783) accounted for 68.3 percent of total WY salvage. Striped Bass were salvaged every month at both the SDFPF and the TFCF, with the lowest monthly salvages occurring in October at the SDFPF (608) and in May at the TFCF (28).

Delta Smelt

Salvage of adult Delta Smelt continued the pattern of mostly low salvage observed since WY 2005 (Figure 10). Salvage at the TFCF (32) was a small increase from the record low in WY 2016 (12), a small decrease from WY 2015 (68), but decreased substantially from WY 2013 (300). Salvage at the SDFPF (25) increased slightly from WY 2016 (8) and WY 2015 (4), but decreased substantially from WY 2013 (1,701).

Salvage of adult Delta Smelt at both facilities occurred in the winter. Delta Smelt at the TFCF were salvaged in January (4), February (4), and March (24). Delta Smelt at the SDFPF were salvaged in February (21)

Figure 7 Monthly salvage of wild Steelhead at the SDFPF and the TFCF, WY 2017.

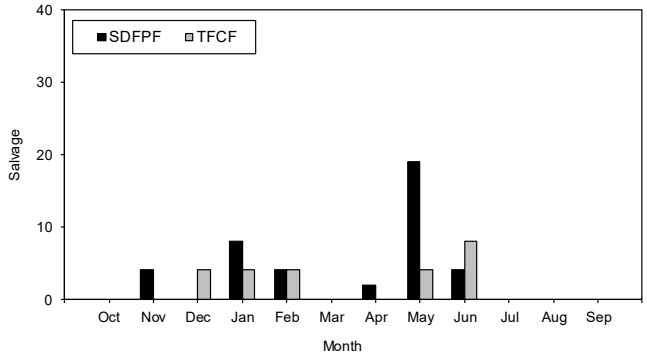
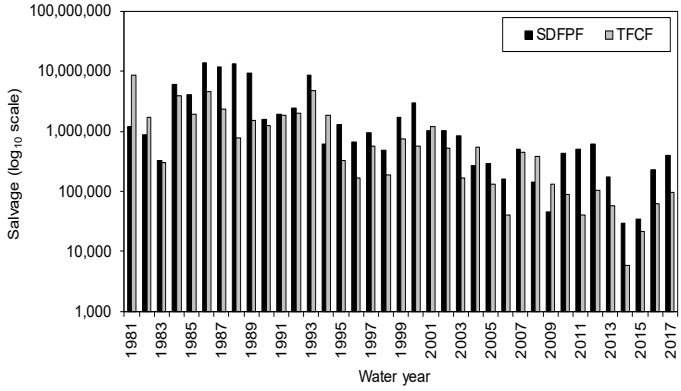
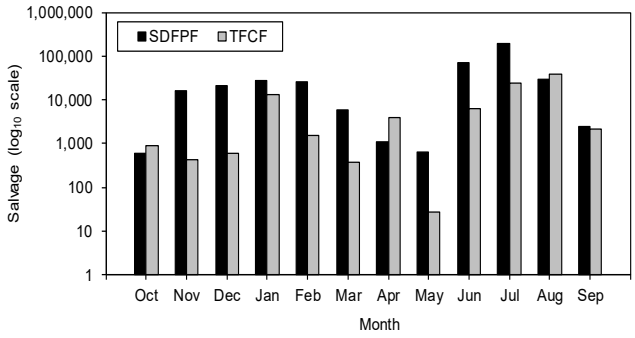


Figure 8 Annual salvage of Striped Bass at the SDFPF and the TFCF, WYs 1981 to 2017.



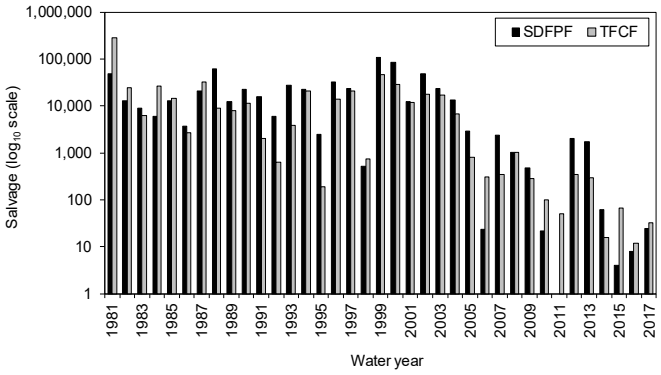
Note: The logarithmic scale is $\log_{10}$.

