Interagency Ecological Program for the San Francisco Estuary

IEP NEWSLETTER

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IEP QUARTERLY HIGHLIGHTS

Fish Salvage at the State Water Project's and Central Valley Project's Fish Facilities During the 2011 Water Year

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Introduction

Two facilities are intended to reduce the fish loss 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 remove fish from the exported water. The diverted fish are periodically loaded into tanker trucks and transported to fixed release sites in the western Delta. The TFCF began operations in 1957. Operations at the SDFPF began in 1967.

This report summarizes the 2011 water year (10/1/2010-9/30/2011) salvage information from the TFCF and the SDFPF, and discusses data from 1981 to 2011 water years for its relevance to salvage trends in recent years. The following species are 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 once every 1 to 2 hours for 1 to 30 minutes at the SDFPF and once every 2 hours for 10 to 120 minutes at the TFCF. Fish 20 mm FL (fork length) or larger were identified and numerated. 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 sub-sample duration of 10 minutes over a 120-minute salvage period equals an expansion factor of 12. These incremental salvage estimates were then summed across time to develop monthly and annual species-salvage totals for each facility.

Chinook salmon loss estimates are presented because the loss model has been widely accepted and has undergone extensive field validation. Loss is the estimated number of fish entrained by the facility minus the number of fish that survive salvage operations (California Dept. 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, spring). Race of Chinook salmon is determined solely by criteria based on length and salvage date.

Larval fish (< 20 mm FL) were also collected and examined to determinethe presence of sub-20 mm delta smelt. Larval sampling at TFCF ran from March 17 through June 17 and from March 17 through June 23 at SDFPF. Larval samples were collected once for every 6 hours of water export. 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 TFCF were identified to species by TFCF personnel and larval fish from SDFPF were identified to species by California Dept. of Fish and Game personnel.

Water Exports

The SWP exported 4.90 billion m^3 of water which was the highest export rate recorded for 1981-2011 and a marked increase from exports in 2010 (3.04 billion m^3) and 2009 (1.99 billion m^3) (Figure 1). The CVP exported 3.13 billion m^3 of water which was an increase from exports in 2008-2010 (ranging from 2.30 to 2.60 billion m^3), but was comparable to exports in recent years from 2002 to 2007.

The exports of the two water projects generally followed a similar seasonal pattern. Exports at the CVP reached a maximum in October through December 2010, January, and July -September 2011 (Figure 2). During these periods, 2.16 billion m^3 was exported by the CVP, representing about 69.0% of annual export. Exports at the

1 Pelagic Organism Decline (POD) species

SWP reached a maximum in December 2010 and January and July through September 2011 (Figure 2). During these periods, 2.62 billion m^3 was exported by the SWP, representing about 53.5% of annual export. CVP monthly exports ranged from 125.85 to 316.66 million m^3. SWP monthly exports ranged from 123.57 to 537.55 million m^3.

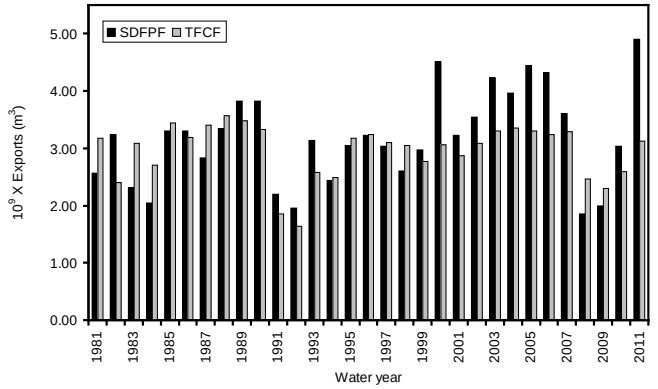

Figure 1 Annual water exports in billions of cubic meters for the SWP and the CVP, 1981 to 2011

