2006 Fish Salvage at the Tracy Fish Collection Facility

by

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Introduction

The Tracy Fish Collection Facility (TFCF) diverts (salvages) fish from water exported from the Sacramento-San Joaquin Estuary. The TFCF began operation in 1957 and uses a louver-bypass system to salvage fish from the exported water. The salvaged fish are returned to the San Francisco Estuary by loading the salvaged fish into tanker trucks and trucking them to predetermined release sites.

This report summarizes salvage information from the TFCF collected in 2006. The following species are given individual consideration: Chinook salmon (*Oncorhynchus tshawytscha*), steelhead (*O. mykiss*), striped bass[1] (*Morone saxatilis*), American shad (*Alosa sapidissima*), longfin smelt (*Spirinchus thaleichthys*), delta smelt[1] (*Hypomesus transpacificus*), inland silversides[1] (*Menidia beryllina*), threadfin shad[1] (*Dorosoma petenense*), Sacramento splittail (*Pogonichthys macrolepidotus*), green sturgeon (*Acipsenser medirostris*), white sturgeon (*A. transmontanus*), common carp (*Cyprinus carpio*), and Chinese mitten crab (*Eriocheir sinensis*).

Methods

The daily volume of water exported was reported daily from gauge readings from the Tracy Pumping Plant (TPP) at Byron. Water temperature was recorded during routine counts at both the TFCF. Monthly water exports were plotted and examined for time trends. Annual exports were determined from 1981 – 2006 for the Central Valley Project (CVP). Daily mean water temperature was calculated and examined for time trends during 2006.

1. Pelagic Organisms Decline (POD) species of interest

Abundance of fish/mitten crabs was reported in terms of estimated salvage. Only fish that are greater than 20 mm FL (TL in the case of sturgeon, *Acipenser spp.*) were numerated (counts) as the salvage efficiency of the facility drop off rapidly for fish less than this size. Salvage estimates are primarily obtained by expanding the routine sample counts for the given time that water was pumped using the following equation:

$$SALVAGE_{SAMPLE} = COUNT_{SAMPLE} \mathbf{x} (MINUTES\ PUMPING \mathbf{/} MINUTES_{SAMPLE}). \quad (1)$$

Fish collected from predator removals are not expanded:

$$SALVAGE_{PREDAROR\ REMOVAL/SECONDARY\ FLUSH} = COUNT_{PREDAROR\ REMOVAL/SECONDARY\ FLUSH.} \quad (2)$$

Monthly or annual salvage estimates were calculated by the summation of Equations (1) and (2) by month or year. Intra-annual abundance were examined by plotting the monthly salvage totals for selected species and for all taxa combined for 2006. Relative abundance between years was analyzed by graphing the annual salvages for selected species/all taxa combined from 1981-2006. The prevalent species in salvage were determined by ranking the annual salvage totals in descending order with the 10 most prevalent species identified.

The annual and daily salvage estimates for Chinook salmon and steelhead were subcategorized as wild, hatchery or fish of unknown origin. Salmonids of wild or hatchery origin were determined by the presence (wild) or absence (hatchery) of adipose fins. The race of Chinook salmon was classified by the Delta Salmon Length-Race Key using body size and date of capture information. Salmonids were recorded as unknown race or origin when the count observations were insufficient to categorize their status.

Fish loss was reported for Chinook salmon only since key loss information are lacking for other species. Loss is the difference of the estimated number of fish encountered by the facility minus the fish that survive salvage operations. Loss was subcategorized by origin and race.

Length measurements were taken systematically to determine the size of fish/mitten crabs. The annual minimum, maximum, and mean lengths measurements were calculated for all selected species. Fork length (FL) was measured for all species except for sturgeon (*Acipenser spp.*) and mitten crabs where total length (TL) or carapace width was reported respectively.

Water Exports

The CVP exported 2,598,459 acre-feet (AF) of water in 2006 with the majority of water exported from June through December. The 2006 annual export was comparable to exports in recent years (Figure 1). The 2006 annual export was slightly less than the 2005 annual export of 2,697,081. The CVP export water for almost the entire year, 360 days.

Monthly exports ranged from 48,483 (April) to 270,452 (July) AF with 58% of the exports occurring from July through December (Figure 2). Exclusive of March through June, monthly exports ranged from 239,602 to 270,452 AF with a mean of 254,920 AF.

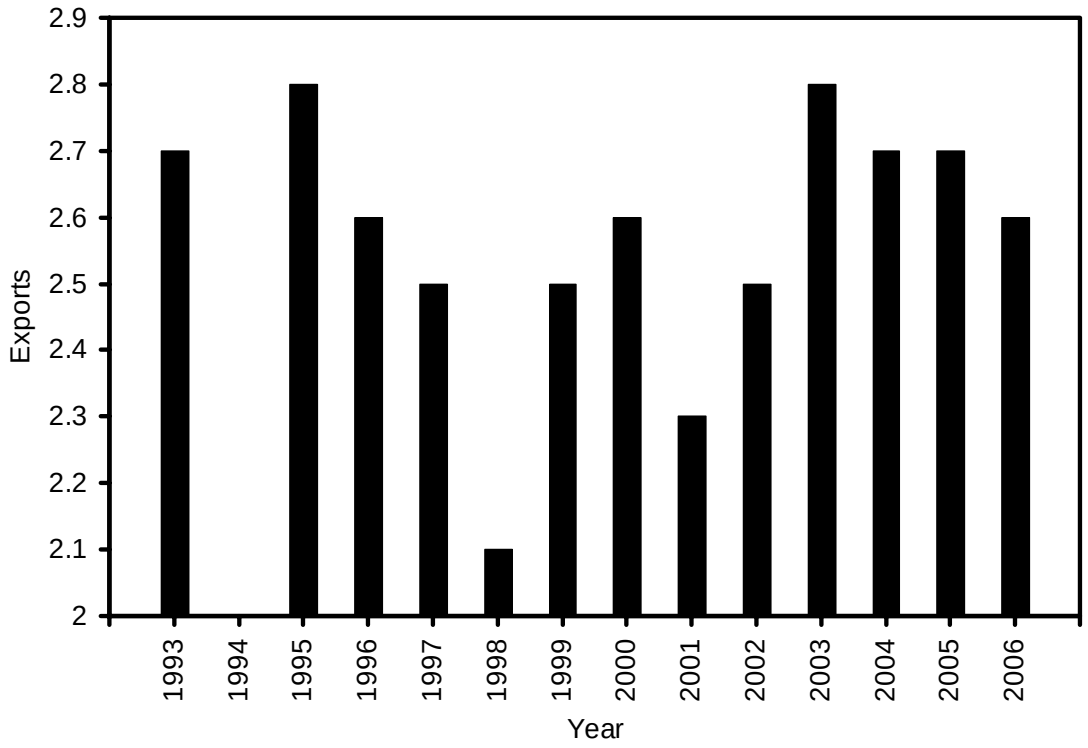

Figure 1. Annual exports (in millions of acre-feet) for the Central Valley Project, 1993 – 2006.

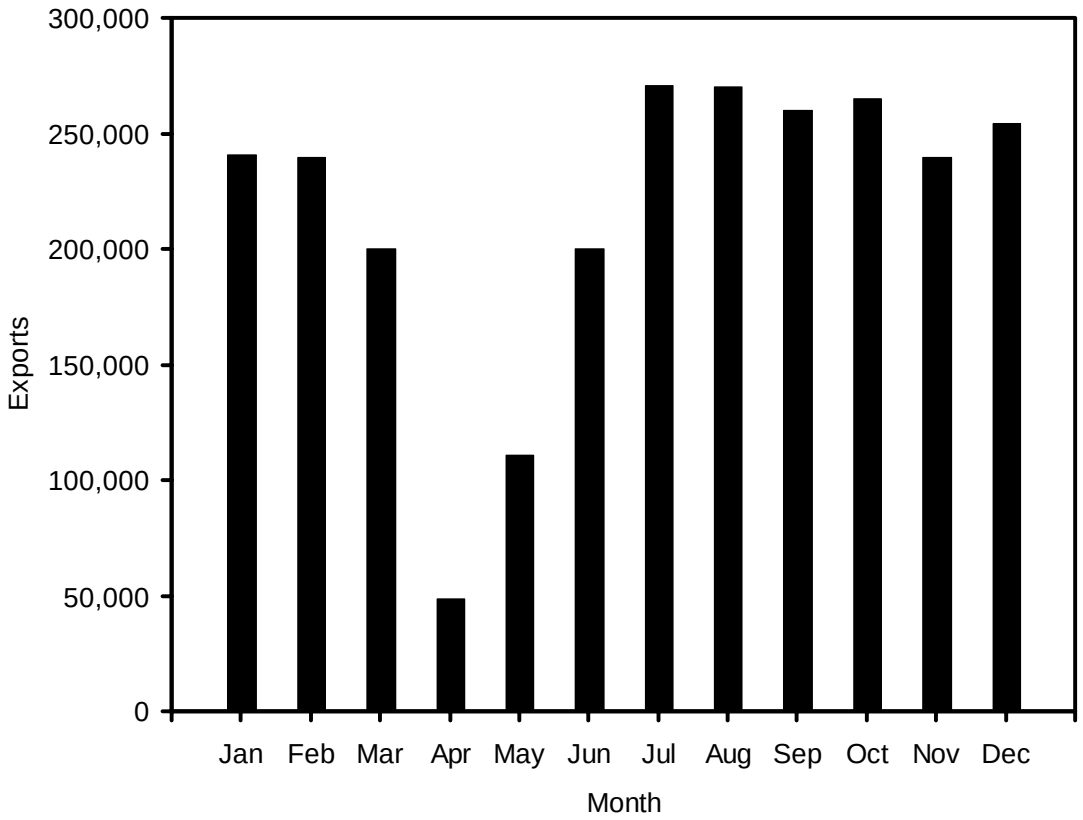

Figure 2. Monthly exports (in acre-feet) for the Central Valley Project, 2006.

Water Temperature

The graph of the daily mean temperature displays the expected trend of rising temperature through the winter and spring, peaking in the summer, and declining thereafter (Figure 3). Daily mean temperature ranged from 46.3 to 83.5 ^{o}F with mean of 62.3 ^{o}F. The thermograph reported distinct peak temperatures from July 15th though July 31st with the maximum mean temperature on July 25th (Figure 3).