Figure 9 Monthly salvage of Striped Bass at the SDFPF and the TFCF, WY 2017.



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

Figure 10 Annual salvage of Delta Smelt at the SDFPF and the TFCF, WYs 1981 to 2017.



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

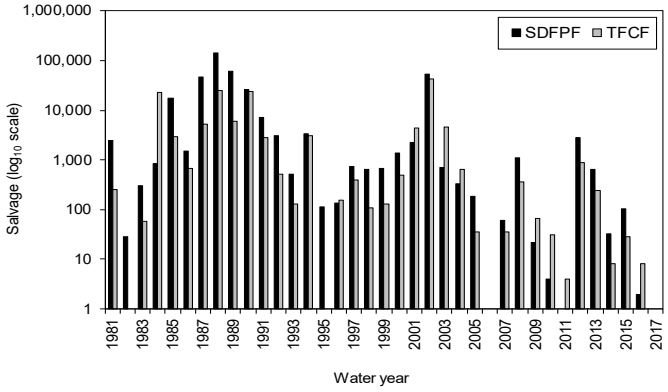
and March (4). No young-of-the-year Delta Smelt were salvaged at either facility.

No Delta Smelt less than 20-mm FL were detected at the SDFPF in WY 2017, which was equal to WY 2016, but a small decrease from WY 2015 (1). No Delta Smelt less than 20-mm FL were detected at the TFCF in WY 2017, as in WY 2016 and WY 2015.

Longfin Smelt

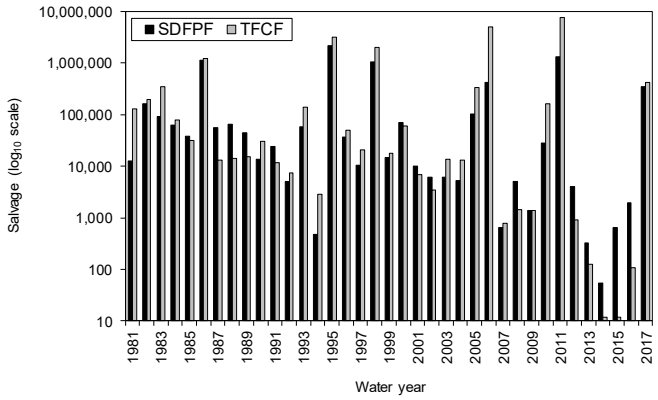
No Longfin Smelt were salvaged at either facility in WY 2017. At the SDFPF, low salvage numbers occurred in WY 2016 (2) and WY 2015 (102). No salvage of Longfin Smelt also occurred in WY 2006 and WY 2011. At the TFCF, low salvage numbers also occurred in WY 2016 (8) and WY 2015 (28). No salvage of Longfin Smelt also occurred in WY 2006, WY 1995, and WY 1982 (Figure 11).

Figure 11 Annual salvage of Longfin Smelt at the SDFPF and the TFCF, WYs 1981 to 2017.



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

Figure 12 Annual salvage of Splittail at the SDFPF and the TFCF, WYs 1981 to 2017.



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

No Longfin Smelt less than 20-mm FL were detected at the SDFPF in WY 2017, which was equal to WY 2016, but a decrease from WY 2015 (13). No Longfin Smelt less than 20-mm FL were detected at the TFCF in WY 2017, which was a decrease from WY 2016 (1) and WY 2015 (5).