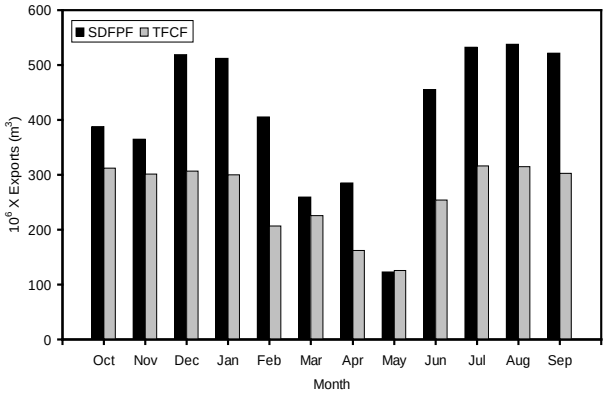

Figure 2 Monthly water exports in millions of cubic meters for the SWP and the CVP, 2011

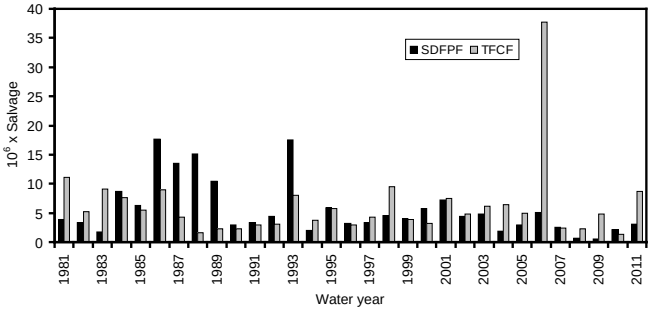

Figure 3 Annual salvage of all fish taxa combined at the SDFPF and the TFCF, 1981 to 2011

Total Salvage and Prevalent Species

Annual fish salvage (all fish species combined) at the TFCF was high at 8,724,498 (Figure 3). TFCF salvage was an increase from the record-low in 2010 (1,318,613), but well below the record high salvage of 37,659,835 in 2006 (Figure 3). Annual salvage at the SDFPF was 3,092,553. SDFPF salvage was an increase from 2007-2010 which ranged from 646,290 to 2,484,282.

Splittail were the most-salvaged species at both facilities (Figure 4 and Table 1). Threadfin shad and American shad were the 2nd and 3rd most-salvaged fish at TFCF. American shad and striped bass were the 2nd and 3rd most-salvaged fish at SDFPF. Relatively few Chinook salmon, steelhead, delta smelt, and longfin smelt were salvaged at the SDFPF (< 0.7% of total annual salvage combined) and the TFCF (< 0.3% of total annual salvage).

Chinook Salmon

SDFPF salvage (18,830) was an increase from 2010 (1,882) and 2009 levels (2,463), but continued a declining trend which started in 2001 (Figure 5). Mean 2001-2011 SDFPF salvage was about 10-fold lower than salvage in the 1980's and the late 1990's. Salvage of Chinook salmon at the TFCF (18,135) was higher than in 2010 (7,463) and 2009 (4,668). Mean 2001-2011 TFCF salvage was about 7-fold lower than salvage in the 1980's and the late 1990's.

Salvaged Chinook salmon at TFCF were primarily wild spring-run and fall-run fish which comprised 94% of wild fish (Table 2). Salvaged Chinook salmon at SDFPF were also primarily wild spring-run and fall-run fish which comprised 95% of wild fish. The majority of wild fall-run fish at the SDFPF and TFCF were salvaged in June (Figure 6).

Loss of Chinook salmon (all origins and races) was higher at the SDFPF (87,132) than at the TFCF (13,546; Table 2). Greater entrainment loss at the SDFPF than at the TFCF was attributable to greater pre-screen loss.

Table 1 Annual (by water year) fish salvage and percentage of annual fish salvage (%) collected from the SDFPF and TFCF in 2011