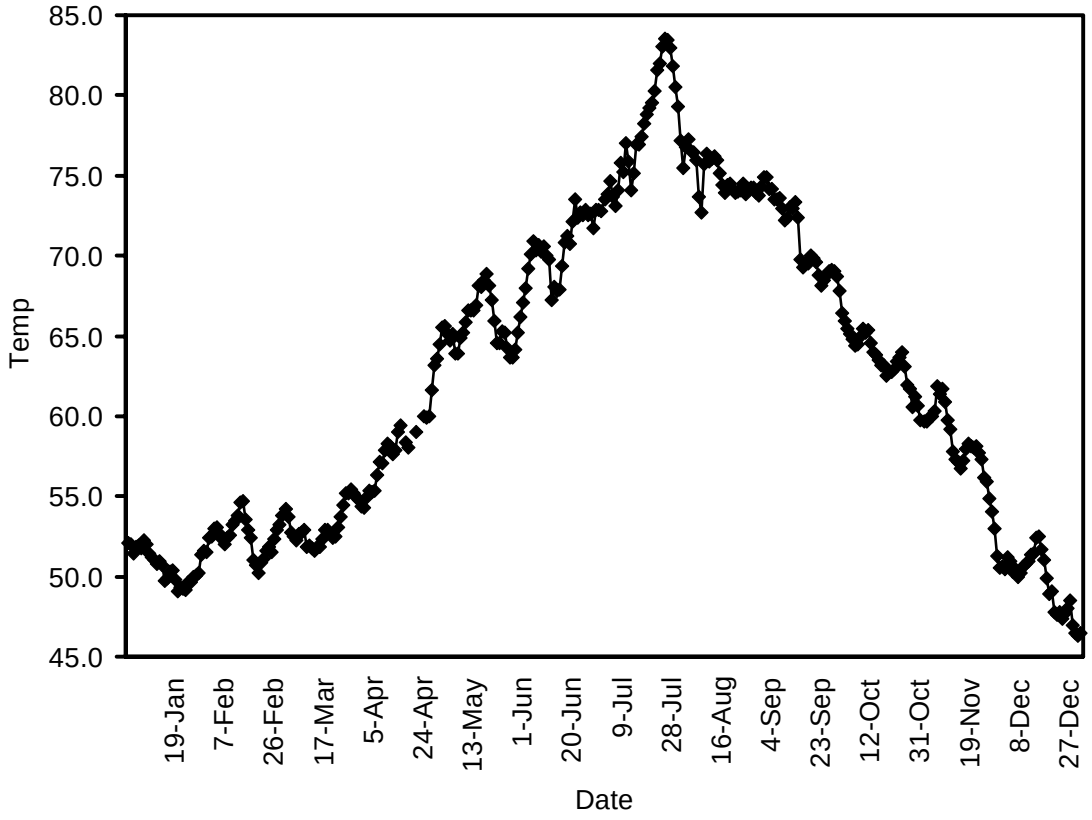

Figure 3. Daily mean water temperature (^{o}F) for the TFCF, 2006.

Total Salvage and Prevalent Species

Annual salvage in 2006 of 37,266,449 fish and mitten crabs was a record high for the period of record with the majority of salvage occurring in June. Annual salvage values were typically below 10 million per year (Figure 4). However, the 2006 annual salvage dwarfed any previous

value and represented an order of magnitude increase from the TFCF annual salvage in 2005 (2,430,645). The June salvage of 34,913,860 accounted for 93.7% of the annual salvage. Exclusive of June, monthly salvage ranged from 20,903 (March) to 1,276,708 (July).

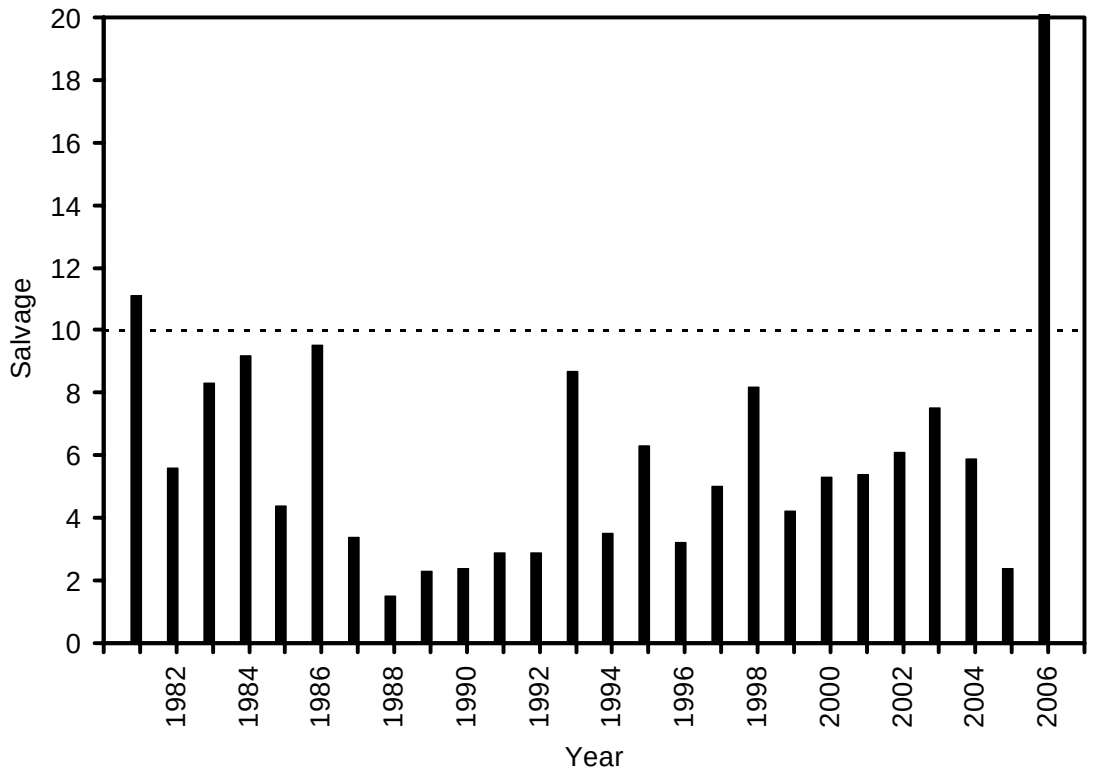

Figure 4. Annual salvage (in millions) of all taxa combined at the TFCF, 1981 – 2006. The 2006 annual salvage of 37,266,449 has been truncated for scale considerations.

The daily salvage on June 20th of 11,552,136 fish was the largest recorded daily total since 1957. This day accounted for 31% of the 2006 annual salvage total for TFCF. Common carp composed over 98% of the fish salvaged. Only 3 other dates had daily salvages over 10 million fish per day: July 1st 1965 (10,278,474: mostly striped bass), July 1st 1967 (10,585,712: mostly white catfish and American shad) and July 1st 1970 (10,539,158: mostly striped bass).

Common carp dominated the annual salvage total. Common carp accounted for 81.8% of the annual salvage. Sacramento splittail was the second most prevalent species collected at the TFCF. The other 8 most prevalent species were: threadfin shad, white catfish (*Ameiurus catus*), largemouth bass (*Micropterus salmoides*), American shad, bluegill (*Lepomis macrochirus*), black crappie (*Pomoxis nigromaculatus*), channel catfish (*Ictalurus punctatus*), and striped bass (Figure 5).

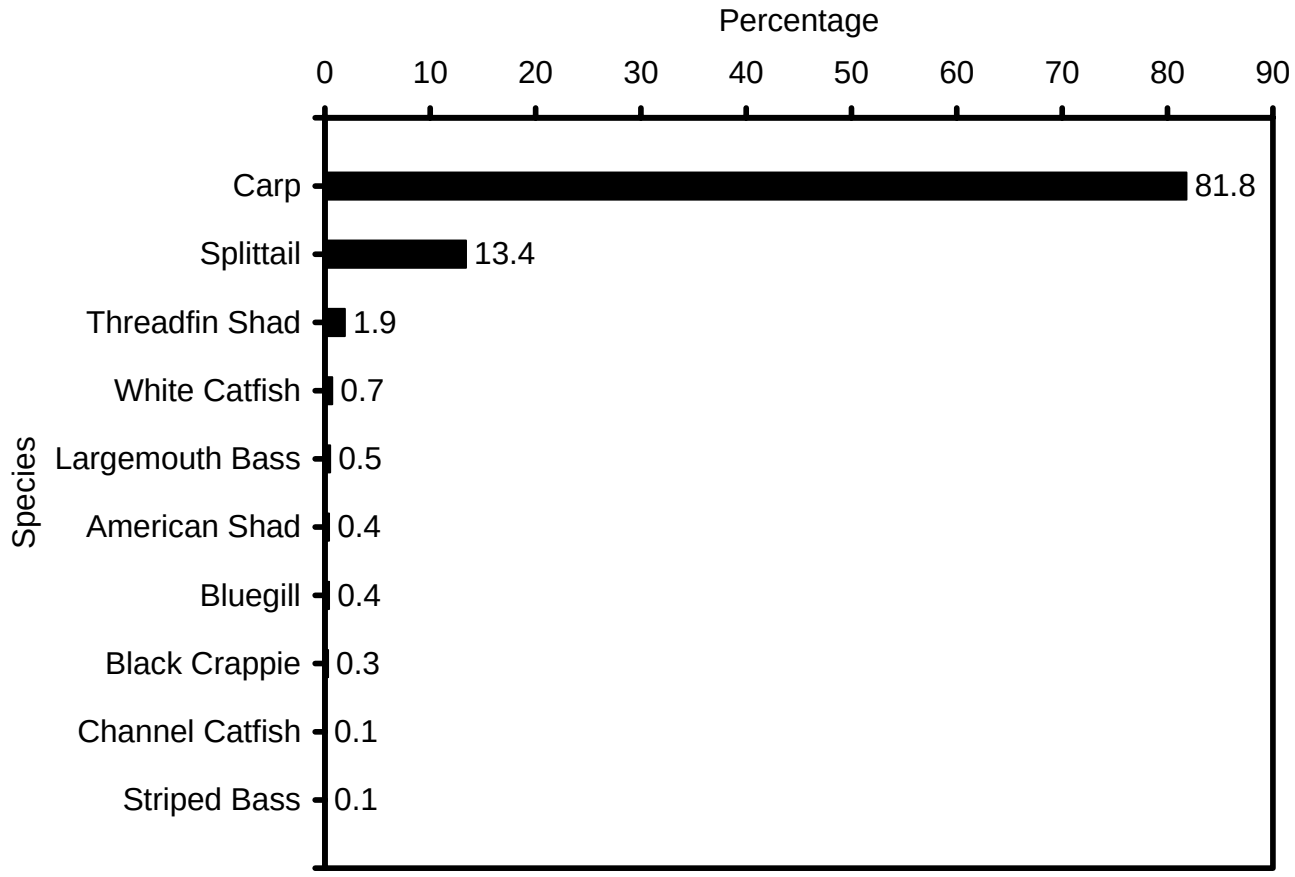

Figure 5. Percentage of annual salvage of the 10 most prevalent species at TFCF, 2006.

In recent years, threadfin shad has made up the bulk of the annual salvage. Large proportions of carp and splittail have occurred only in 1995 and 1998 (Figure 6). Therefore, the

domination of salvage by carp and splittail may be rare and similar to the “boom and bust” nature of splittail salvage.

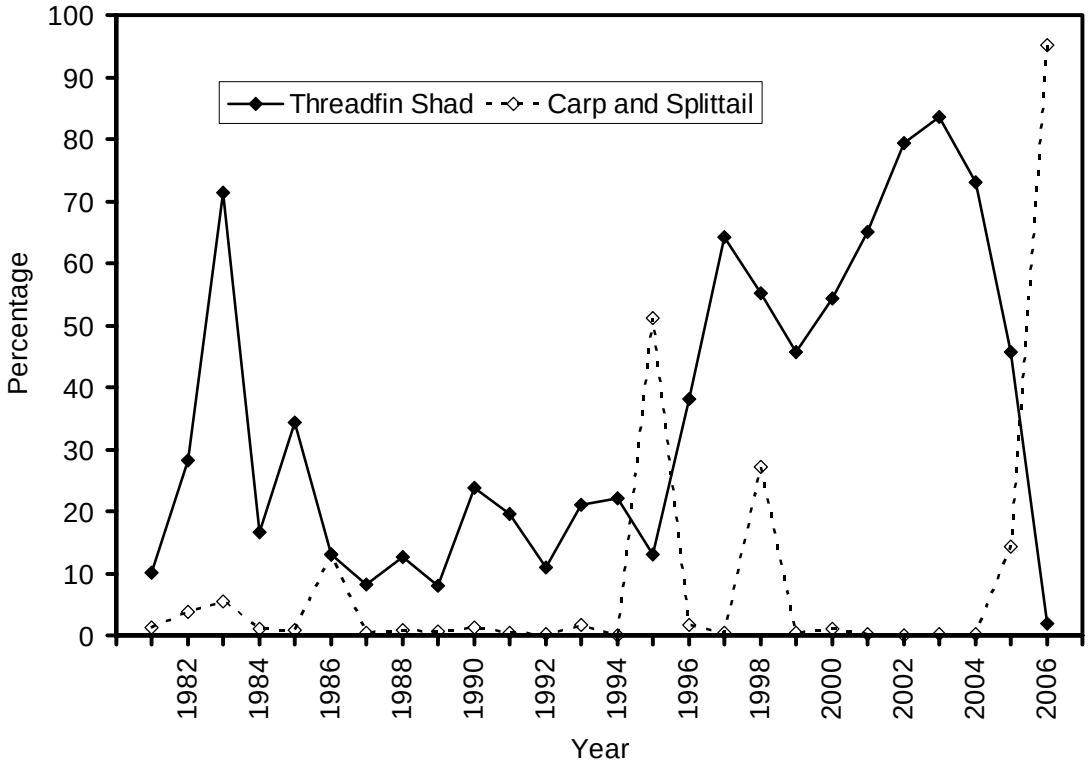

Figure 6. Percentage of annual salvage represented by threadfin shad and carp+splittail at the TFCF, 1981 – 2006.

