Flow and Export Limitation Standards

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Representing: California Sportfishing Protection Alliance (CSPA)
Water Quality Control Plan Update Workshop 2: Bay-Delta Fisheries Resources
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Relevant Background and Experience

I am an estuarine fisheries ecologist and biostatistician and have been involved in Delta fishery issues for more than 35 years. I began my study of striped bass in estuaries as the statistician and technical director of the Hudson River Estuary Ecological Studies from 1972-1977. I have been involved in the Bay-Delta from 1977 to the present. During my years on the Hudson River, I consulted on several occasions with CDFG scientists working on striped bass in the Bay-Delta. Pete Chadwick, DFG's lead Delta scientist, was a consultant to the Hudson River program. From 1977-1980 I was project director of Bay-Delta ecological studies for PG&E's Bay-Delta power plants impact programs.

From 1980-82, I was a consultant to the State Water Contractors, the National Marine Fisheries Service, the Electric Power Research Institute (ERPI), and State Water Resources Control Board focusing on evaluating the effectiveness of the D-1485 Bay-Delta Water Quality Standards in protecting the Bay-Delta ecosystem and the striped bass population. I developed a report for NMFS on the importance of the Bay-Delta for Chinook salmon in 1982.

From 1986-1987 I was a consultant to the State Water Contractors and US Bureau of Reclamation during the SWRCB hearings on water quality standards. From 1994-1995, I was a consultant to the State Water Contractors and the California Urban Water Agencies, working on the 1995 Bay-Delta Water Quality Standards and how the new standards would affect the Bay-Delta ecosystem and striped bass, delta smelt, and salmon populations (and water supplies).

From 1995-2003, I was a consultant to the CALFED Bay-Delta Program where I worked on various projects including the Ecosystem Restoration Program Plan (ERPP), the Delta Entrainment Effects Team (DEFT), the Tracy Technical Advisory Team (TTAT), the Environmental Water Account (EWA), and the Delta Cross Channel – Through Delta Facility (DCCTDF) evaluation team, where again potential effects on the fish populations and the ecosystem were subjects of interest.

I prepared a comprehensive review of impacts from the south Delta pumping plants, the uses and benefits of an Environmental Water Account, and the potential effects from a Through Delta Facility. I also participated in project planning and development of the Delta Wetlands Project, the Montezuma Wetlands Project, and many other Bay-Delta development and restoration projects. In 2002 I participated in a DFG review of the status of the striped bass population. From 2002 to 2005, I was involved in activities related to the Striped Bass Stamp Program including stocking and tagging striped bass, continuing coordination with DFG on Delta issues, and as CSBA's representative on the DFG/DWR Four Pumps Mitigation Committee.

In 2004 I prepared white papers on "The Importance of the Sacramento-San Joaquin Estuary as a Nursery Area for Chinook Salmon Populations of the Sacramento and San Joaquin River Systems" and "Factors Related to Salvage of Juvenile Salmon at South Delta Pumping Plants" for the IEP Delta Rearing Salmonid Project Work Team. In 2007 I prepared a report for the Fishery Foundation of California on "Fish Use Of Shallow Water Habitats Of The Western Delta 1978-79 and 2002-07."

More recently I have advised California Striped Bass Association on proposed new striped bass fishing regulations, and advised USBR staff on the merits of proposed new Fall X2 Standards. From 2005 through 2010 I undertook several new estuary habitat restoration projects in the Sacramento River, Yolo Bypass, and Suisun Bay.

Introduction

The California Sportfishing Protection Alliance asked me to prepare a schedule of flow and export criteria, which in my opinion would protect pelagic and salmonid fish and water quality, while reserving sufficient cold water in upstream reservoirs to meet temperature requirements.

Based on my experience and analyses of Delta fisheries data over the past 35 years I believe many of the Delta fish "problems" including the Pelagic Organism Decline (POD) are caused by insufficient Delta outflow in combination with exports at the South Delta pumping plants. Water quality standards under D-1485 and D-1641 not only do not protect the fish resources of the Delta, but also have exacerbated the problems over the years.

In my report and presentation for Workshop #1, I focused on the effect of Delta exports, inflow, and outflow on the Low Salinity Zone, the principal habitat of many of the Delta fishes. I portrayed the combination of increasing inflows, decreasing outflows, and increasing exports as a "Vise" that drove fish and their low-salinity habitat and food supply toward the South Delta pumps.

In this report, I describe conditions of outflow, inflow, and exports that would provide reasonably good protections for the fish, and minimize or eliminate conditions that have been detrimental. I illustrate how low outflow and high exports increase the loss of fish to the pumps through entrainment, salvage, or poor habitat related mortality. I provide example years under D-1641 standards that have not protected fish.

My conclusion is that there are times when even low exports (≤2000 cfs) threaten fish populations and their habitat. At other times high exports (up to 8,000 cfs) appear safe. Exports higher than 8,000 cfs generally lead to sporadic high salvage rates.

The outflow, inflow, and export criteria I propose in this submission are what I believe, based upon my best professional judgment, would protect Delta fish and their habitat (salinity, temperature, turbidity, flow, etc.), including their food supply (forage fish and invertebrate plankton and benthos). These recommendations should be considered minimum criteria to protect fisheries, water quality and ensure adequate cold-water storage to protect upstream temperature. They are integrally related and must be considered in context to each other.

PROPOSED OUTFLOW-EXPORT-INFLOW CRITERIA FOR BAY-DELTA STANDARDS

PROPOSED SEASONAL CRITERIA BY YEAR TYPE

I developed proposed criteria by season and year type for Delta Inflow (lower and upper daily limits), Delta outflow (minimum daily), export limits (maximum daily), and Delta Cross Channel (open or closed). The proposed criteria are protective of the LSZ and its major biological constituents including plankton and fish, as well as water quality (water temperature and turbidity).

Early Summer – June and July

EARLY SUMMER is the months of June and July. The goal of early summer is to keep the Lower Salinity Zone (LSZ: 500-5000 surface EC) and the Slightly Brackish Zone (SBZ: 200-500 surface EC) away from the influence of the South Delta pumping plants. Generally, sufficient Delta outflow provides the necessary protection; however, in all years it is necessary to limit exports to a certain extent to protect the SBZ and the fish and their food supply in that zone. Delta Cross Channel (DCC) should be open to protect the LSZ and POD species.

Table 1. EARLY SUMMER RECOMMENDATIONS.

EARLY SUMMER – JUNE JULY Lower LSZ (2500-5000 EC) – Target: Western Suisun Bay Upper LSZ (500-2500 EC) – Target: Eastern Suisun Bay Freshwater Brackish Zone (200-500 EC) – Target: Western Delta				
YEAR TYPES	Inflow	Outflow	Export Limits	DCC Closure
Very Wet Years 1995, 1998, 2006, 2011	**24,000**[1]	**16,000**	**6,000**[2]	Open
Wet and AN Years 1993, 1996, 1997, 1999, 2000, 2003, 2005, 2010	**20,000**	**12,000**	**4,000**	Open
BN and Dry Years 2001, 2002, 2004, 2009, 2012	**16,000**	**10,000**	**2,000**	Open
Very Dry Years post Wet 1994, 2007	**12,000**	**8,000**	**2,000**	Open
Very Dry Years post Dry 2008	**10,000**	**6,000**	**2,000**	Open

[1]Minimum Daily = blue font
[2]Maximum Daily = red font

Spring – March, April, May

SPRING is the months March, April, and May. The goal of spring criteria is to keep the Lower Salinity Zone (LSZ: 500-5000 surface EC) and the Slightly Brackish Zone (SBZ: 200-500 surface EC) away from the influence of the South Delta pumping plants. Generally, sufficient Delta outflow provides the necessary protection; however, in all years it is necessary to limit exports to a certain extent to protect the SBZ and the fish and their food supply in that zone. Spring criteria also protect smolt salmon migrating through the Delta from the Sacrament River, Delta tributaries, and the San Joaquin River. Periodic closure of the DCC is prescribed in all but drier years to protect Sacramento River winter and spring run salmon movement through the Delta to the Bay, and to limit their movement into the Central and South Delta under the higher exports of wetter years. In drier years, the DCC should remain open to protect the LSZ and POD species, as well as San Joaquin salmon. Low exports should provide protection for Sacramento River salmon in drier years.

Table 2. SPRING RECOMMENDATIONS

SPRING – MARCH, APRIL, MAY Lower LSZ (2500-5000 EC) – Target: Western Suisun Bay Upper LSZ (500-2500 EC) – Target: Eastern Suisun Bay Freshwater Brackish Zone (200-500 EC) – Target: Western Delta				
YEAR TYPES	Inflow	Outflow	Export Limits	DCC Closure
Very Wet Years 1995, 1998, 2006, 2011	**32,000**	**20,000**	**4,000**	Periodic Closure[3]
Wet and AN Years 1993, 1996, 1997, 1999, 2000, 2003, 2005, 2010	**24,000**	**16,000**	**3,000**	Periodic Closure
BN and Dry Years 2001, 2002, 2004, 2009, 2012	**18,000**	**12,000**	**2,000**	Periodic Closure
Very Dry Years post Wet 1994, 2007	**16,000**	**10,000**	**2,000**	Open
Very Dry Years post Dry 2008	**12,000**	**8,000**	**2,000**	Open

[3] Specific criteria

Late Summer and Fall

LATE SUMMER AND FALL include the months August through November. These are generally the drier months of the year. The goal of these criteria is to keep the Lower Salinity Zone (LSZ: 500-5000 surface EC) and the Slightly Brackish Zone (SBZ: 200-500 surface EC) away from the influence of the South Delta pumping plants. Generally, sufficient Delta outflow provides the necessary protection; however, in all years it is necessary to limit exports to a certain extent to protect the SBZ and the fish and their food supply in that zone. The DCC should be open to protect the LSZ and POD species as well as homebound adult San Joaquin salmon. Low exports should provide protection for Sacramento River salmon in drier years.