SDFPF			*TFCF*		
Species	Salvage	%	Species	Salvage	%
Splittail	1,326,065	42.9	Splittail	7,660,024	87.8
American shad	558,731	18.1	Threadfin shad	591,111	6.8
Striped bass	507,619	16.4	American shad	100,233	1.1
Threadfin shad	463,622	15.0	Bluegill	86,932	1.0
Bluegill	88,112	2.8	White catfish	74,913	0.9
White catfish	34,767	1.1	Channel catfish	40,288	0.5
Largemouth bass	32,420	1.0	Striped bass	39,583	0.5
Chinook salmon	18,830	0.6	Largemouth bass	29,096	0.3
Inland silverside	17,278	0.6	Sacramento sucker	27,362	0.3
Yellowfin goby	15,398	0.5	Yellowfin goby	22,081	0.3
Prickly sculpin	9,587	0.3	Chinook salmon	18,135	0.2
Channel catfish	5,888	0.2	Common carp	8,841	0.1
Unknown species	5,100	0.2	Inland silverside	8,359	<0.1
Shimofuri goby	2,035	<0.1	Golden shiner	3,200	<0.1
Rainwater killifish	1,446	<0.1	Unknown lamprey	2,651	<0.1
Unknown lamprey	1,346	<0.1	Shimofuri goby	2,080	<0.1
Steelhead	1,213	<0.1	Rainwater killifish	1,921	<0.1
Western mosquitofish	1,007	<0.1	Black crappie	1,909	<0.1
Bigscale logperch	689	<0.1	Prickly sculpin	1,680	<0.1
Common carp	499	<0.1	Redear sunfish	1,454	<0.1
Golden shiner	350	<0.1	Warmouth	796	<0.1
Black crappie	222	<0.1	Steelhead	445	<0.1
Starry flounder	85	<0.1	Western mosquitofish	408	<0.1
Pacific staghorn sculpin	72	<0.1	White sturgeon	133	<0.1
Brown bullhead	55	<0.1	Brown bullhead	132	<0.1
Riffle sculpin	20	<0.1	Threespine stickleback	123	<0.1
Tule perch	14	<0.1	Fathead minnow	108	<0.1
Sacramento pikeminnow	12	<0.1	Bigscale logperch	104	<0.1
Threespine stickleback	12	<0.1	Tule perch	102	<0.1
White sturgeon	10	<0.1	Black bullhead	57	<0.1
Black bullhead	8	<0.1	Delta smelt	51	<0.1
Redear sunfish	8	<0.1	Goldfish	40	<0.1
Goldfish	5	<0.1	Pacific brook lamprey	28	<0.1
Hardhead	4	<0.1	White crappie	24	<0.1
Hitch	4	<0.1	Sacramento pikeminnow	12	<0.1
Warmouth	4	<0.1	Sacramento blackfish	12	<0.1
Smallmouth bass	4	<0.1	Green sturgeon	12	<0.1
Fathead minnow	4	<0.1	Pacific staghorn sculpin	12	<0.1
Pumpkinseed	4	<0.1	Red shiner	12	<0.1
Blue catfish	4	<0.1	Starry flounder	11	<0.1
Green sturgeon	2	<0.1	Green sunfish	9	<0.1
White crappie	1	<0.1	Blue catfish	8	<0.1
			Hitch	4	<0.1
			Longfin smelt	4	<0.1