Common Carp

The annual salvage of common carp set a record high with the majority collected in June. The 2006 annual salvage was 30,495,884 with the annual total ranging from 84 to 175,374. Typical annual salvages of carp are less than 4,000/year (Figure 7). Years that salvaged more than 4,000 fish were 1982-1984, 1995, 1998, and 2005-2006 (Figure 7). The June salvage of 30,018,630 accounted for 98.4% of the annual salvage of carp. The next highest monthly salvage was in July: 463,488. Exclusive of these 2 months, monthly salvage ranged

from 0 to 7,324. Carp salvaged at the TFCF ranged from 20 to 285 mm FL with a mean of 58 mm FL (n = 4,420) and the 75th percentile estimated at 67 mm FL.

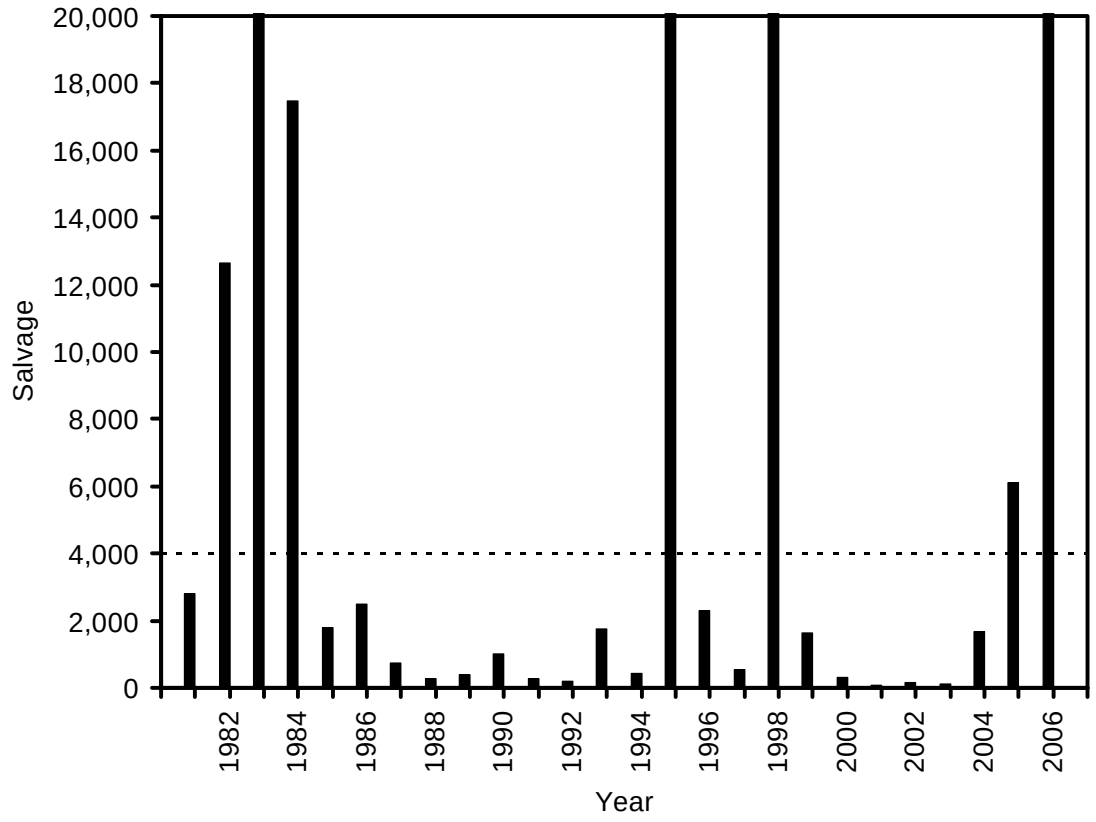

Figure 7. Annual salvage of carp at the TFCF, 1981 – 2006. The annual salvages for the following years have been truncated for scale considerations: 1983 (109,549), 1995 (75,654), 1998 (175,374), and 2006 (30,495,884).

Sacramento Splittail

The annual salvage of splittail was higher in 2006 than opposed to 2005 and a new record high. The 2006 annual salvage was 5,002,611 and a dramatic increase from the 2005 value of 342,595. Large annual salvages (> 150,000) have been seen in 1982, 1983, 1986, 1995, 1998, and 2006 (Figure 8).

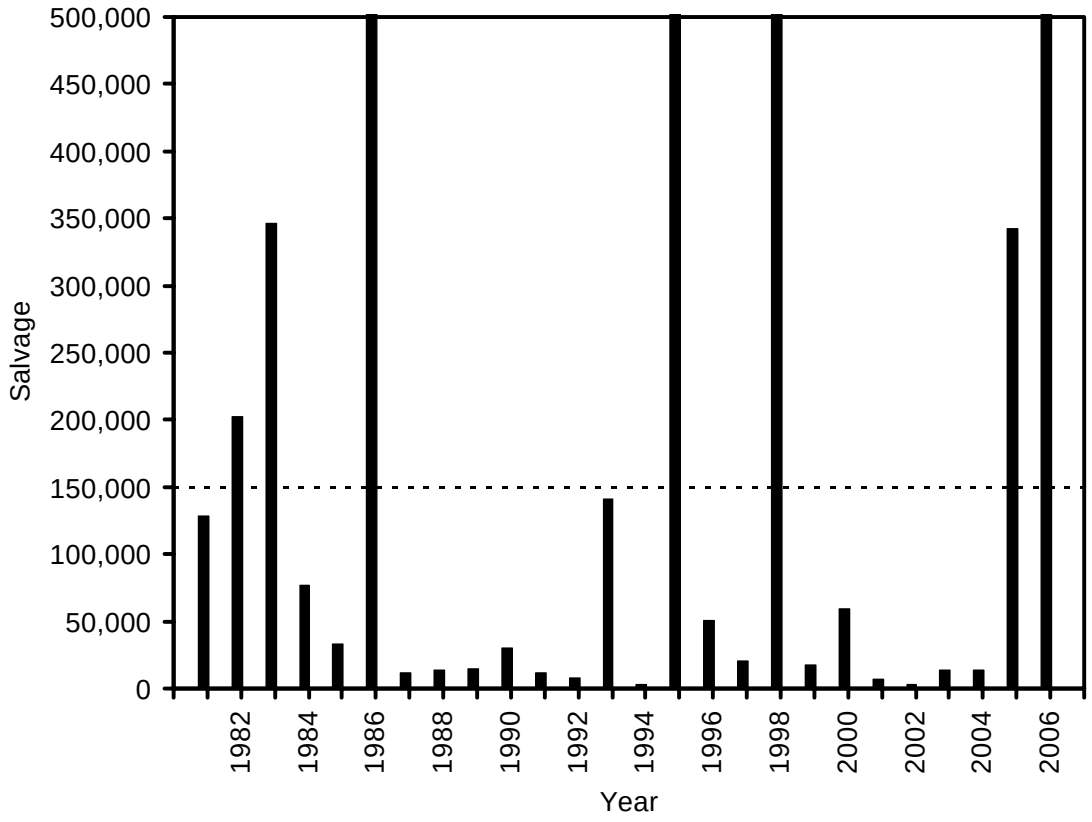

Figure 8. Annual salvage of Sacramento splittail at the TFCF, 1981 – 2006. The following annual salvages for the following years have been truncated for scale considerations: 1986 (1,231,283), 1995 (3,143,156), 1998 (2,051,660), and 2006 (5,002,611).

Most splittail were salvaged during May through July and were young-of-the-year. The combined salvage of May (231,858), June (4,565,037), and July (205,032) accounted for almost 100% of the annual salvage. During this period splittail lengths ranged from 20 to 335 mm FL with a mean of 48 mm FL (n = 4,862) and the 99th percentile estimated at 84 mm FL. Splittail salvaged outside the above time frame ranged from 0 to 576 mm FL.

Threadfin Shad

Annual salvage of threadfin shad was lower in 2006 than in 2005. The 2006 annual salvage was 717,112, less than the 2005 salvage of 1,111,569. Annual salvage totals over 2 million are historically the exception and not the rule and is a relatively recent phenomenon. The

TFCF had annual salvages over 2 million, eight years out of the last 26 (Figure 9). The record low occurred in 1989 (182,112).

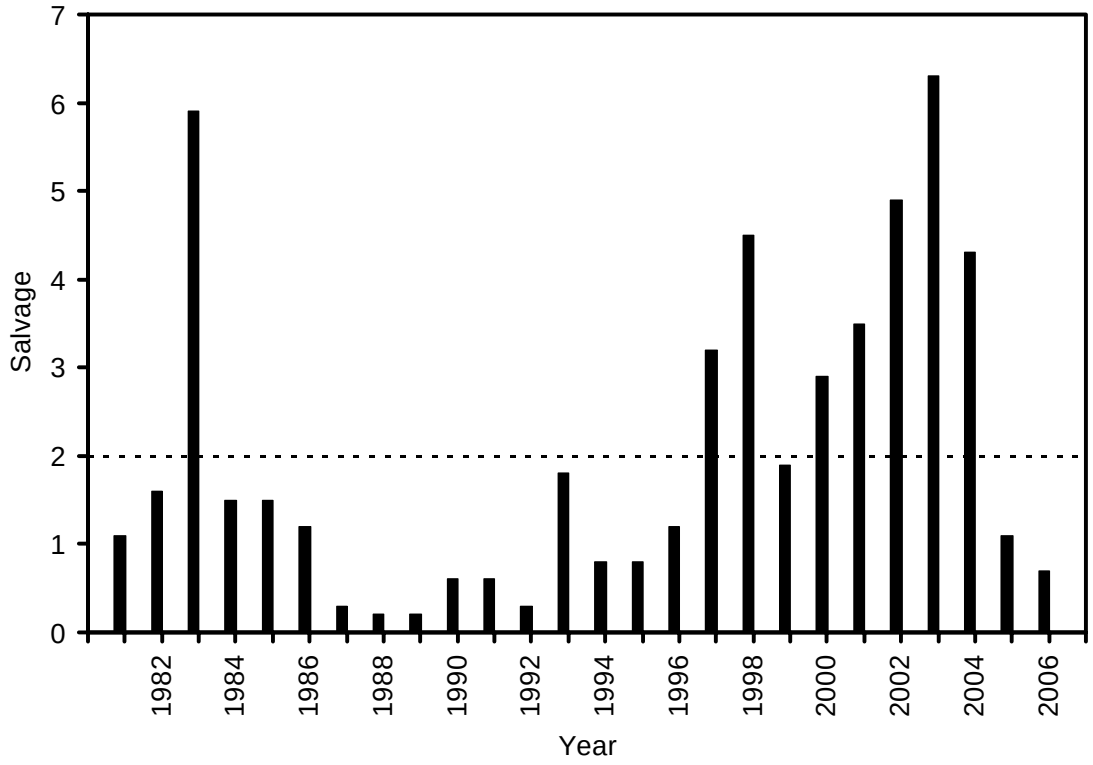

Figure 9. Annual salvage (in millions) of threadfin shad at the TFCF, 1981 – 2006.