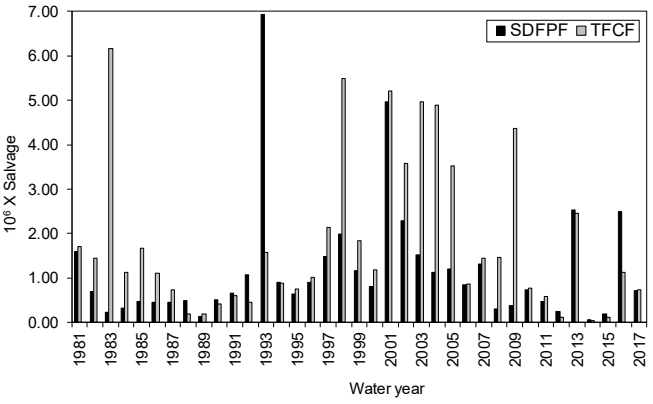
Splittail

Annual salvage estimates of juvenile and adult Splittail at both facilities were similar (Figure 12). Salvage at the TFCF (415,517) was a large increase from WY 2016 (109) and the record low in WY 2015 (12). Salvage at the SDFPF (355,538) was a large increase from WY 2016 (1,951) and 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 slightly higher at the TFCF (731,760) than at the SDFPF (717,753) (Figure 13). Salvage at the TFCF was lower than in WY 2016 (1,127,956) but higher than in WY 2015 (114,804). Similarly, salvage at the SDFPF was lower than WY 2016 (2,494,795) but higher than in WY 2015 (186,368). Similar to Splittail, annual salvage estimates of Threadfin Shad have varied greatly through time.

Figure 13 Annual salvage of Threadfin Shad at the SDFPF and the TFCF, WYs 1981 to 2017.



Notes

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

References

Aasen GA. 2013. "Predation on salvaged fish during the collection, handling, transport, and release phase of the State Water Project's John E. Skinner Delta Fish Protective Facility." Sacramento (CA): Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. California Department of Water Resources. Technical Report 86. p. 103.

California Dept. of Fish and Game. 2006. *Chinook salmon loss estimation for Skinner Delta Fish Protective Facility and Tracy Fish Collection Facility*. Available from: ftp://ftp.dfg.ca.gov/salvage/.

California Dept. of Fish and Wildlife. 2014. *Delta Model length at date table*. Available from: ftp://ftp.dfg.ca.gov/salvage/.

Harvey BN, Stroble C. 2013. "Comparison of genetic versus Delta Model length-at-date race assignments for juvenile Chinook Salmon at State and Federal South Delta salvage facilities." Sacramento (CA): Interagency Ecological Studies Program for the Sacramento-San Joaquin Estuary. California Department of Water Resources. Technical Report 88. p. 1–48 plus appendices.

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

2017 20-mm Survey

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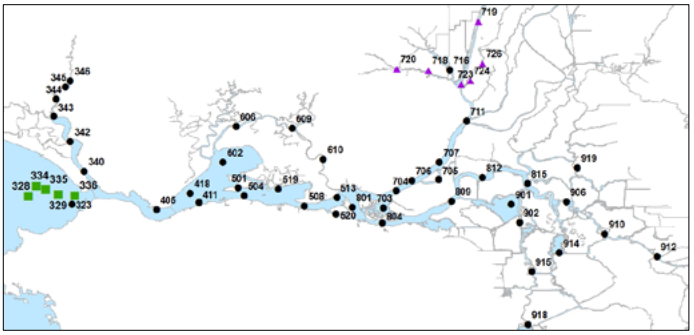
The California Department of Fish and Wildlife (CDFW) conducts the 20-mm Survey annually to monitor the distribution and relative abundance of larval and juvenile Delta Smelt (*Hypomesus transpacificus*) in the upper San Francisco Estuary. The survey began in 1995 and provides near real-time catch data to water and fisheries managers to assess the risk of entrainment to Delta Smelt at water export facilities.

The 20-mm survey uses a conical net with 1600-micron nylon mesh to collect young-of-the-year fish. The net is 5.1 meters long with a mouth area of 1.51 square meters and is attached to a rigid steel D-ring frame mounted on skis. Nine biweekly surveys are conducted annually, and each survey typically samples 47 fixed sites, or "stations" (Figure 1). During periods of high flow, five additional "high outflow stations" are sampled each survey in San Pablo Bay to better capture potential Delta Smelt distribution. At each station, the entire water column is sampled using three stepped-oblique fish tows and a single zooplankton tow. All samples are preserved in 10 percent buffered formalin dyed with rose bengal for later identification and enumeration in the laboratory. Fish are measured to the nearest millimeter by fork length if the caudal fin is forked or by total length if the caudal fin is not forked. In this article, "length" is used as a generic

Figure 1 The 2017 CDFW 20-mm Survey station map, showing current sampling locations in the upper San Francisco Estuary.



Note: Stations marked with a black dot are index stations. Stations marked with a purple triangle are non-index stations that were added in 2008. Stations marked with a green square are high-outflow stations.

■ Interagency Ecological Program for the San Francisco Estuary ■

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The Interagency Ecological Program for the San Francisco Estuary
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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
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