Table 3. LATE SUMMER AND FALL RECOMMENDATIONS

LATE SUMMER AND FALL – AUGUST - NOVEMBER Lower LSZ (2500-5000 EC) – Target: Western Suisun Bay Upper LSZ (500-2500 EC) – Target: Eastern Suisun Bay Freshwater Brackish Zone (200-500 EC) – Target: Western Delta				
YEAR TYPES	Inflow	Outflow	Export Limits	DCC Closure
Very Wet Years 1995, 1998, 2006, 2011	**16,000[1]-24,000[2]**	**12,000**	**8,000**	Open
Wet and AN Years 1993, 1996, 1997, 1999, 2000, 2003, 2005, 2010	**16,000-24,000**	**12,000**	**8,000**	Open
BN and Dry Years 2001, 2002, 2004, 2009, 2012	**14,000-18,000**	**10,000**	**4,000**	Open
Very Dry Years post Wet 1994, 2007	**12,000-16,000**	**8,000**	**4,000**	Open
Very Dry Years post Dry 2008	**10,000-14,000**	**6,000**	**4,000**	Open

[1]Minimum
[2]Maximum (unless uncontrollable)

Winter – December, January, and February

WINTER is the months December, January, and February. The goal of winter criteria is to keep the Lower Salinity Zone (LSZ: 500-5000 surface EC) and the Slightly Brackish Zone (SBZ: 200-500 surface EC) away from the influence of the South Delta pumping plants. Generally, sufficient Delta outflow provides the necessary protection; however, in all years it is necessary to limit exports to a certain extent to protect the SBZ and the fish and their food supply in that zone. Winter criteria also protect fry and smolt salmon migrating into and through the Delta from the Sacrament River, Delta tributaries, and the San Joaquin River. Periodic closure of the DCC is prescribed in all but drier years to protect Sacramento River winter and spring run salmon moving through the Delta to the Bay, and limit their movement into the Central and South Delta under the higher exports of wetter years. In drier years, the DCC should remain open to protect the LSZ and POD species, as well as San Joaquin salmon. Low exports should provide protection for Sacramento River salmon in drier years.

Table 4. WINTER RECOMMENDATIONS

WINTER – DECEMBER - FEBRUARY Lower LSZ (2500-5000 EC) – Target: Western Suisun Bay Upper LSZ (500-2500 EC) – Target: Eastern Suisun Bay Freshwater Brackish Zone (200-500 EC) – Target: Western Delta				
YEAR TYPES	Inflow	Outflow	Export Limits	DCC Closure
Very Wet Winters 1995, 1997, 1998, 2006, 2011	**10,000[1]-32,000[2]**	**6,000-12,000**	**2,000[1]-8,000[2]**	Periodic Closure[3]
Wet and AN Years – major storms 1993, 1996, 1997, 1999, 2000, 2003, 2005, 2010	**10,000-32,000**	**6,000-12,000**	**2,000-8,000**	Periodic Closure
BN and Dry Years – substantial storms 2001, 2002, 2004, 2012	**10,000-24,000**	**6,000-10,000**	**2,000-8,000**	Periodic Closure
Dry Years – some storms 1994, 2007, 2008, 2009	**10,000-20,000**	**6,000-8,000**	**2,000-8,000**	Open
Very Dry Winters – no storms	**10,000**	**6,000**	**2,000**	Open

[1] Minimum starting
[2] After substantial storms
[3] Specific criteria

JUSTIFICATION AND EXAMPLES

The following figures and narrative provide examples of how the above criteria would provide protections under various year types. Examples are taken from various year types for the years 2000 to 2012. Year 2000 starts the example period just after a period of significant improvement in Delta fish populations during the wet years of 1995-1999. Delta smelt, striped bass, and salmon had undergone significant population improvements over the previous decade.

The period 2000-2012 also represents a continuous period of good biological and hydrological data collection and analysis under the Bay-Delta Standards of D-1641. The years 2000-2002 represent the first three non-wet year types under D-1641. I contend that operations in these three years led directly to the “Pelagic Organism Decline” or POD, wherein, pelagic species including delta smelt, longfin smelt, and striped bass exhibited very sharp population declines.

Year 2000

I start with year 2000, an “above” or “below” normal year type depending on classification scheme that followed five wet years.

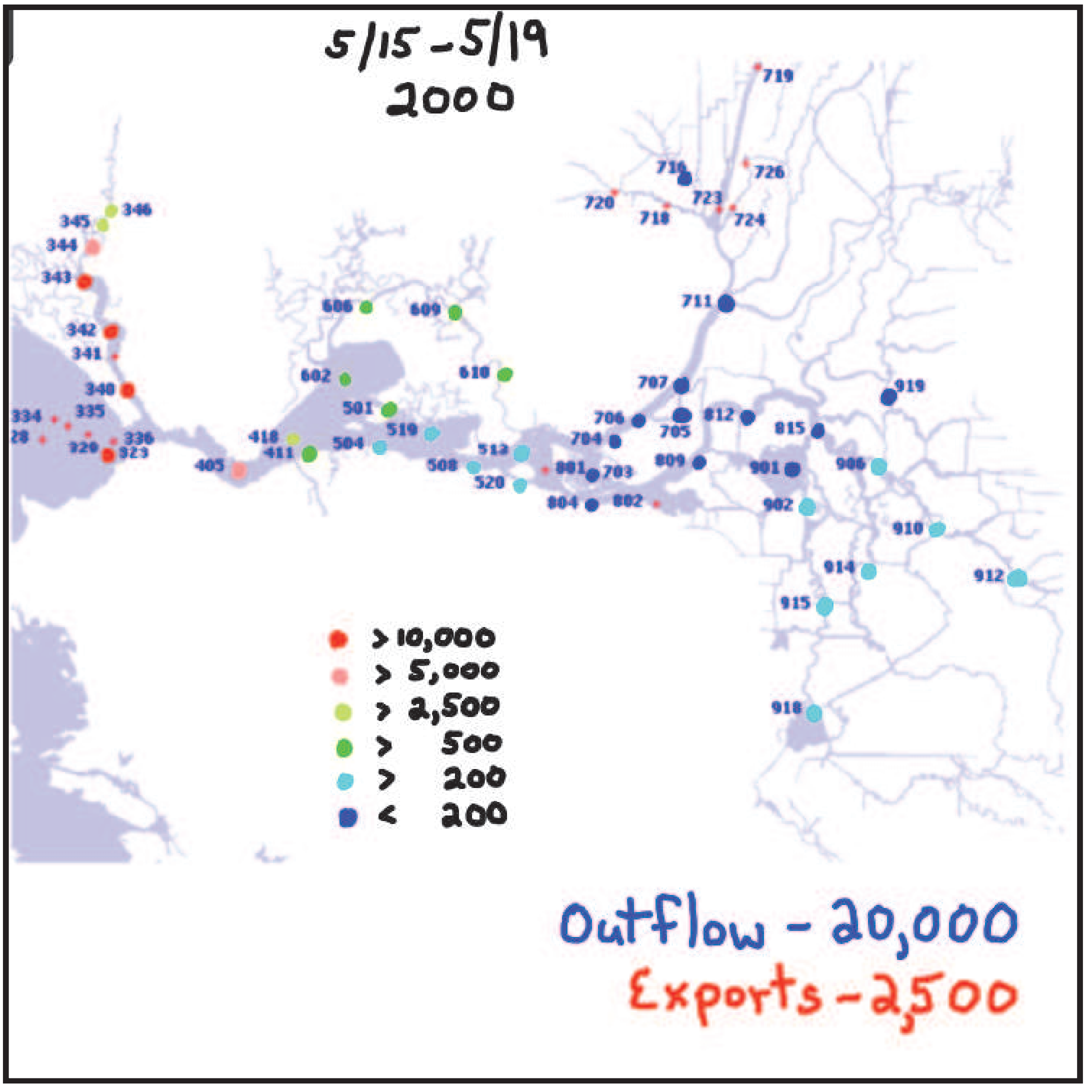


Figure 1. EC data from the 5/15-5/19 2000 20-mm survey.

- Outflow was 20,000 cfs
- Exports were 2,500 cfs
- The LSZ was in western Suisun Bay and Montezuma Slough, generally considered optimum conditions.
- Conditions were well within the proposed criteria for this year type (Table 2).

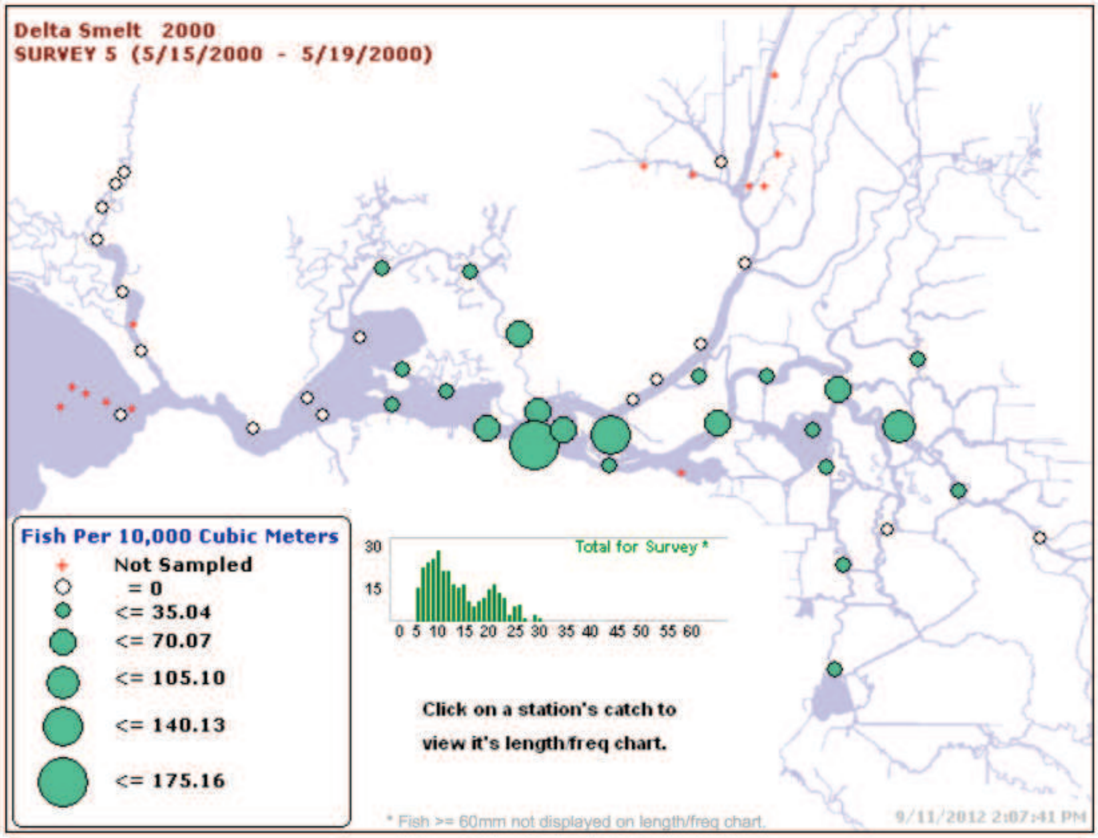


Figure 2. Delta smelt catch distribution in the 5/15-5/19 2000 20-mm survey.