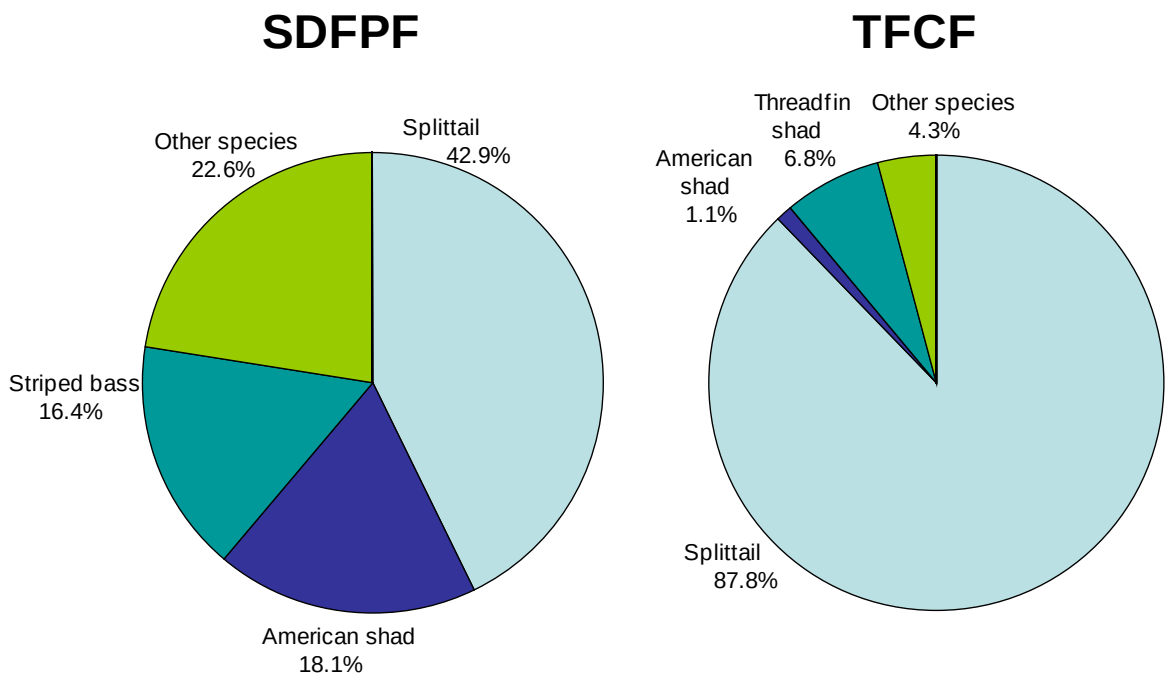

Figure 4 Percentages of annual salvage for the 3 most prevalent fish species and other fish species combined at the SDFPF and TFCF, 2011

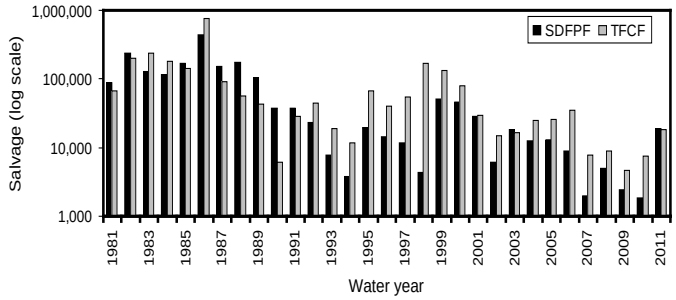

Figure 5 Annual salvage of Chinook salmon (all races and wild and hatchery origins combined) at the SDFPF and the TFCF, 1981 to 2011. The logarithmic scale is log_{10}.

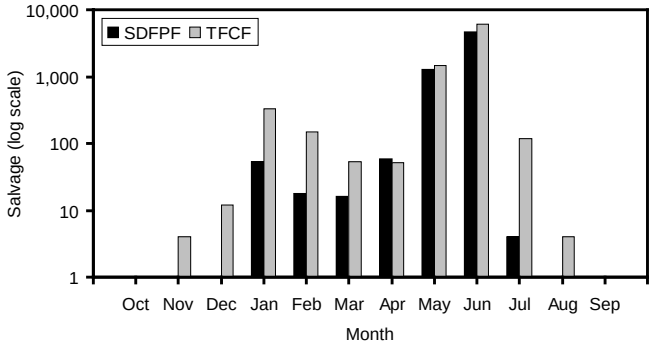

Figure 6 Monthly salvage of wild, fall-run Chinook salmon at the SDFPF and the TFCF, 2011. The logarithmic scale is log_{10}.

Steelhead

Salvage of steelhead (wild and hatchery origins combined) continued the pattern of mostly low salvage observed since 2005 (Figure 7). Salvage at the SDFPF (1,213) was lower than in 2010 (1,543). Similarly, TFCF salvage (445) was lower than in 2010 (3,088).

The TFCF salvaged 274 hatchery steelhead and 171 wild steelhead. The SDFPF salvaged 609 hatchery steelhead, 577 wild steelhead, and 27 steelhead of unknown origin.

Salvage of wild steelhead at both facilities occurred predominantly in the first half of the calendar year (Figure 8). Wild steelhead at the SDFPF were salvaged most frequently in April and June and in March at the TFCF.

Striped Bass

Salvage at the TFCF (39,583) was a record-low. Salvage at the TFCF and SDFPF (507,619) continued the generally-low trend observed since the mid-1990's (Figure 9). Prior to 1995, annual striped bass salvage was generally above 1,000,000 fish.