The majority of threadfin shad were salvaged in the summer months (Figure 10). The June – September salvage accounted for 76% of the annual salvage. Monthly salvaged ranged from 469 in April to 249,660 in July with threadfin shad being salvaged in all months (Figure 10).

The majority of threadfin shad salvaged were age-1 and age-2 fish. Threadfin shad lengths ranged from 20 to 192 mm FL with a mean length of 64 mm FL (n = 8,670) with the 99th percentile estimated at 115 mm FL. Moyle (2002) indicated that threadfin shad are normally 60 - 100 mm TL by the end of their second year. Threadfin shad lengths greater than 200 mm FL (4 lengths) were excluded.

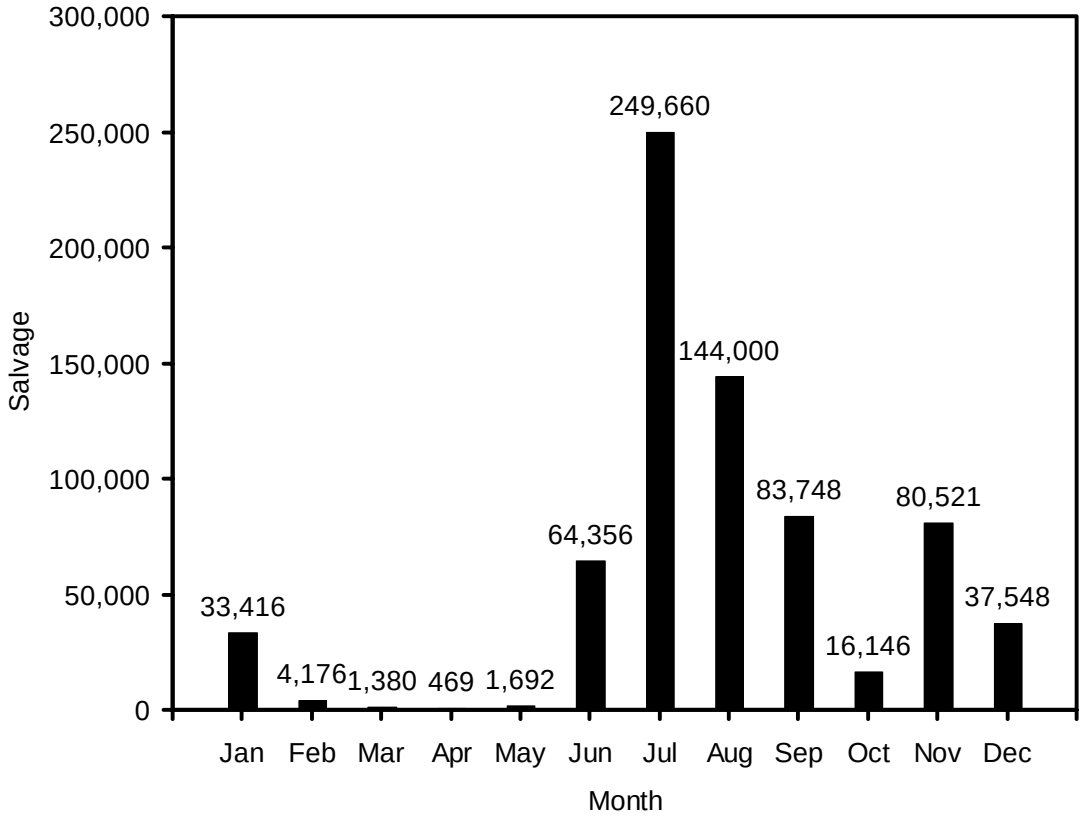

Figure 10. Monthly salvage of threadfin shad at the TFCF, 2006.

American Shad

The annual salvage of American shad was lower in 2006 as opposed to 2005. The 2006 annual salvage was 151,068 compared to the 329,119 American shad salvaged in 2005. The annual salvage in 2006 was a continuation of the declining trend that started in 2003 (Figure 11).

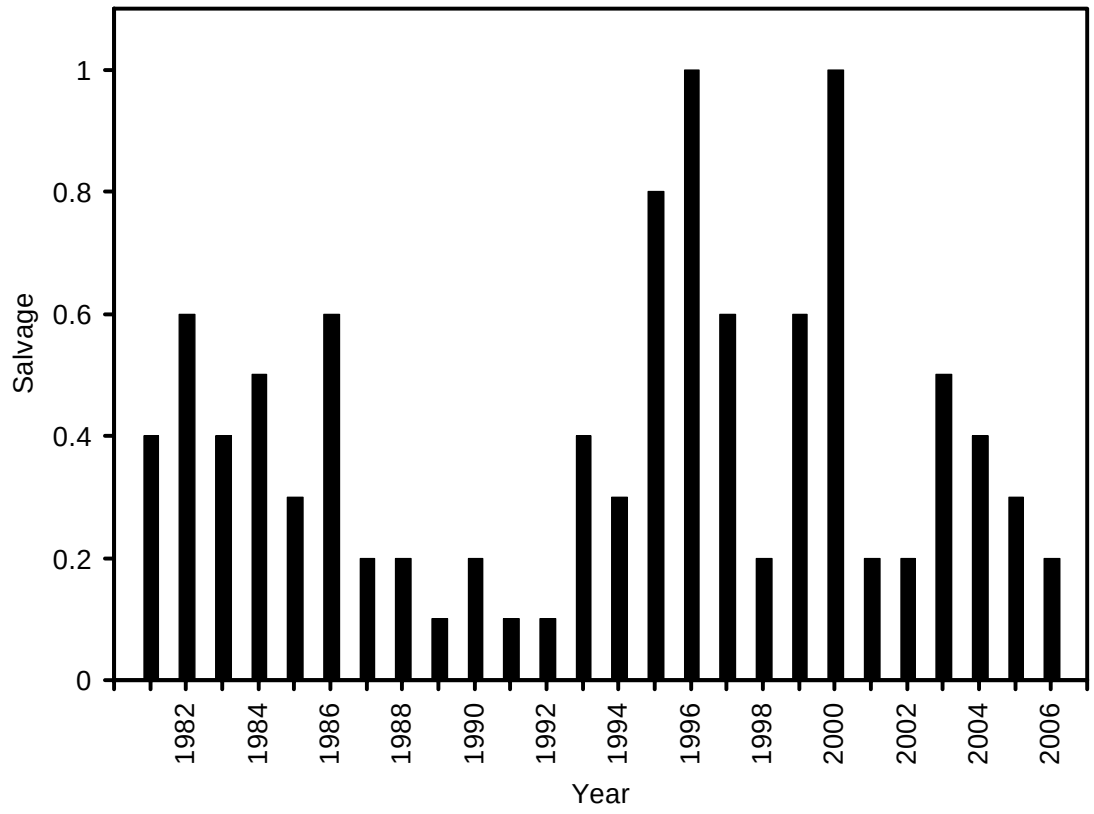

Figure 11. Annual salvage (in millions) of American shad at the TFCF, 1981 – 2006.

The majority of American shad salvaged in 2006 were salvaged in the last half of the year (Figure 12) with most fish salvaged being young-of-the-year. The monthly salvage ranged from 0 to 47,460 with the July – December salvage accounting for 83% of the annual salvage.

American shad ranged from 20 to 470 mm FL with a mean of 80 mm FL (n = 3,506) with the 90th percentile estimated at 112 mm FL.

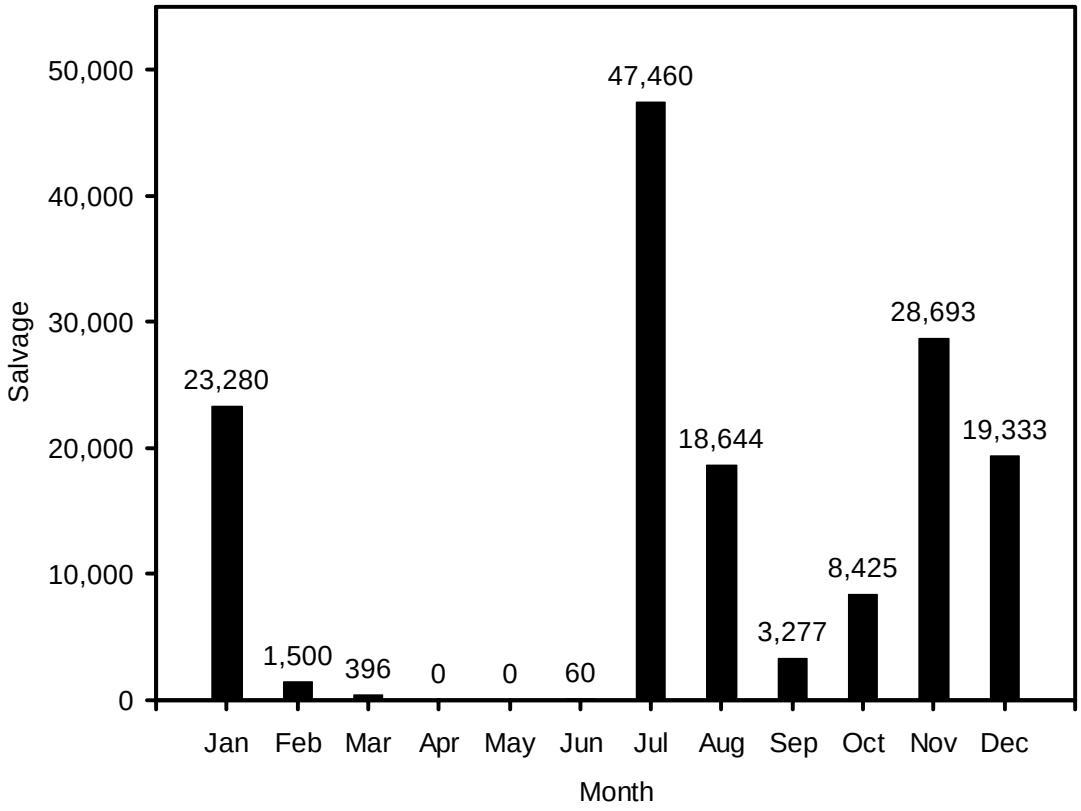

Figure 12. Monthly salvage of American shad at the TFCF, 2006.

Striped Bass

The salvage of striped bass in 2006, 37,359, was a new low for the period of record and continued the recent decline that started in 2004 (Figure 13). The next lowest annual salvage was observed in 2005: 124,645. Since 1994, annual salvage of striped bass has been much less than in previous years (Figure 13).