- Smelt were small and in the entrainable size (<25 mm) and not salvageable.
- Smelt were concentrated just upstream of the LSZ in slightly brackish waters (200-500 EC).
- Some smelt were likely entrained into Clifton Court Forebay and pumping plants despite low export because of their general distribution throughout the Delta.
- The DCC was closed during the period and the week prior, which may have contributed to smelt being in the South Delta. Under these conditions I recommend the DCC not be closed.

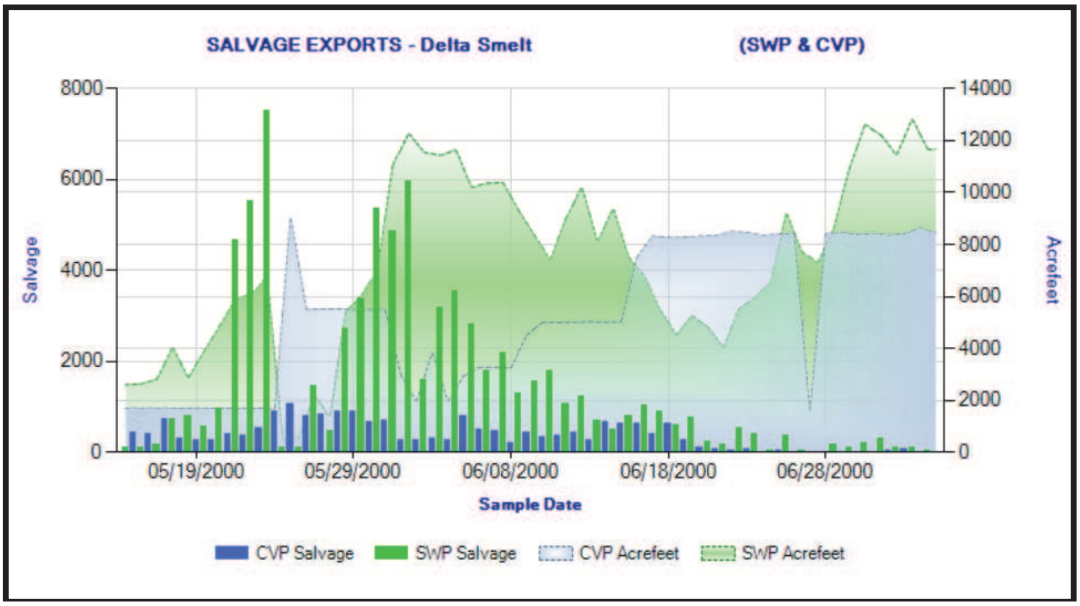


Figure 3. Delta smelt salvage from mid May through mid July 2000.

- Note delta smelt salvage was very low on May 15, but increased after exports increased on the 18^{th} and 19^{th}.

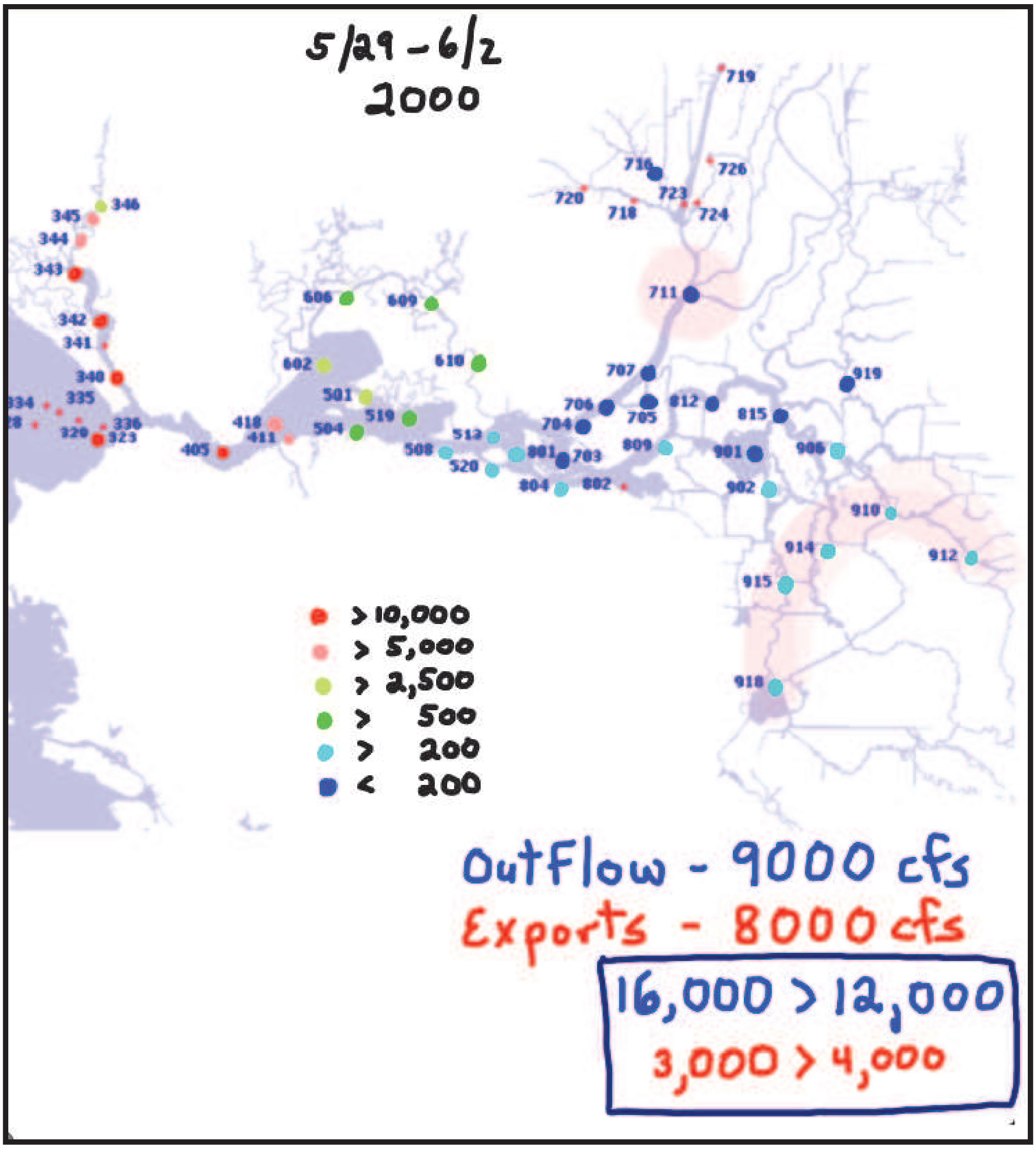


Figure 4. EC data from the 5/29-6/2 2000 20-mm survey.

- Outflow was down to 9,000 cfs
- Exports had recently been raised from 3,000 to 8,000 cfs (see Figure 3).
- Salvage was also up sharply at 2000-6,000 per day, a very high number for the CCF fish facility (the facility has less than 1% efficiency for delta smelt (see FWS 2010).
- The LSZ had moved upstream into eastern Suisun Bay (see Figure 1) but remained in Montezuma Slough, still generally considered good conditions.
- The brackish zone (light blue dots with EC 200-500) had also moved upstream into the western Delta and lower San Joaquin channel.

- Inflow remained about 20,000 cfs but continued to drop, thus most of the additional demand at the pumps was being drawn from the west.
- The DCC was again closed, but under high exports, which are conditions that should not be allowed.
- If the proposed criteria had been operating (see Table 2), outflow would have fallen more gradually, first to 16,000 then to 12,000, leaving the LSZ in western Suisun Bay. Exports would have only been raised to 4,000 cfs, and the loss of smelt would have been much less.
- Conditions in the south, east, and north Delta were deteriorating for smelt as water temperatures reached above 22ºC (pink infill) (23-25º is lethal range for smelt).

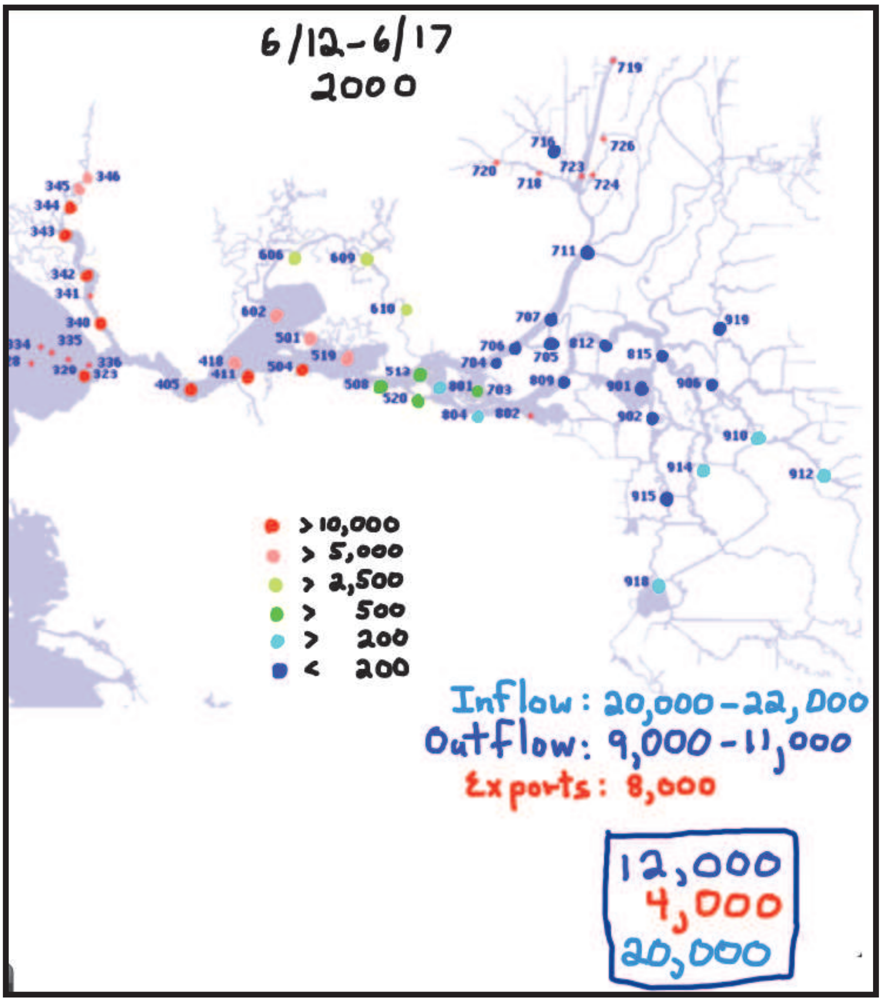


Figure 5. EC data from the 6/12-6/17 2000 20-mm survey.