Table 2 Chinook salmon annual (by water year) salvage, percentage of annual salvage, race and origin (wild or hatchery), and loss at the SDFPF and the TFCF, 2011

Facility	*Origin*	*Race*	*Salvage*	*Percentage*	*Loss*
SDFPF					
	Wild				
		Fall	6,044	36	28,397
		Late-fall	36	<1	152
		Spring	10,018	59	46,453
		Winter	861	4	3,783
	Total Wild		**16,959**		**78,785**
	Unknown Race		**4**		**17**
	Hatchery				
		Fall	912	50	4,293
		Late-fall	469	25	2,009
		Spring	140	8	681
		Winter	312	17	1,347
	Total Hatchery		**1,833**		**8,330**
	Unknown Race and origin		**34**		**148-158***
	Grand Total		**18,830**		**87,132**
TFCF					
	Wild	Fall	8,238	49	5,906
		Late-fall	160	1	105
		Spring	7,636	45	6,051
		Winter	842	5	577
	Total Wild		**16,876**		**12,639**
	Hatchery				
		Fall	736	59	532
		Late-fall	224	18	154
		Spring	136	11	111
		Winter	151	12	102
	Total Hatchery		**1,247**		**899**
	Unknown Race		**12**		**8**
	Grand Total		**18,135**		**13,546**

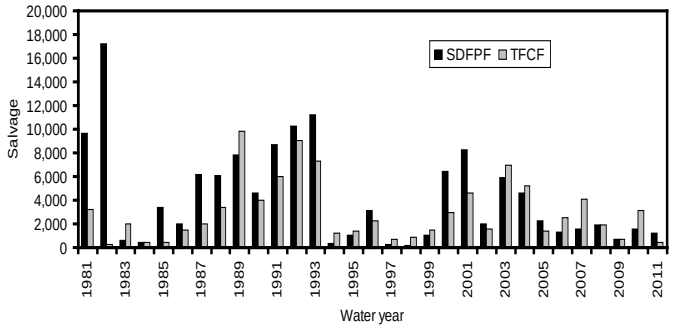

Figure 7 Annual salvage of steelhead (wild and hatchery origins combined) at the SDFPF and the TFCF, 1981 to 2011

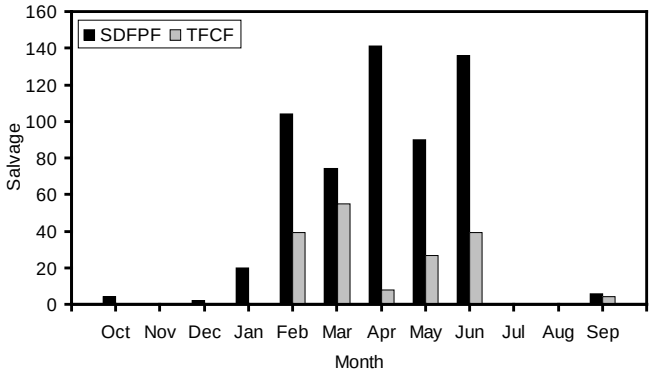

Figure 8 Monthly salvage of wild steelhead at the SDFPF and the TFCF, 2011

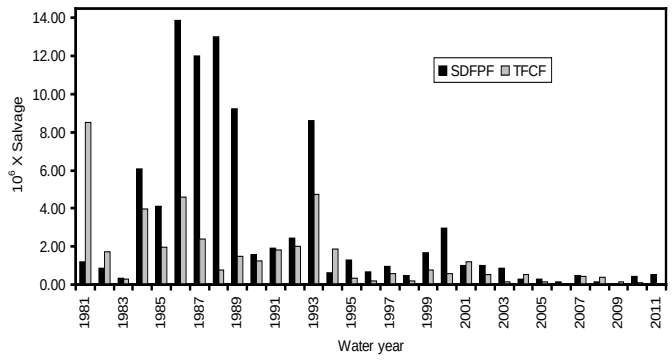

Figure 9 Annual salvage of striped bass at the SDFPF and the TFCF, 1981 to 2011

Most striped bass salvage at the SDFPF and the TFCF occurred in July and August (Figure 10). At the SDFPF, July salvage (331,167) and August salvage (63,006) accounted for 77.7% of annual salvage. At the TFCF, salvage during July (14,575) and August (8,236) accounted for 57.6% of annual salvage. Striped bass were salvaged every month at both facilities, with the lowest monthly salvage occurring in May at both the SDFPF (501) and the TFCF (37).