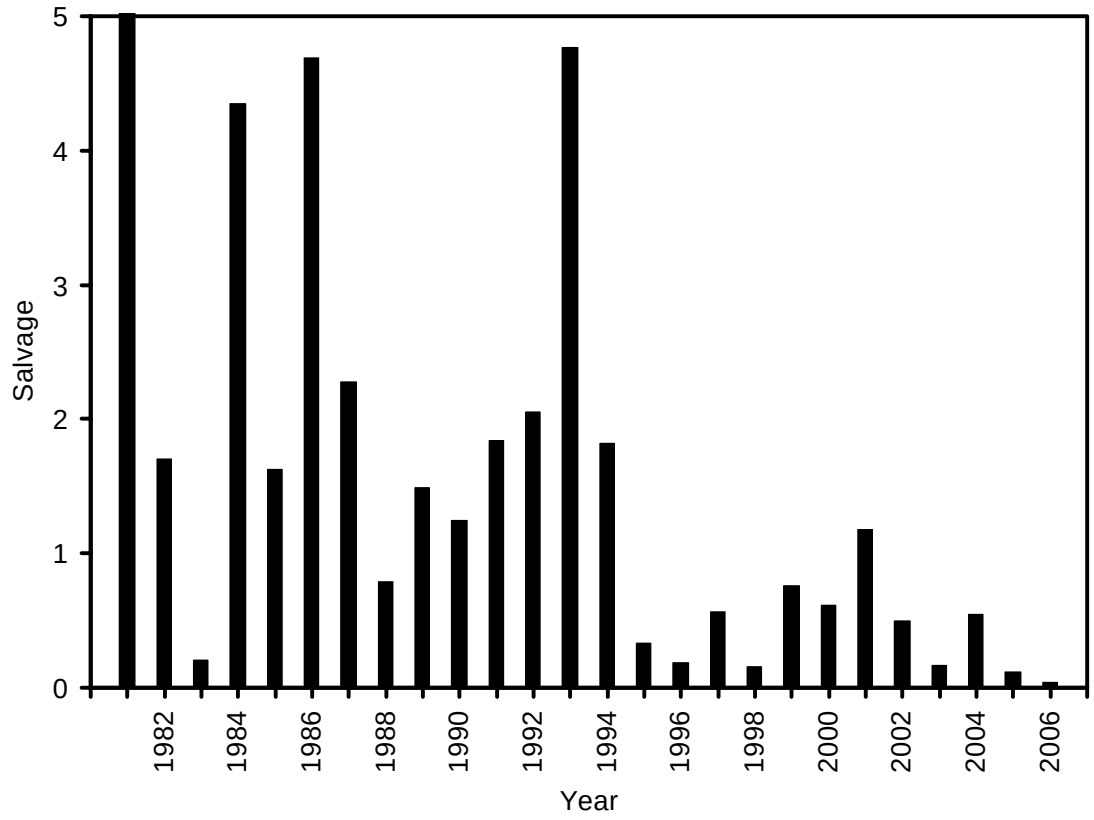

Figure 13. Annual salvage (in millions) of striped bass at the TFCF, 1981 – 2006. The annual salvage of 8,341,684 in 1981 has been truncated for scale considerations.

The months of July and August accounted for the majority of striped bass salvage in 2006. The July salvage of 14,016 and the August salvage of 6,511 accounted for 55% of the annual salvage. Exclusive of July and August, striped bass were salvaged every month with salvage ranging from 278 to 2,983 (Figure 14).

Salvaged striped bass were composed of multiple age classes. Striped bass lengths ranged from TFCF ranged from 20 to 560 mm FL with a mean length of 125 mm FL (n = 924).

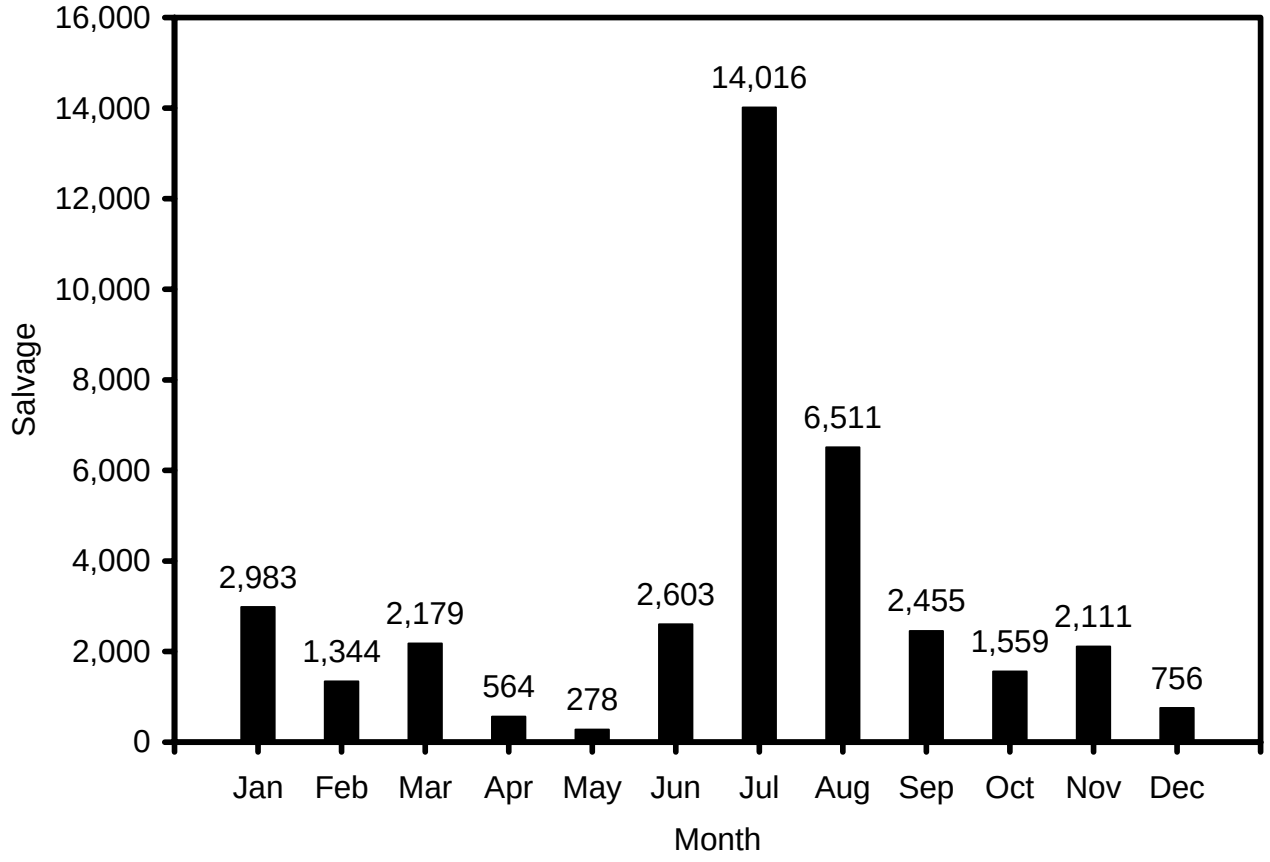

Figure 14. Monthly salvage of striped bass at the TFCF, 2006.

Chinook Salmon

Annual salvage (all races and origins combined) of Chinook salmon (salmon) in 2006 continued to be low when compared to historical data. The 2006 salvage of salmon at the TFCF of 35,319 was an increase from the annual salvage of 25,637 observed in 2005. The 2006 total continues the recent increasing trend that started in 2002 (Figure 15). However, these annual totals are dwarfed by annual salvages observed in the 1980's and the late 1990's (Figure 15).

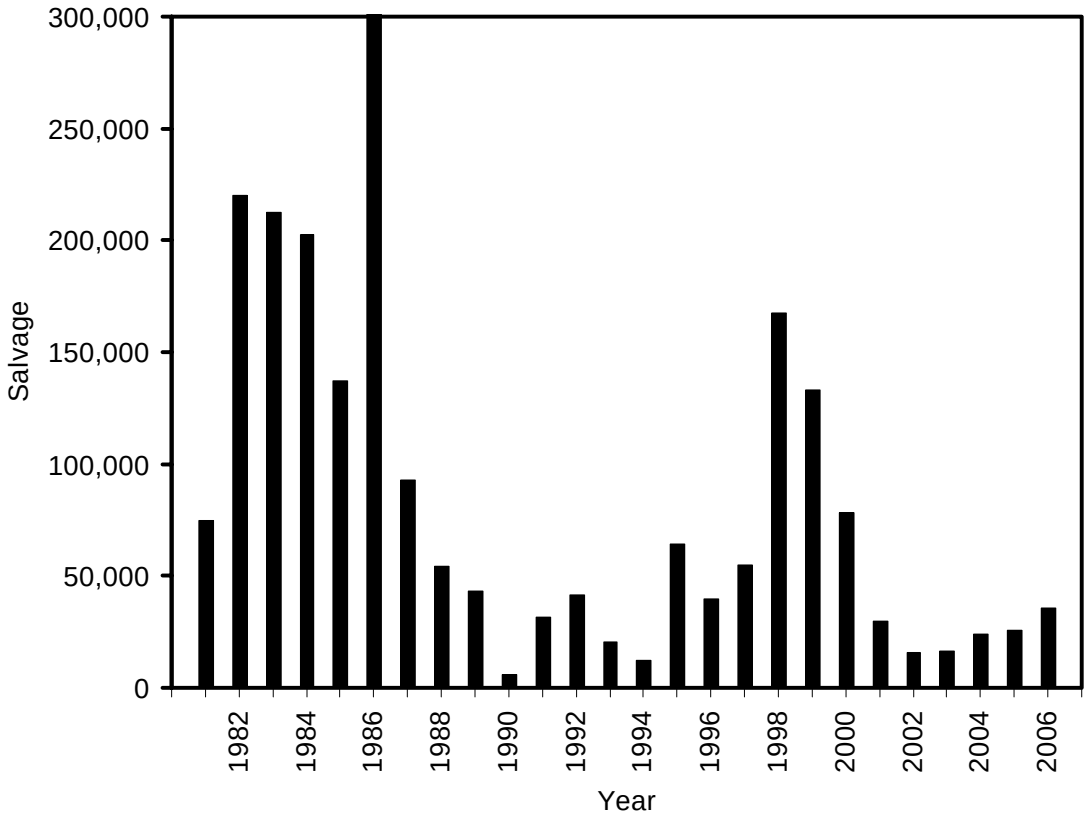

Figure 15. Annual salvage of Chinook salmon (all races and origins combined) at the TFCF, 1981 – 2006. The 1986 salvage of 752,039 have been truncated for scale considerations.

Salvage of Chinook salmon at both facilities was primarily wild, fall run fish followed wild, spring run fish with the majority of salvage occurring in a narrow time frame. Salvage of salmon by origin was: 32,828 wild, 2,095 hatchery, and 396 unknown. Salvage of wild fish by race was:

- Fall: 28,841 – 82% of the annual salvage
- Late-fall: 12 - <1% of the annual salvage
- Spring: 3,456 - 10% of the annual salvage
- Winter: 519 – 1% of the annual salvage.

The majority of fall run fish (83%) were salvaged in June. The majority of spring run salvage (69%) occurred in May (Figure 16).