- Conditions remained stable through mid June. Outflow remained 9,000-11,000 cfs under 8,000 cfs exports and 20,000 cfs inflow.
- Salvage losses continued at over 1000 per day (Figure 3).
- The LSZ was now confined to eastern Suisun Bay just east of Chipps Island.
- The brackish zone (light blue dots with EC 200-500) was in the western Delta and lower end of the San Joaquin channel near the Confluence.
- Inflow remained about 20,000 cfs but was stable.
- The DCC was again closed, again under high exports, which are conditions that should not be allowed.
- If the proposed criteria had been operating (see Table 2), outflow would have been stable at 12,000, leaving the LSZ in Suisun Bay and Montezuma Slough. Exports would have only 4,000 cfs, and the loss of smelt would have been much less, especially if the DCC had remained open. (Note: WEST Dayflow flows were -3,000 cfs in the period, indicating with the DCC shut, the lower San Joaquin flows were negative and moving net toward the export pumps.)

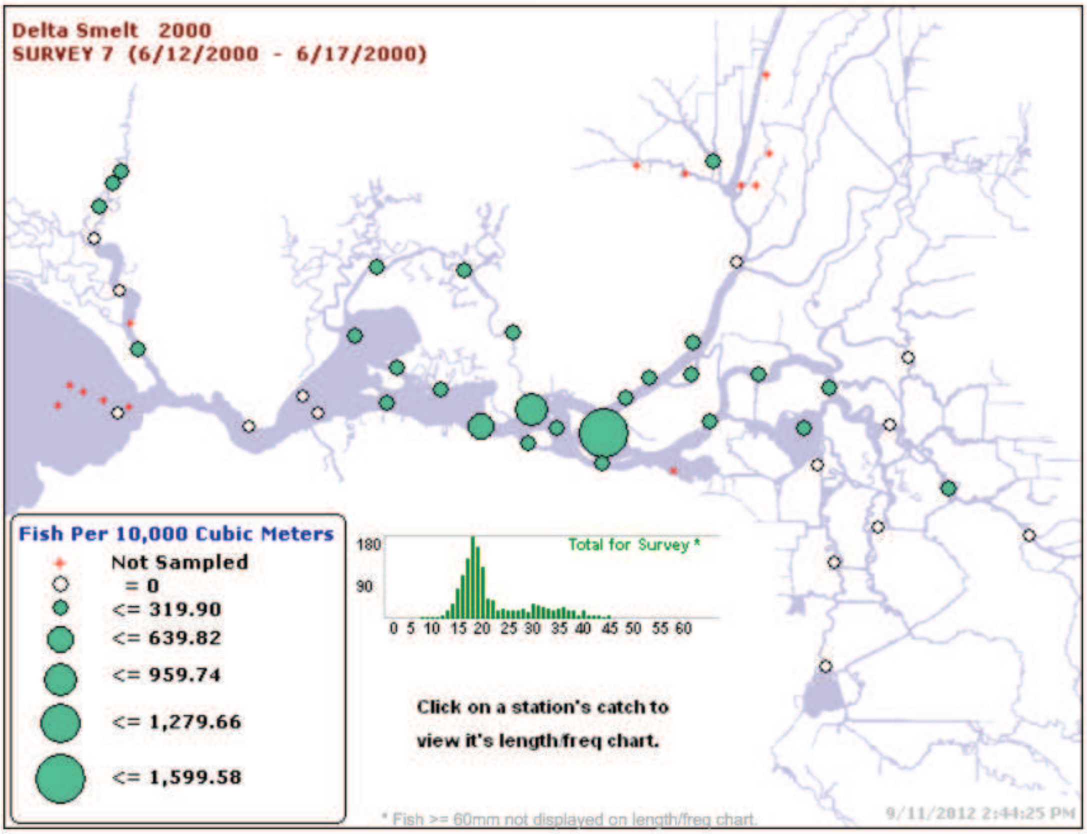


Figure 6. Delta smelt catch distribution in the 6/12-6/17 2000 20-mm survey.

- Smelt remained small and in the entrainable size (<25 mm), but some were salvageable size.
- Smelt were concentrated in and just upstream of the LSZ in slightly brackish waters (200-500 EC).

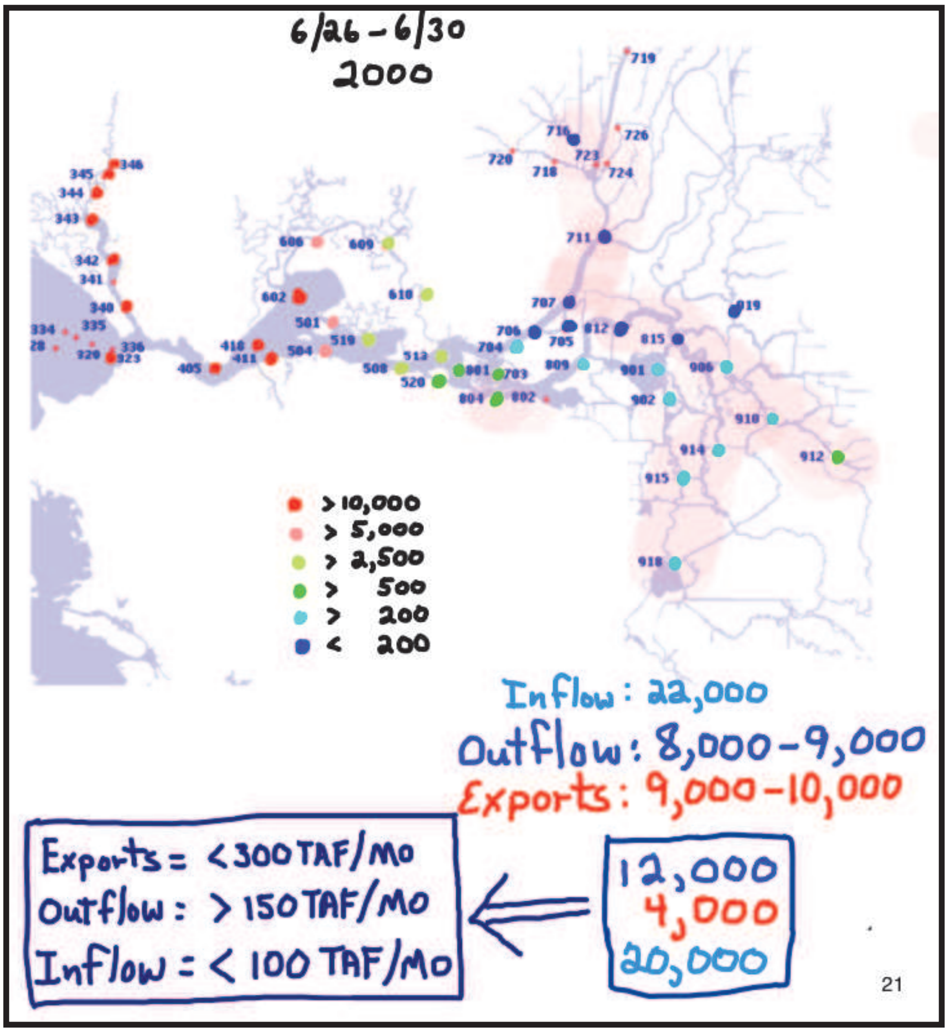


Figure 7. EC data from the 6/26-6/30 2000 20-mm survey.

- Conditions deteriorated through late June. Outflow remained near 9,000 cfs or but exports rose to 9,000-10,000 cfs with 22,000 cfs inflow.
- Salvage losses were low (Figure 3). High water temperatures through the central and south Delta limited smelt survival if drawn into the area.
- The LSZ was now confined to the Western Delta near the Confluence.
- The brackish zone (light blue dots with EC 200-500) was in the central and south Delta.
- The DCC was open.
- If the proposed criteria had been operating (see Table 1), outflow would have been stable at 12,000, leaving the LSZ in Suisun Bay and Montezuma Slough. Exports would have only 4,000 cfs, and the loss of smelt during June would have been much less, especially if the DCC had remained open all month. For the month, exports would have been reduced about 300 TAF, outflow to the Bay would have been 150 TAF higher, and reservoir releases would have been reduced about 100 TAF.

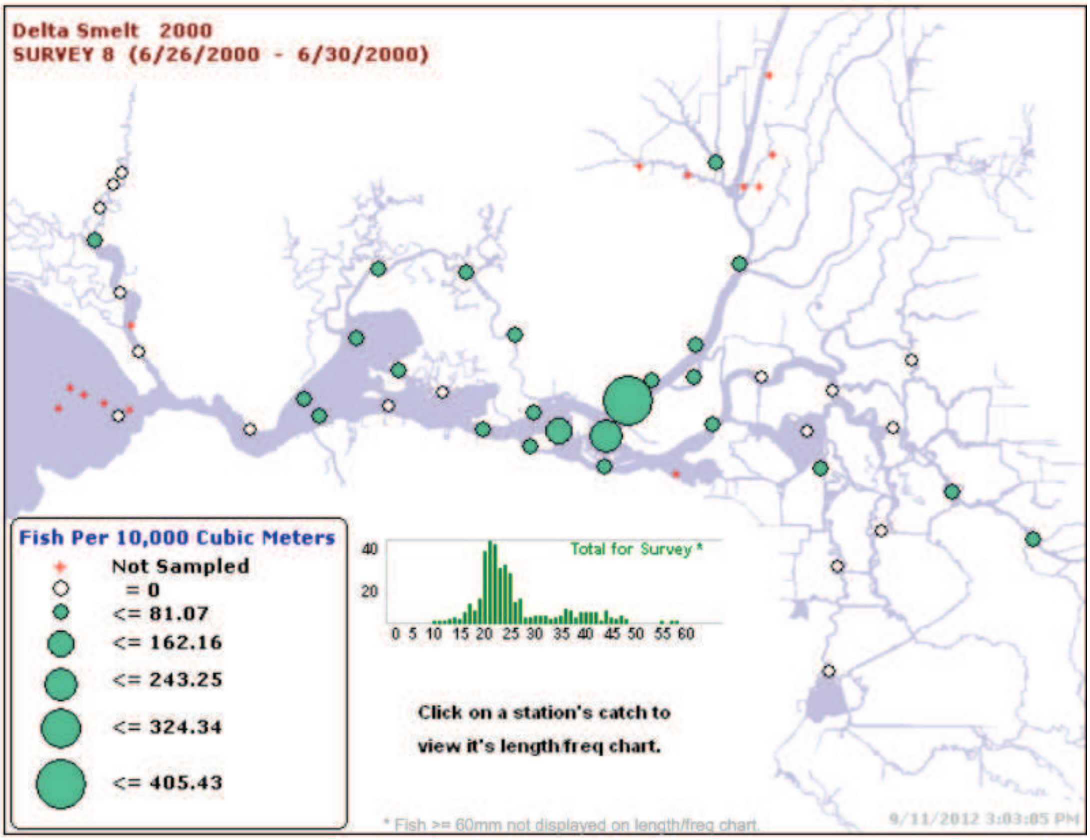


Figure 8. Delta smelt catch distribution in the 6/26-6/30 2000 20-mm survey.