Delta Smelt

Record-low numbers of delta smelt were salvaged at TFCF (51) (Figure 11). Salvage at the TFCF was also low in 2010 (99). No delta smelt were salvaged at SDFPF for the first time recorded for 1981-2011 and salvage was low in 2010 (22).

Adult delta smelt were only salvaged in January (8), February (4), March (36), and April (3) at the TFCF. No juvenile delta smelt were salvaged at the TFCF.

Delta smelt less than 20 mm were first detected on June 9 at the SDFPF and were observed for 3 days there. No delta smelt less than 20 mm were detected at the TFCF.

Longfin Smelt

Longfin smelt at both facilities continued to be salvaged at very low levels or not at all compared to the early 2000s and the late 1980s (Figure 12). Only 4 adult longfin smelt were salvaged in January at TFCF and none were salvaged at SDFPF. No longfin smelt less than 20 mm were detected at either facility.

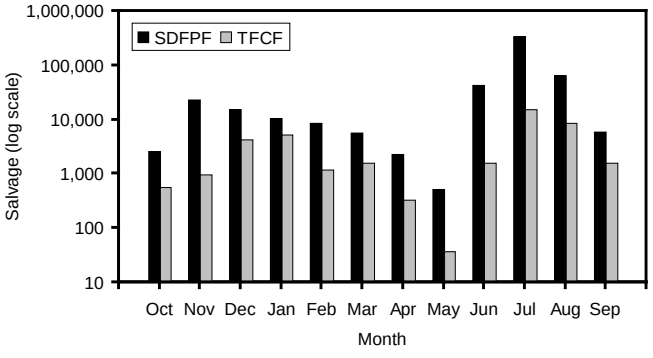

Figure 10 Monthly salvage of striped bass at the SDFPF and the TFCF, 2011. The logarithmic scale is log_{10}.

Splittail

Salvage of splittail at both facilities was higher than in 2010 (Figure 13). Salvage at the SDFPF (1,326,077) was much higher than in 2010 (28,062). Salvage was a record high at the TFCF (7,660,024) which was substantially higher than in 2010 (160,929). Splittail salvage has followed a boom-or-bust pattern, often varying year to year by several orders of magnitude.

Threadfin Shad

Annual salvage at the SDFPF (463,610) was lower than at the TFCF (591,111) (Figure 14). Salvage at the SDFPF was lower than in 2010 (725,433). Similarly, TFCF salvage was lower than in 2010 (763,105). Similar to splittail, annual salvage of threadfin shad has varied greatly through time.

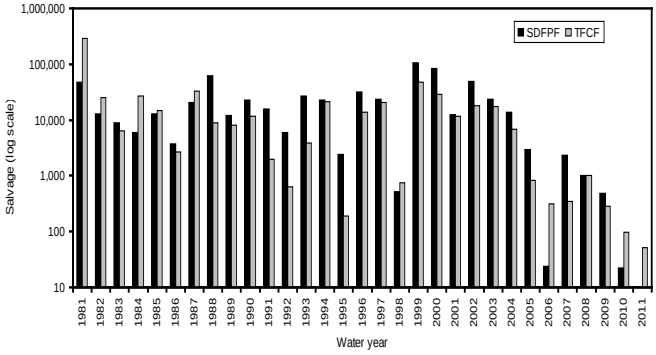

Figure 11 Annual salvage of delta smelt at the SDFPF and the TFCF, 1981 to 2011. The logarithmic scale is log_{10}.

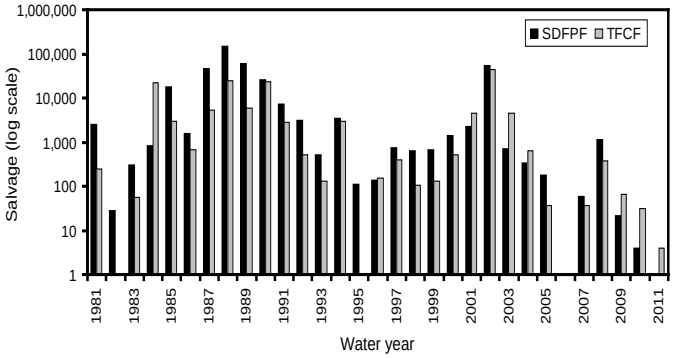

Figure 12 Annual salvage of longfin smelt at the SDFPF and the TFCF, 1981 to 2011. The logarithmic scale is log_{10}.