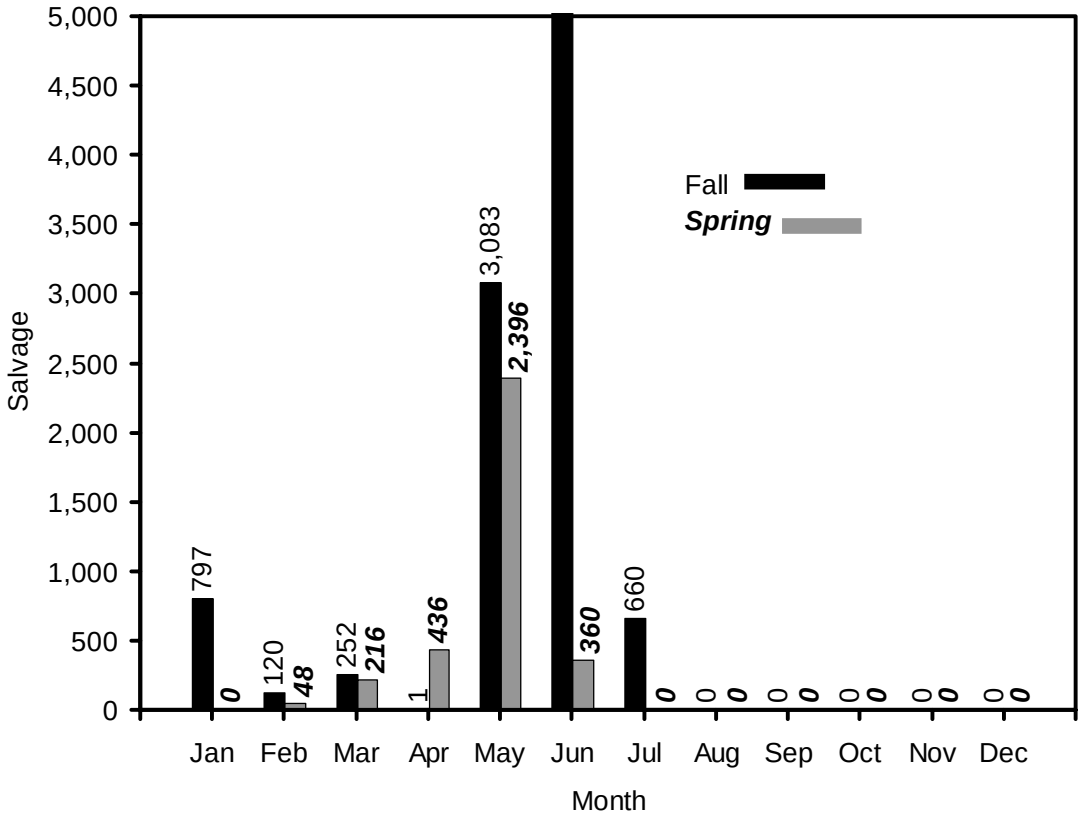

Figure 16. Monthly salvage of wild fall and spring run Chinook salmon at the TFCF, 2006. The June salvage of fall run salmon, 23,928 has been truncated for scale considerations.

Loss at the TFCF in 2006 paralleled salvage. Loss by origin was 21,928 wild fish and 1,480 hatchery fish. Loss was not calculated for fish of unknown origin. Loss of wild fish by race was:

- Fall run: 18,863
- Late-fall run: 8
- Spring run: 2,720
- Winter run: 337

The size of salmon salvaged in 2006 ranged from 30 to 182 mm FL. Salvaged winter and late-fall run fish tended to be larger (Table 1).

Table 1. Minimum length, mean length, maximum length, and sample size (n) by origin and race for Chinook salmon salvaged by the TFCF, 2006. All lengths are in mm FL.

Origin	Race	Min. Length	Mean Length	Max. Length	n
Wild					
	Fall	30	92	125	1,582
	Late-fall	n/a	139	n/a	1
	Spring	55	105	130	324
	Winter	98	127	182	46
Hatchery					
	Fall	78	99	114	86
	Late-fall	143	165	186	2
	Spring	94	112	132	40
	Winter	100	127	173	17

Inland Silversides

Annual salvage of inland silversides decreased at the TFCF in 2006 and is in the declining limb of a mode. The 2006 annual salvage at the TFCF was 18,809 as opposed to 22,686 in 2005. Annual salvage of silversides has occurred in roughly 3 large modes. The first mode is qualitatively defined from 1981 – 1989, the second from 1990 – 1997 and the third from 1991 – 2006 (Figure 17). The magnitude of the mode peaks, 1982-1983, 1992, and 2003-2004, have declined through time (Figure 17).

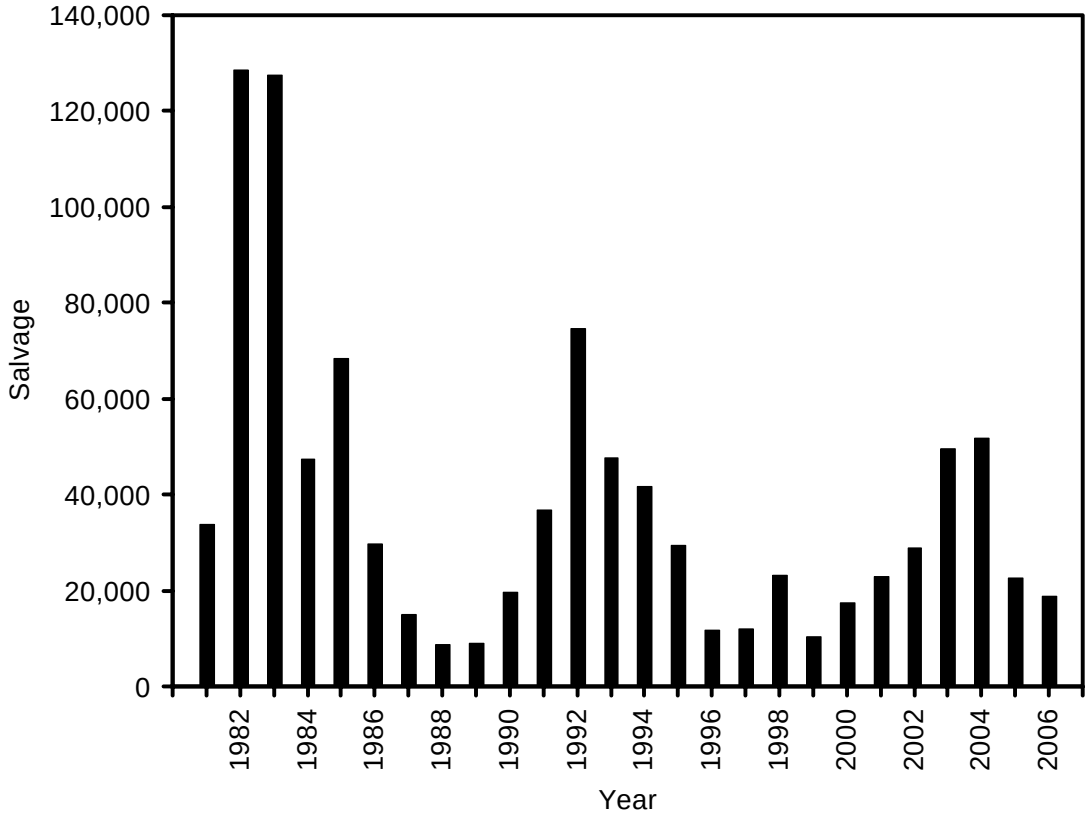

Figure 17. Annual salvage of inland silversides at the TFCF, 1981 – 2006.

The majority of silversides salvage occurred in July (Figure18). The July salvage of 10,560 accounted for 56% of the annual salvage. Exclusive of July, monthly salvage at the TFCF ranged from 81 to 2,124. At the TFCF silversides lengths ranged from 20 to 102 mm FL with a mean of 46 mm FL (n = 378).

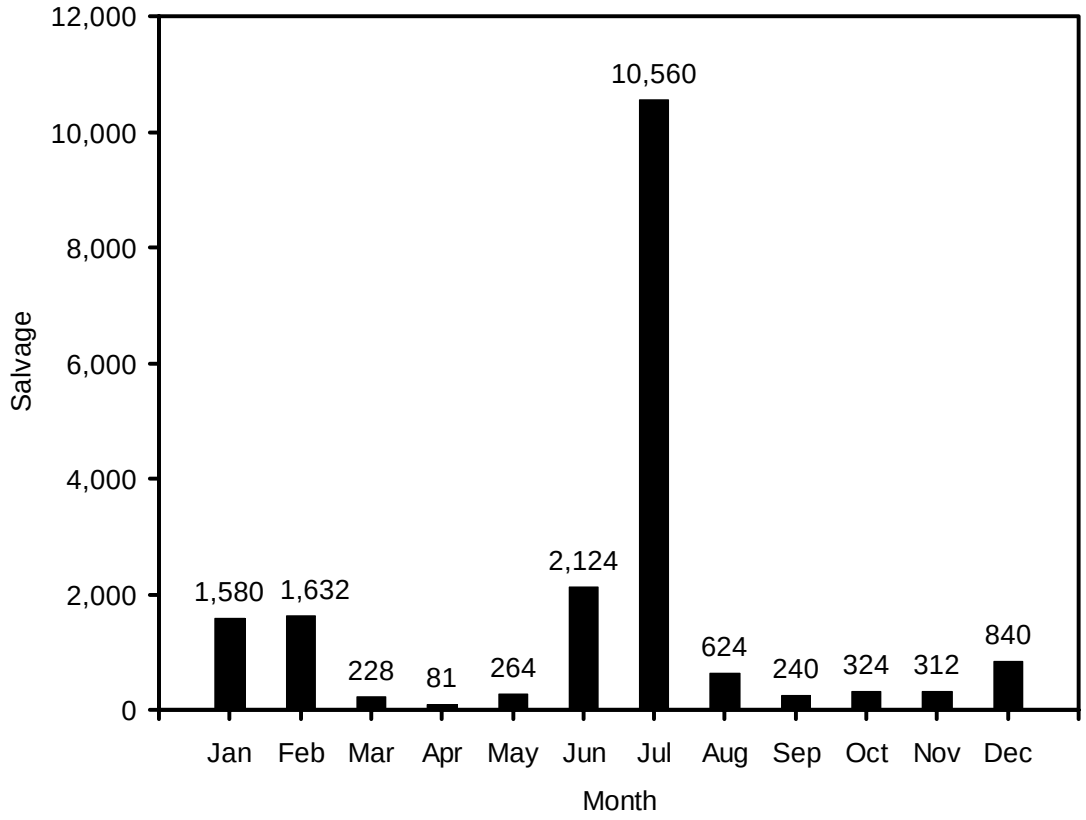

Figure 18. Monthly salvage of inland silversides at the TFCF, 2006.

Steelhead

It is premature to determine whether the increase in annual salvage of steelhead in 2006 was the beginning of an increasing trend and if 2005 was the end point of a mode. The annual salvage in 2006 was greater than in 2005: 2,516 as opposed to 1,347. Annual salvages from 1984 through 1994 exhibited a large mode or pulse (Figure 19). Annual salvage has increased from 1998 – 2003 (with the exception of 2002) and decreased from 2003 – 2005, possibly defining a mode (Figure 19).

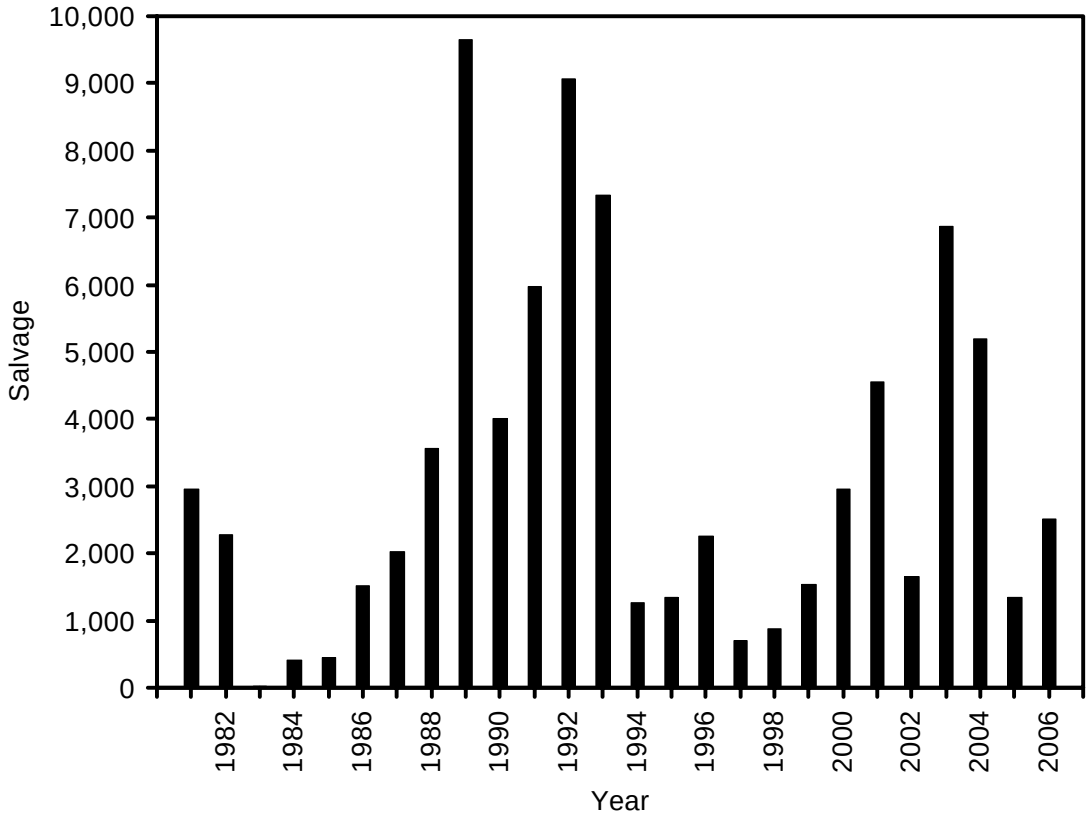

Figure 19. Annual salvage of steelhead (all origins combined) at the TFCF, 1981 – 2006.