- Smelt remained small and in the entrainable size (<25 mm), but some were salvageable size.
- Smelt were concentrated in and just upstream of the LSZ in slightly brackish waters (200-500 EC).

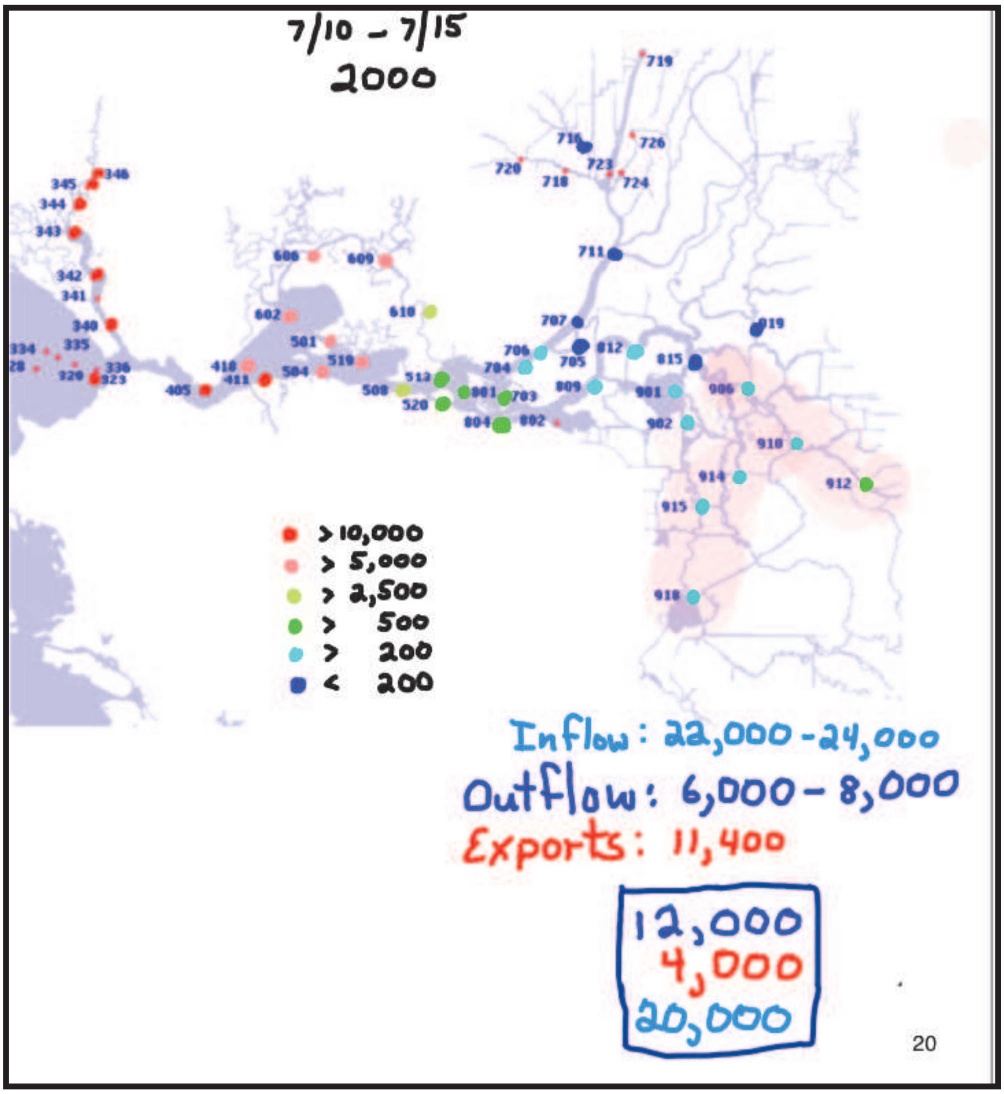


Figure 9. EC data from the 7/10-7/15 2000 20-mm survey.

- Conditions deteriorated in July under very high exports, low outflow, and necessary high inflows. Outflow fell to 6,000-8,000 cfs, while exports rose to 11,000 cfs with 22,000-24,000 cfs inflow.
- Smelt salvage losses were low (Figure 3). High water temperatures through the central and south Delta limited smelt survival if drawn into the area.
- The LSZ was now confined to the Western Delta near the Confluence.
- The brackish zone (light blue dots with EC 200-500) was in the central and south Delta.
- The DCC was open.
- If the proposed criteria had been operating (see Table 1), outflow would have been stable at 12,000, leaving the LSZ in Suisun Bay and Montezuma Slough. Exports would have only 4,000 cfs. For the month of July, exports would have been reduced about 400 TAF, outflow to the Bay would have been 300 TAF higher, and reservoir releases would have been reduced about 100 TAF.

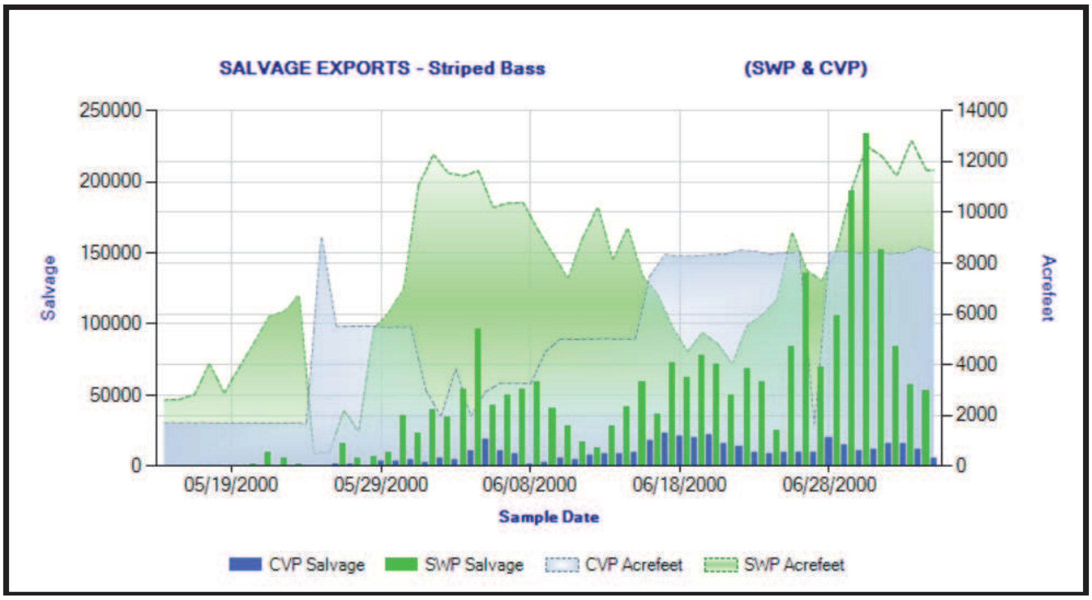


Figure 10. Striped bass salvage from mid May through mid July 2000.

- Note delta salvage was very high in early July under the extremely high exports that ramped up on July 1, and low outflow conditions of the first drier year type under D-1641. Like delta smelt, striped bass also have an affinity for the LSZ (Figure 11).
- The striped bass fall index for 2000 was 388, the lowest on record up to that year.
- Like delta smelt another POD species, striped bass would also benefit from the proposed criteria. Zooplankton (Figure 12) in the Delta food web would also likely benefit.

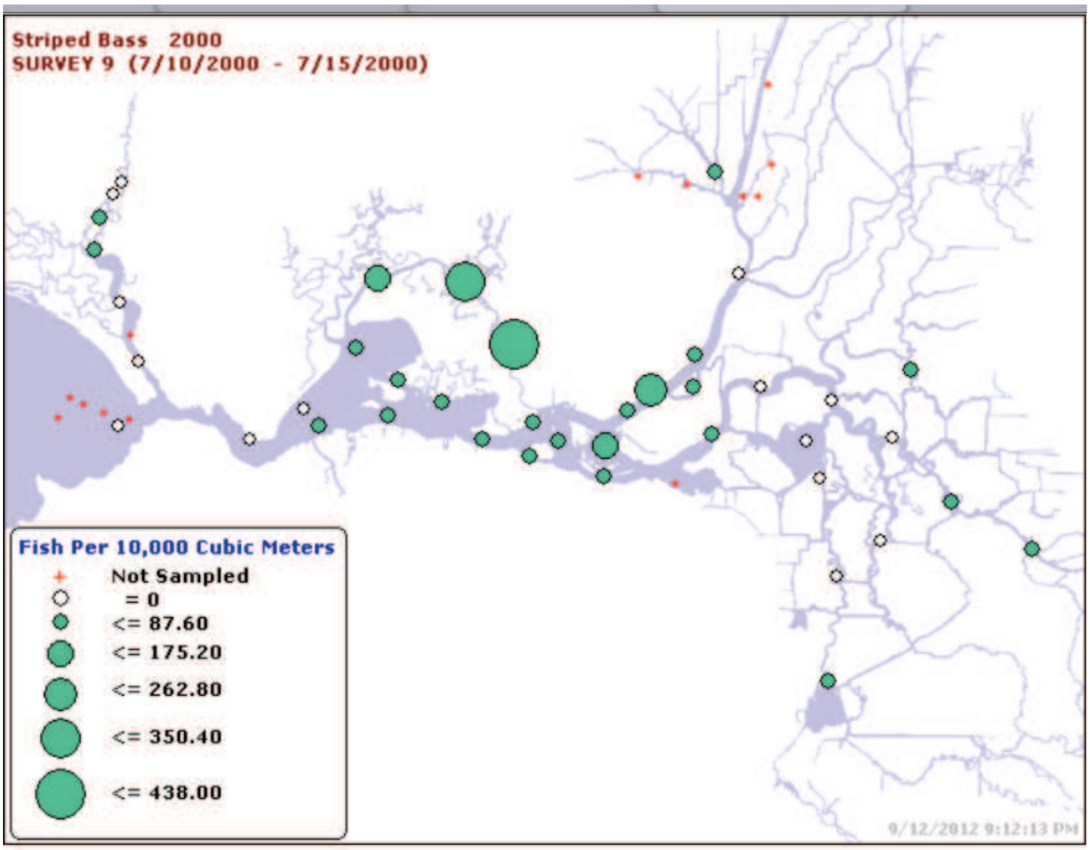


Figure 11. Striped bass distribution in the 7/10-7/15 2000 20-mm survey.