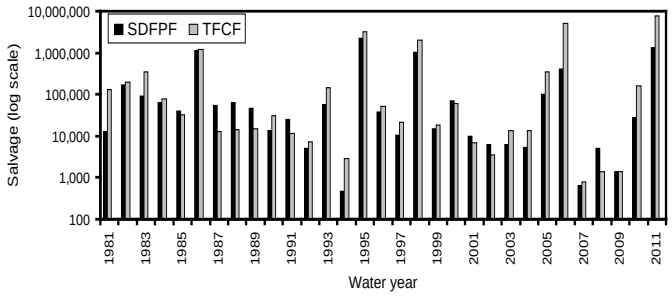

Figure 13 Annual salvage of splittail at the SDFPF and the TFCF, 1981 to 2011. The logarithmic scale is log_{10}.

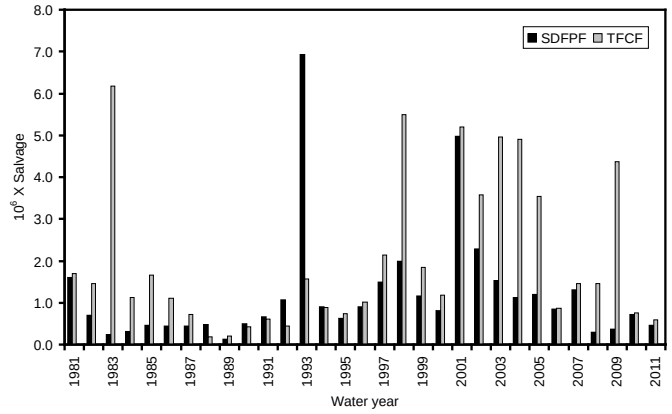

Figure 14 Annual salvage of threadfin shad at the SDFPF and the TFCF, 1981 to 2011

References

California Dept. of Fish and Game. 2006. Chinook salmon loss estimation for Skinner Delta Fish Protective Facility and Tracy Fish Collection Facility. Protocol. Stockton: California Dept. of Fish and Game; p. 4. Available from the California Dept. of Fish and Game, Bay-Delta Region East, 4001 N. Wilson Way, Stockton, California 95205.

Delta Smelt Captive Refugial Population--2011 Season Summary

Kathleen Fisch (UCD and San Diego Zoo Global Institute for Conservation Research kfisch@sandiegozoo.org), Brian Mahardja (UCD), Theresa Rettinghouse, Luke Ellison, Galen Tigan, Joan Lindberg (FCCL-UCD), Bernie May (UCD)

The captive delta smelt refugial population is located at the Fish Conservation and Culture Laboratory (FCCL) of University of California, Davis (UCD), and is managed in collaboration with the UCD Genomic Variation Laboratory. The captive refugial population was initiated in 2008, and has progressed to the F_4 generation in 2011 (Fisch et al. 2009; 2010).

Spawning season 2011 for the delta smelt refugial population started in late January 2011 and concluded on June 1, 2011. A total of 1,753 fish were uniquely tagged and genetically analyzed according to the methods in Fisch et al. (2009, 2010). The pedigree was reconstructed and the pairwise kinship of all individuals was calculated using 12 microsatellite markers. Fish were spawned in genetically recommended single pair crosses, and 516 fish were successfully paired, based on a modified method of minimal kinship selection, representing 187 of the 233 families made in 2010 (Fisch et al. 2010). A total of 68 wild fish were incorporated into the captive population this generation.

The genetic diversity of the parental F_3 generation was assessed to genetically monitor the captive population. A total of 259 alleles were identified and allelic richness (AR) ranged from 6.27 to 29.56 alleles at each locus (Tables 1 and 2). The mean expected heterozygosity (HE), including wild fish incorporated into the captive population, was 0.84 (ranging from 0.46-0.96) (Table 1). These values were not significantly lower than the founding generation F_0. When compared across all loci, the difference between generations was not significant ($P<0.05$).

In conclusion, the captive refugial population continues to maintain the genetic diversity of the delta smelt population and is demographically stable. Future generations in captivity will be similarly managed in an effort to preserve the genetic and demographic integrity of the delta smelt population.

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