The majority of steelhead salvaged were of hatchery origin and were salvaged in March. The salvaged steelhead were categorized as wild: 688, hatchery: 1,828, and no fish of unknown origin. Hatchery steelhead were salvaged in February (240), March (1,587), and April (1). Wild steelhead were salvaged in: January (24), February (84), March (253), May (72), June (243), and July (12).

Results suggest that the wild steelhead salvaged by the TFCF in 2006 were larger than the hatchery steelhead. Wild steelhead ranged from 127 to 423 mm FL with a mean of 258 m FL (n = 55). Hatchery steelhead ranged from 104 to 345 mm FL with a mean of 230 mm FL. (n =

169). After log-transforming the data, a 2 sample t-test was conducted (Ramsey and Schaffer 2002) run under SAS (SAS Institute, Inc. 1989) with results being t = -3.96, p = 0.0001 (222 degrees of freedom).

Green Sturgeon

Relatively large numbers of green sturgeon were salvaged in 2006: 324. Salvage of green sturgeon has been relatively low since the early 1980's (Figure 20). Green sturgeon were salvaged from June through December with monthly salvage ranging from 12 to 96. Green sturgeon lengths ranged from 125 to 400 mm TL with a mean of 248 mm TL (n = 25).

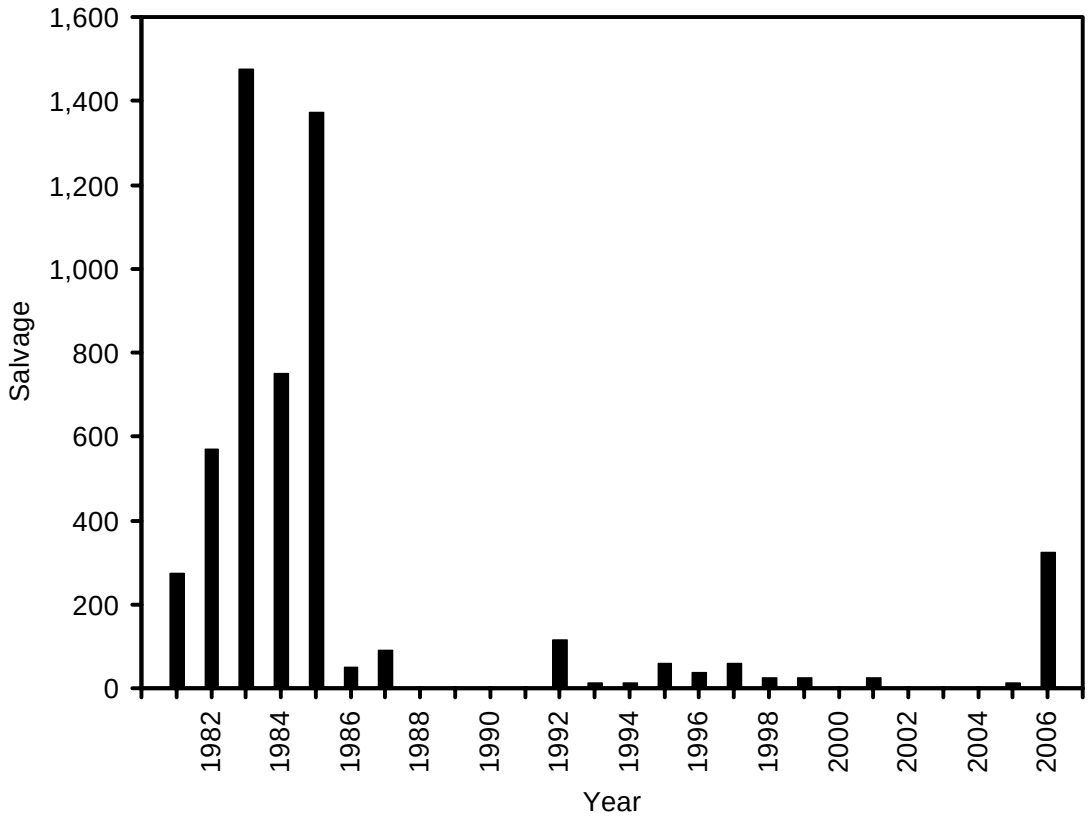

Figure 20. Annual salvage of green sturgeon at the TFCF, 1981 – 2006.

Delta Smelt

Very few delta smelt were salvaged in 2006. Most of these fish were salvaged in March and were likely adults. The 2006 annual salvage of 312 continued the decline in salvage that started in 2002 (Figure 21). The annual salvage in 2006 was less than half the annual salvage of 818 in the preceding year. Delta smelt were salvaged in January (24), February (72) and March (216). Delta smelt lengths ranged from 57 to 77 mm FL with a mean of 72 mm FL (n = 27).

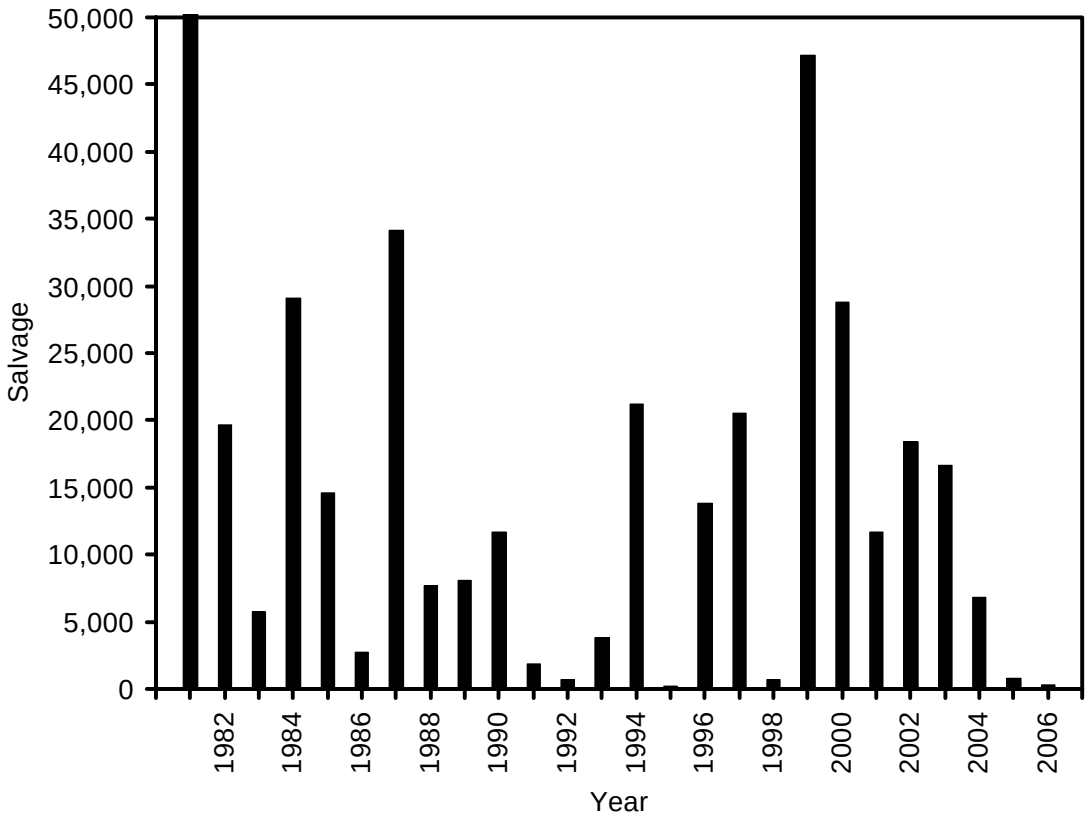

Figure 21. Annual salvage of delta smelt at the TFCF, 1981 – 2006. The annual salvage of 274,288 in 1981 has been truncated for scale considerations.

Chinese Mitten Crabs

Only 12 mitten crabs were salvaged in 2006, 25% of the number salvaged in 2005 (48). No length or sex data is available. With the exception of 2001, mitten crab annual salvage has declined since 1999 (Figure 22).

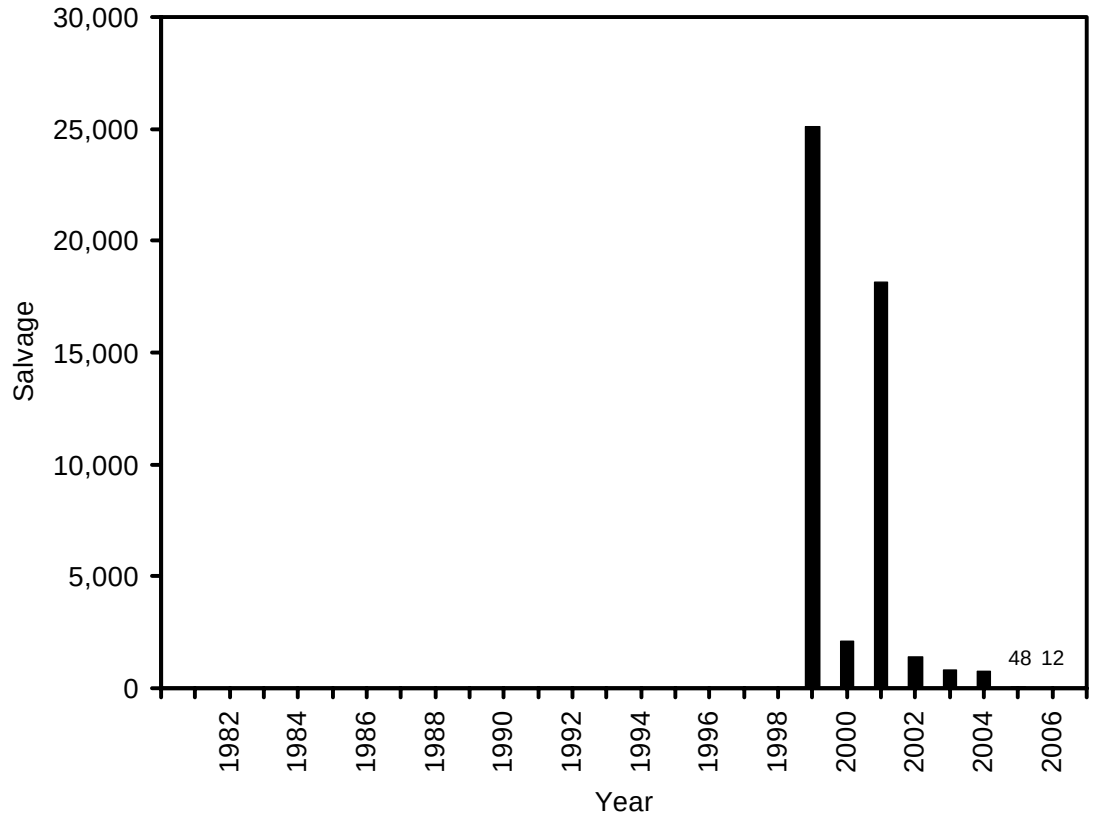

Figure 22. Annual salvage of mitten crabs at the TFCF, 1999 – 2006.