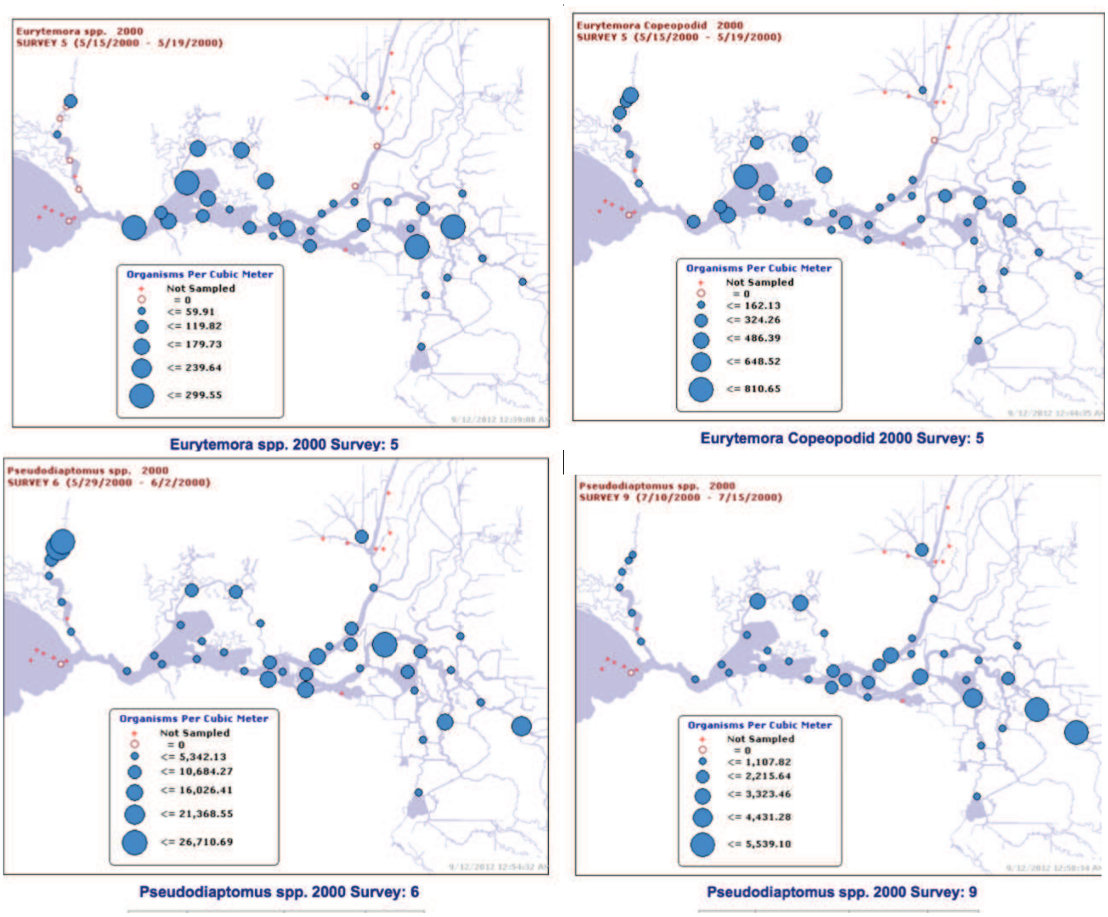


Figure 12. Like delta smelt and striped bass, major zooplankton in the Delta food web also has an affinity to the LSZ and brackish water areas of the Delta.

Year 2001

Year 2001 was the second drier year of the post-D1641 period. It was the first Dry year following five wet years. July outflows were very low (3000-4000 cfs), while exports were 6,000-9,000 cfs, which were too high for a dry year. My recommendation for July of a Dry year is 2,000 cfs export limit and 10,000 cfs minimum outflow (Table 1).

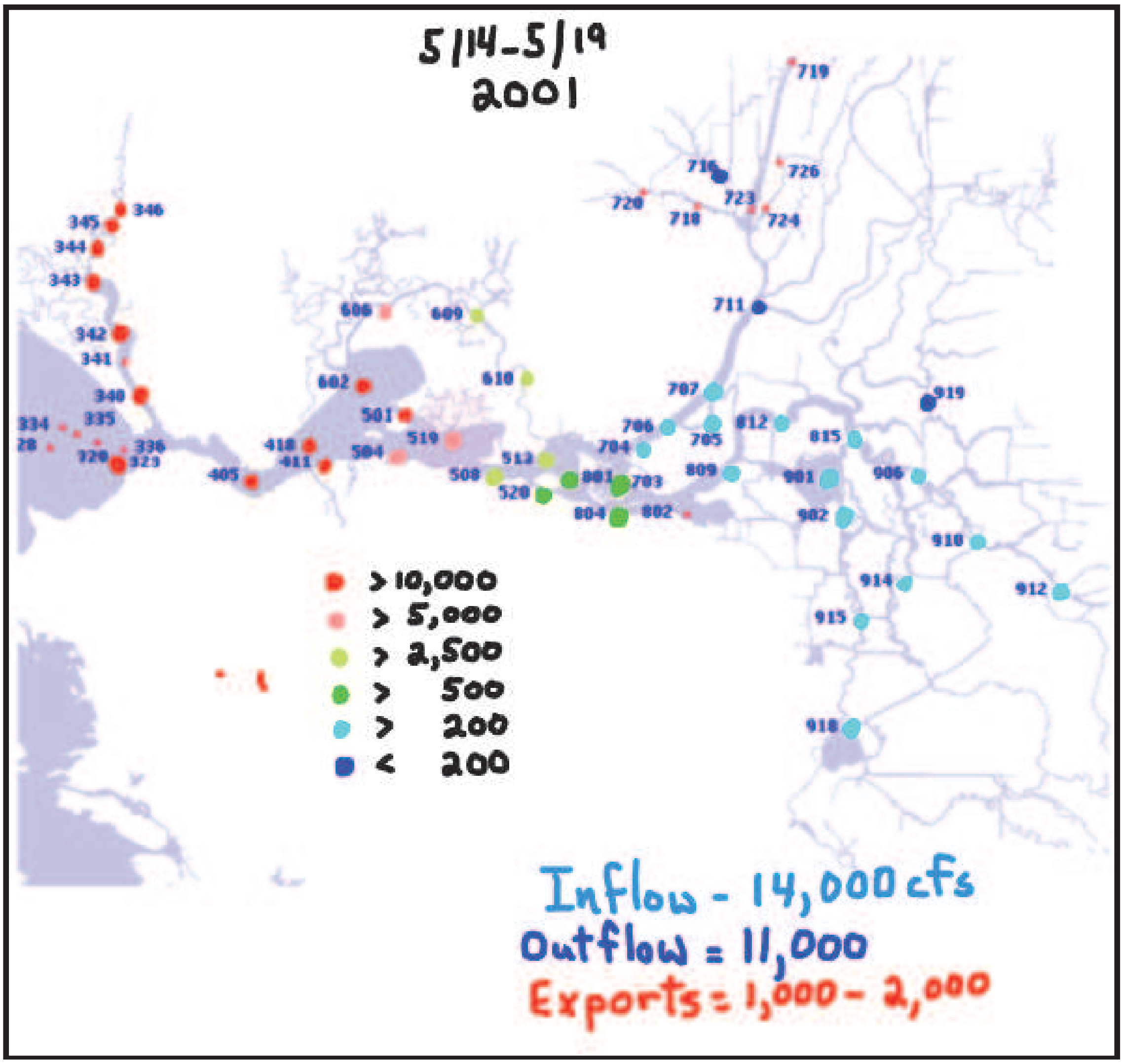


Figure 13. EC data from the 5/14-5/19 2001 20-mm survey.

- Conditions in mid May 2001 at the end of VAMP period were similar to recommendations in Table 2.
- The distributions of delta smelt within the Delta (Figure 14) and their vulnerability to these low export levels (Figure 20) appear related to DCC closure patterns at these low inflow and outflow levels.

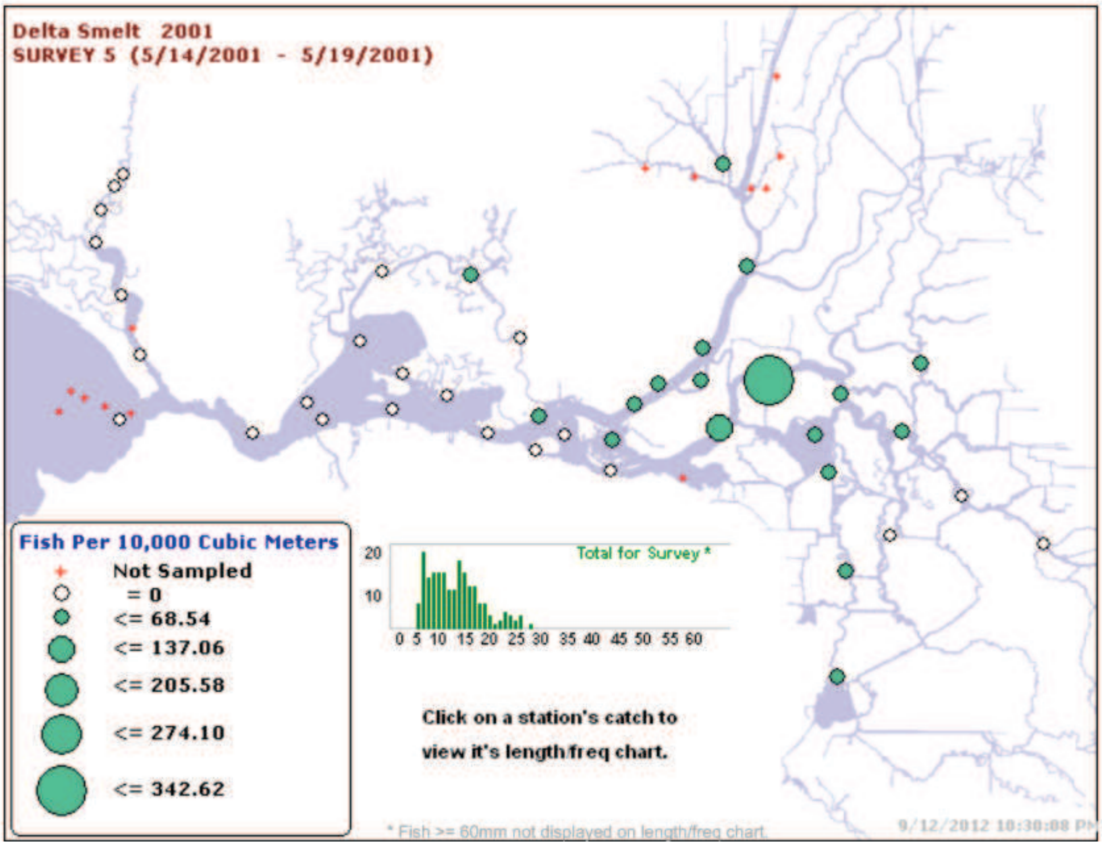


Figure 14. Delta smelt distribution in the 5/14-5/19 2001 20-mm survey.

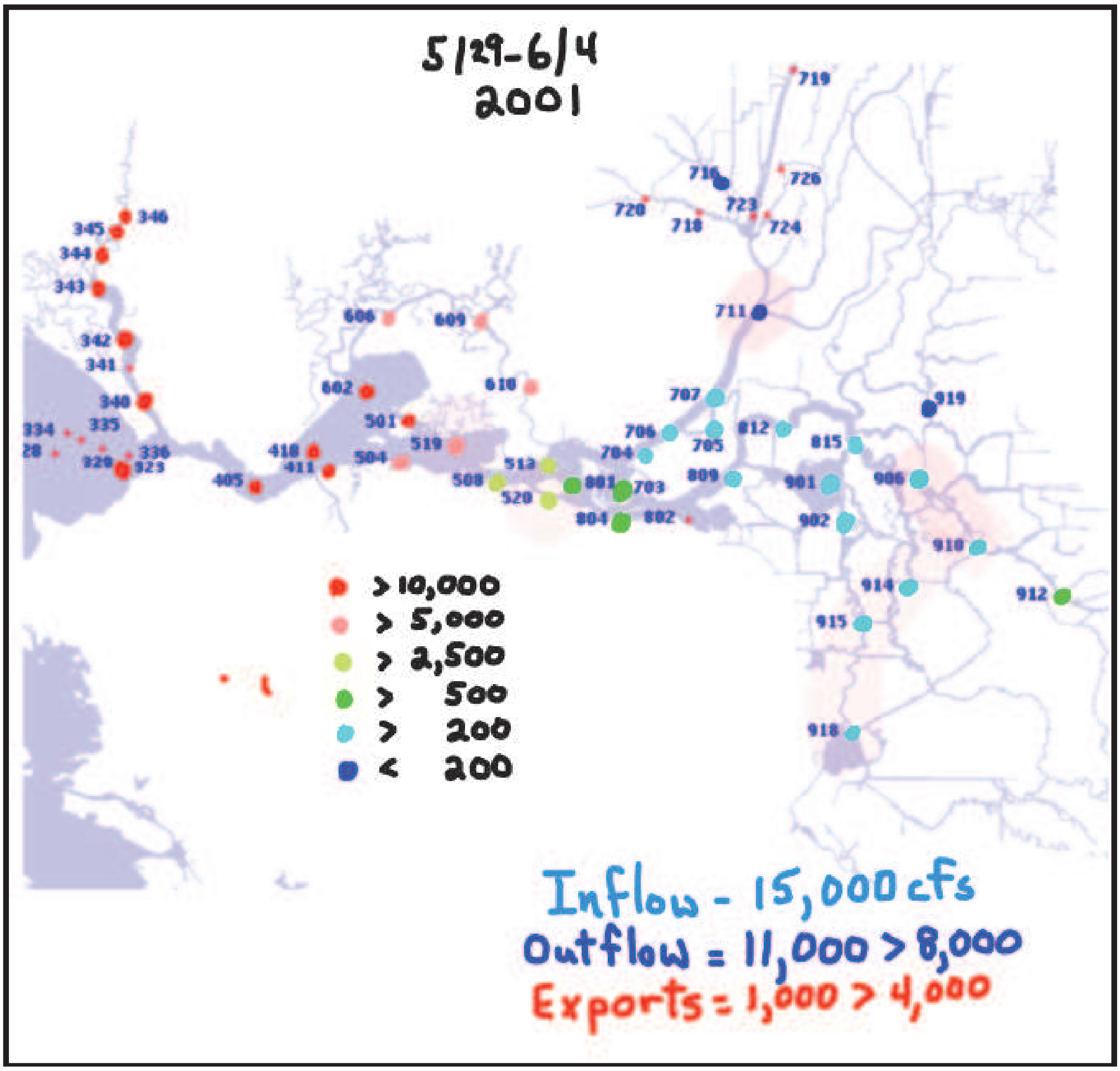


Figure 15. EC data from the 5/29-6/4 2001 20-mm survey.

- These conditions are similar to recommendations for June of Dry Year (Table 1), except for lowering outflow and increasing exports late in the period.
- The DCC was also closed during the period, leading to another spike in smelt salvage (Figure 20). Given the size of the smelt (Figure 16), many smelt were likely entrained in the exports and their loss not accounted for during the period.
- Keeping outflow at 10,000 cfs, limiting exports to 2,000 cfs, and keeping the DCC open would provide protection to the smelt in such dry years.

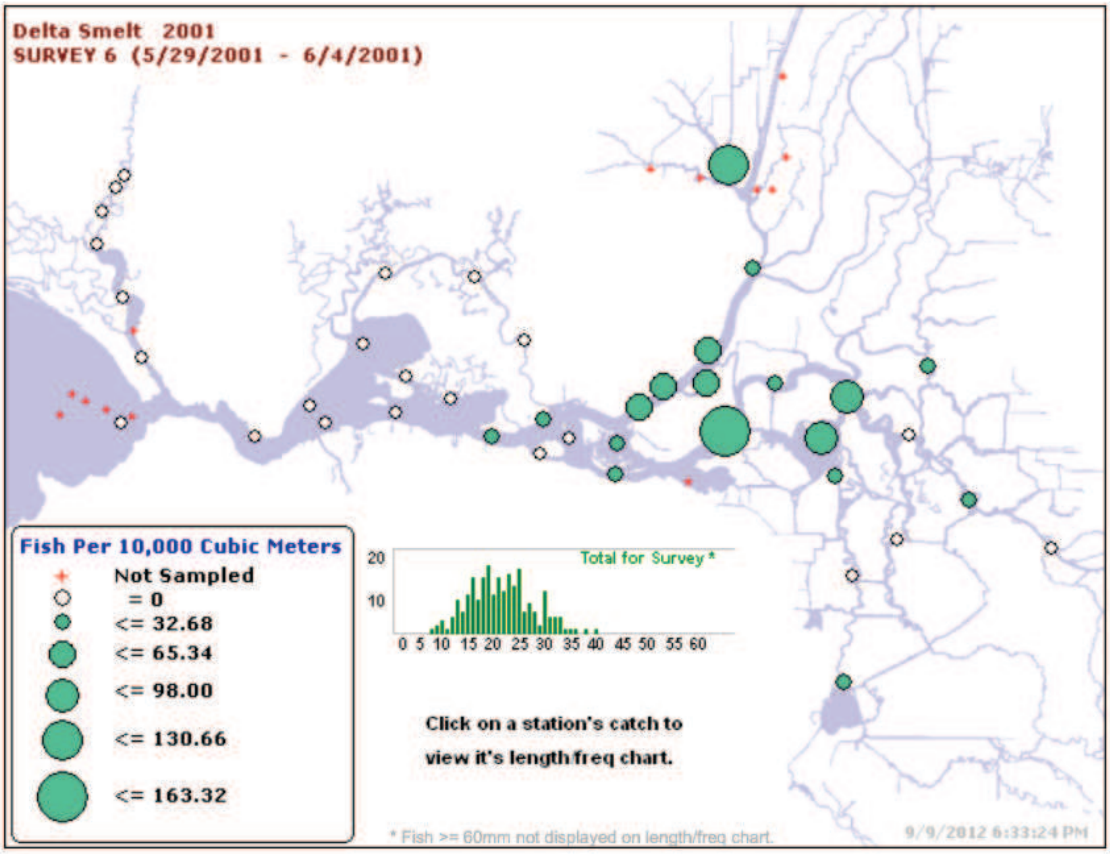


Figure 16. Delta smelt distribution in the 5/29-6/4 2001 20-mm survey.

- The delta smelt are highly vulnerable to exports under these conditions especially with the DCC closed as it was during this period.