White Sturgeon

A single white sturgeon was salvaged at the TFCF in 2006 (247 mm TL). Extremely low occurrences of white sturgeon were not uncommon since 1988. No white sturgeon was salvaged by the TFCF during 1988 to 1991, 1994, 2002, or 2005. Annual salvage of white sturgeon as occurred in 2 large pulses: from 1981 to 1987 and from 1995 to 1999 (Figure 23).

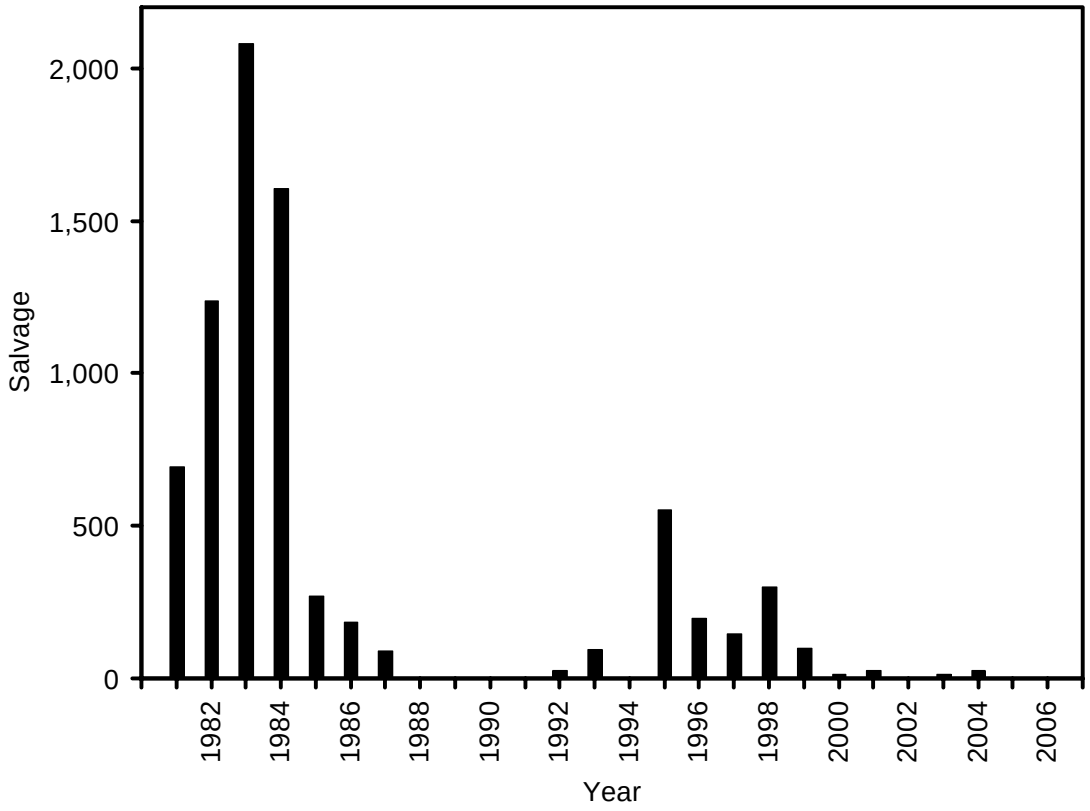

Figure 23. Annual salvage of white sturgeon at the TFCF, 1981 – 2006.

Longfin Smelt

No longfin smelt was salvaged in 2006. Low or zero salvages of longfin smelt are not unknown as no longfin smelt were salvaged in 1982 and 1995. Large (greater than 10,000) annual salvages of longfin smelt have been observed in: 1984, 1988, 1990, and 2002 (Figure 24). Annual abundance of longfin smelt display a “boom and bust” pattern similar to splittail.

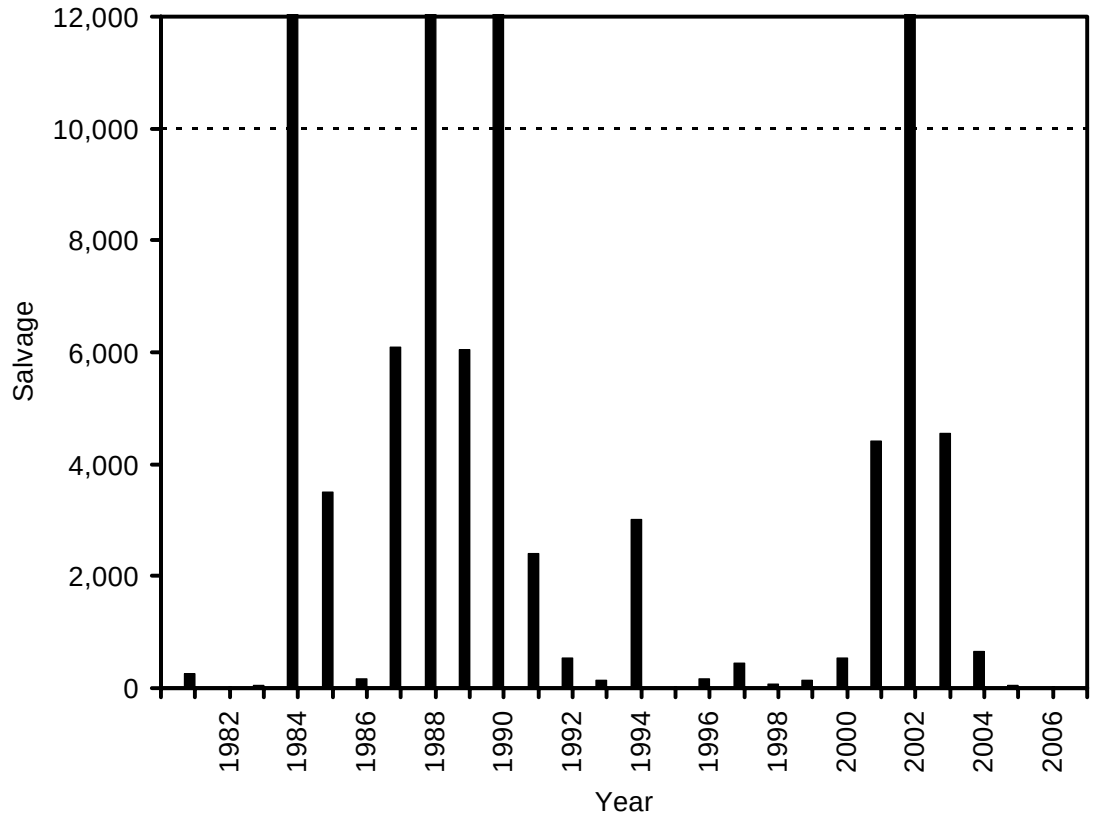

Figure 24. Annual salvage of longfin smelt at the TFCF, 1981 – 2006. The annual salvages in 1984 (22,535) 1988 (24,005), 1990 (24,308) and 2002 (43,080) at the TFCF were truncated for scale considerations.

Operations Events/Variances

Scheduled upgrade of the TFCF electrical system and the remodeling of its Collection Building were started in 2006. Staff continued to perform the routine salvage operations and monitoring, although special studies at the TFCF were curtailed significantly.

Mechanical problems affected the TFCF's ability to salvage fish on 3 occasions. The first event occurred on May 12. TFCF was not operating for 5 hours when the automated lubrication system to the velocity control pumps failed. From June 20th through June 21st, the TFCF bucket hoist broke down during the extreme common carp salvage event. The inability

to remove and haul the large number of carp and overcrowded conditions in the collection tanks contributed to a high mortality of salvaged fish. In addition to this breakdown, high numbers of salvaged carp forced fish sampling times to be reduced from 10 minutes to as little as 1 minute. Despite the operational necessity, shorter sampling times are considered be less accurate and less sensitive for detecting the presence of rare listed species. During December 4th through December 20th, some of the primary bypass controllers were damaged and required the bypass valves to be operated by hand. Normal bypass operations were affected and decreased the effectiveness of the TFCF to salvage fish during this period.

On September 20th, the routine sampling schedule was interrupted for over 6 hours due to prolonged maintenance of the TFCF's dewatering pump. Three routine counts were not performed and salvage estimates could not be calculated for these pumping periods.

Conclusion

Salvage at the TFCF in 2006 was dominated by common carp and to a lesser extent, splittail. The majority of the 2006 annual salvage occurred in June. Other species of interest were caught throughout the year.

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Appendix Table A1. Annual salvage and percentage of annual salvage (percentage) for the TFCF in 2006 and 2005.

	2006		2005	
Species	Salvage	%	Salvage	%
Common Carp	30,495,884	81.8	6,109	0.3
Splittail	5,002,611	13.4	342,595	14.1
Threadfin Shad	717,112	1.9	1,111,569	45.7
White Catfish	256,080	0.7	170,129	7.0
Largemouth Bass	169,927	0.5	22,523	0.9
American Shad	151,068	0.4	329,119	13.5
Bluegill	143,454	0.4	181,045	7.4
Black Crappie	127,452	0.3	3,751	0.2
Channel Catfish	48803	0.1	22,793	0.9
Striped Bass	37,359	0.1	124,645	5.1
Chinook Salmon[1]	35,319	0.1	25,637	1.1
Sacramento Sucker	26086	0.1	2,028	0.1
Inland Silverside	18,809	0.1	22,686	0.9
Sacramento Blackfish	6,972	<0.1	24	<0.1
Yellowfin Goby	6,468	<0.1	44,516	1.8
Prickly Sculpin	6,198	<0.1	2,525	0.1
Golden Shiner	4,589	<0.1	5,061	0.2
Steelhead[2]	2,516	<0.1	1,347	0.1
Warmouth	2,268	<0.1	673	<0.1
Unknown lamprey	2,028	<0.1	2,664	0.1
Redear Sunfish	1,627	<0.1	1,653	0.1
Bigscale Logperch	480	<0.1	277	<0.1
Black Bullhead	440	<0.1	237	<0.1
Shimofuri Goby	438	<0.1	4,350	0.2
Western Mosquito Fish	361	<0.1	444	<0.1
Green Sturgeon	324	<0.1	12	<0.1
Delta Smelt	312	<0.1	818	<0.1
Fathead Minnow	288	<0.1	168	<0.1
Brown Bullhead	240	<0.1	204	<0.1
Sacramento Pikeminnow	205	<0.1	48	<0.1
Red Shiner	204	<0.1	48	<0.1
Tule Perch	144	<0.1	144	<0.1
Riffle Sculpin	72	<0.1	192	<0.1
Green Sunfish	72	<0.1	78	<0.1
Threespine Stickleback	60	<0.1	133	<0.1
Rainwater Killifish	58	<0.1	40	<0.1
Goldfish	48	<0.1	108	<0.1
Wakasagi	36	<0.1	0	0.0
Blue Catfish	24	<0.1	0	0.0
Chinese Mitten Crabs	12	<0.1	48	<0.1
White Sturgeon	1	<0.1	0	0.0
White Bass	0	0.0	48	<0.1
Longfin Smelt	0	0.0	36	<0.1
Starry Flounder	0	0.0	36	<0.1

Appendix Table A1 (continued)

	2006		2005	
Species	Salvage	%	Salvage	%
White Crappie	0	0.0	36	<0.1
Pacific Staghorn Sculpin	0	0.0	24	<0.1
Smallmouth Bass	0	0.0	12	<0.1
Shokihaze Goby	0	0.0	12	<0.1

1. Salvage composed of wild, hatchery, and fish of unknown origin
2. Salvage composed of wild and hatchery fish