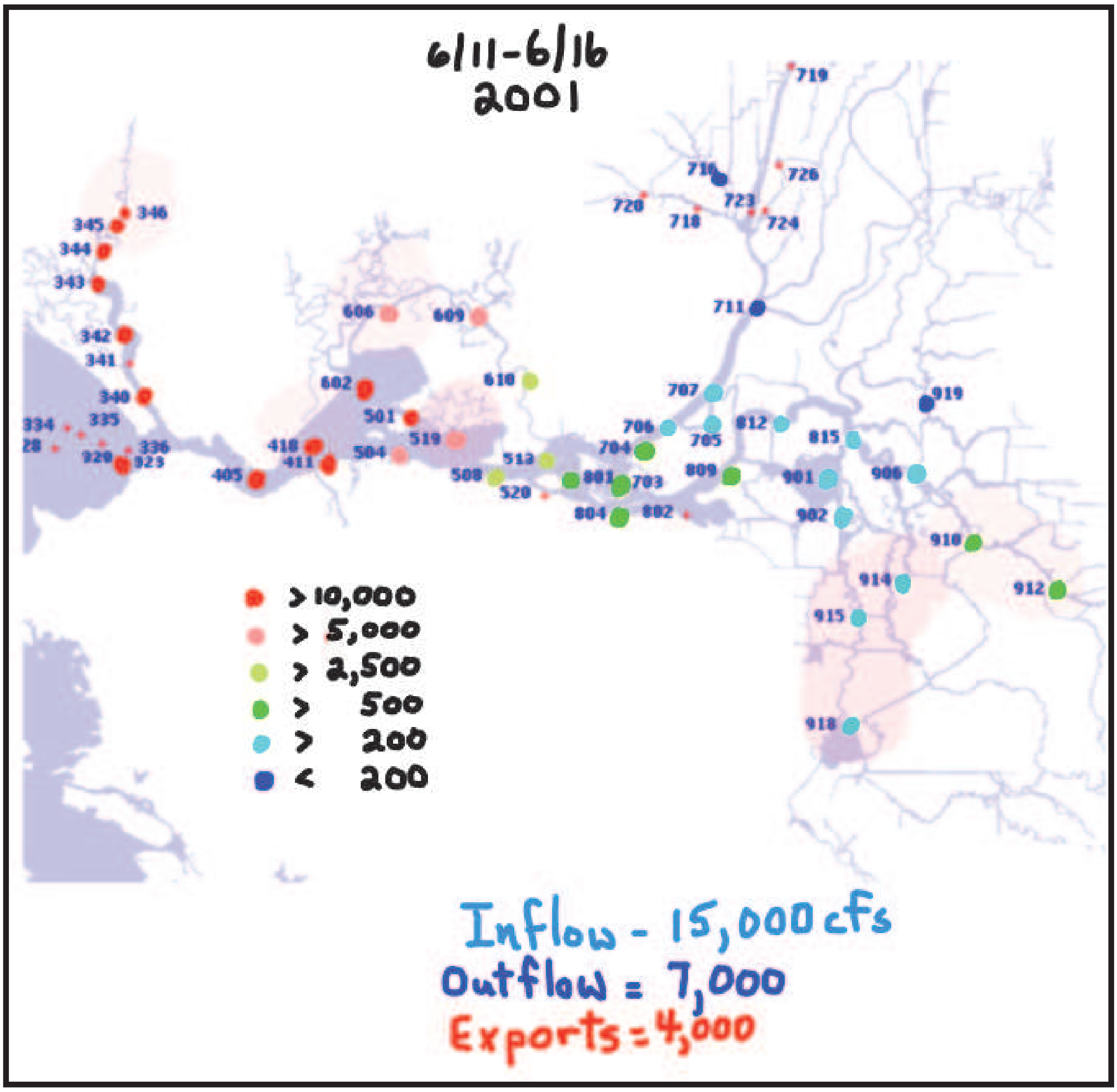


Figure 17. **EC data from the 6/11-6/16 2001 20-mm survey.**

- Outflows are lower and exports are higher recommended for this Year Type in June.
- The SWP export pumps did not operate for most of this period, thus accounting for the low salvage numbers (Figure 20). In any case, the majority of the smelt were too small for salvage (Figure 18).

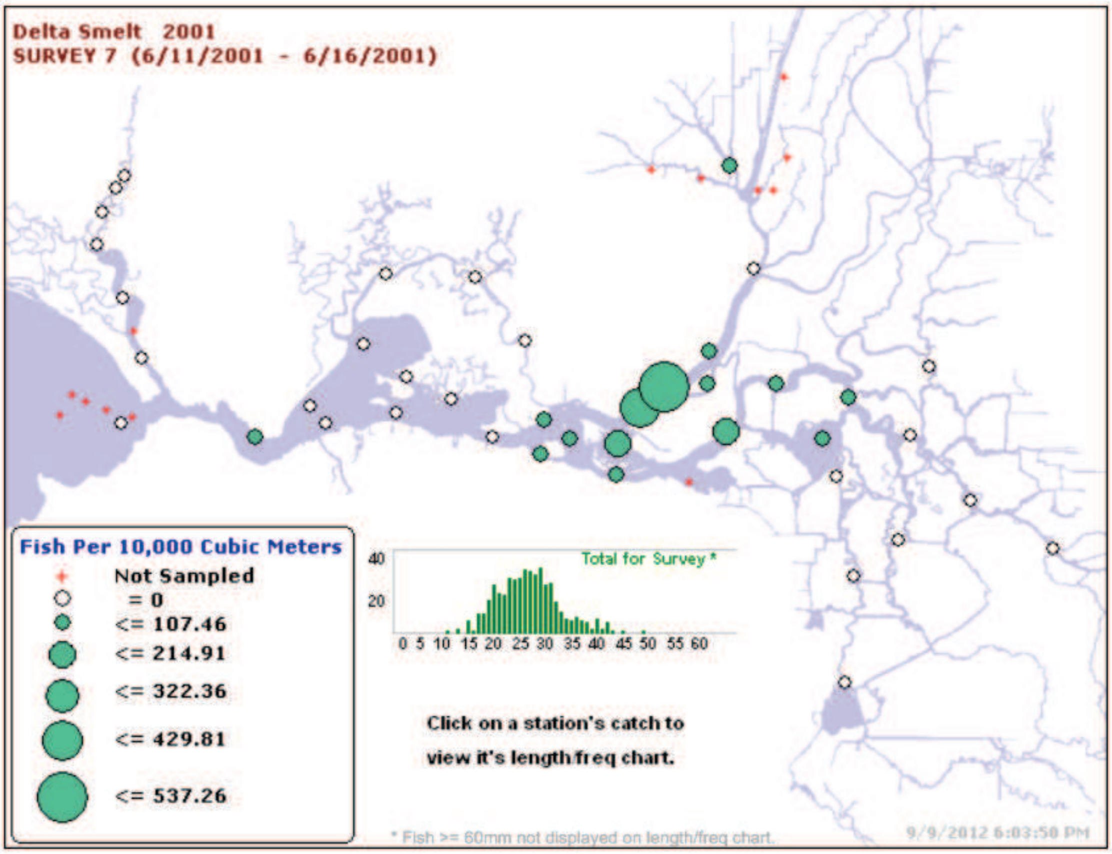


Figure 18. Delta smelt distribution in the 6/11-6/16 2001 20-mm survey.

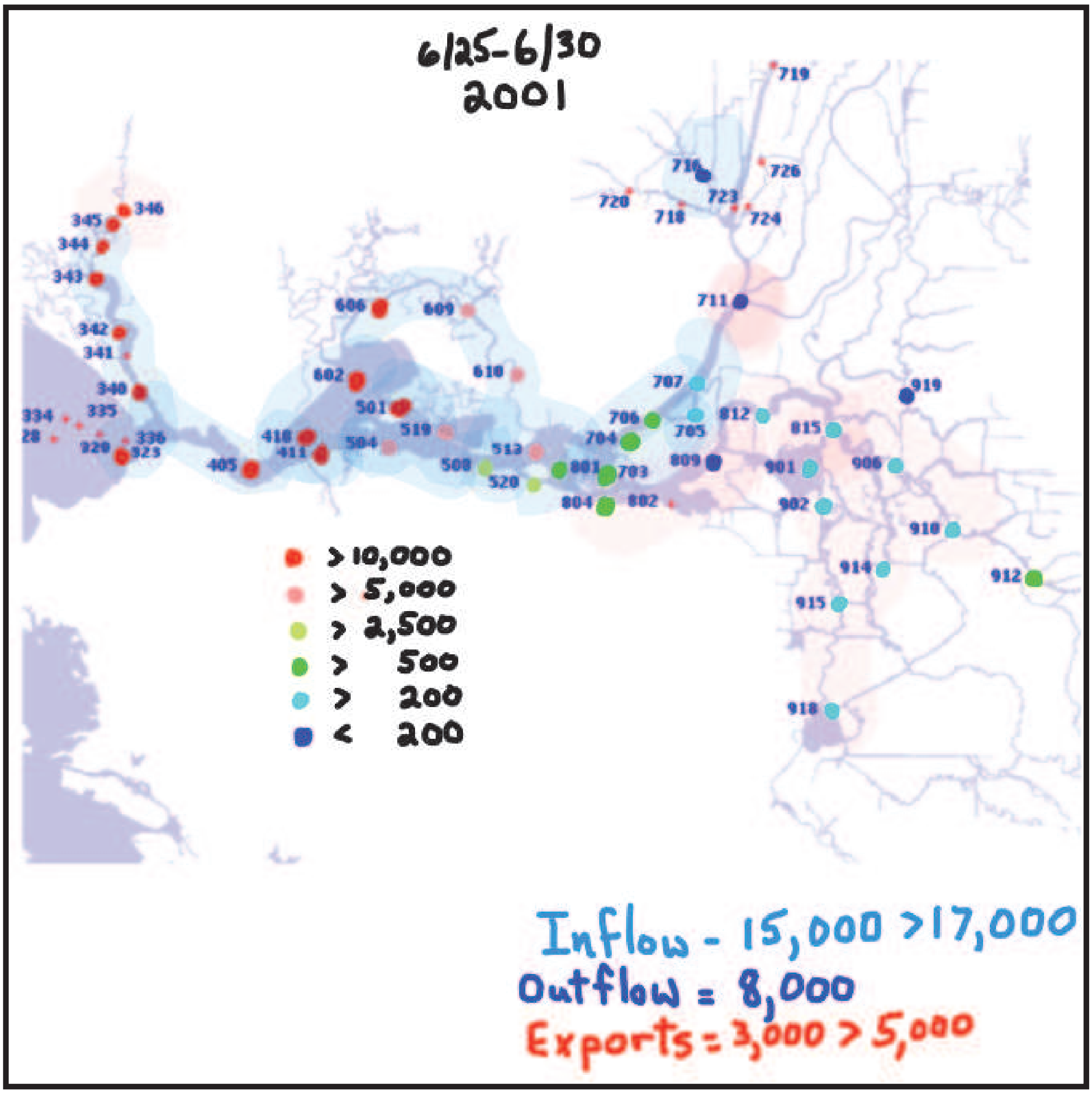


Figure 19. EC data from the 6/25-6/30 2001 20-mm survey.

- Outflows are lower and exports are higher recommended for this Year Type in June.
- The SWP export pumps did not operate for most of this period, thus accounting for the low salvage numbers (Figure 20).

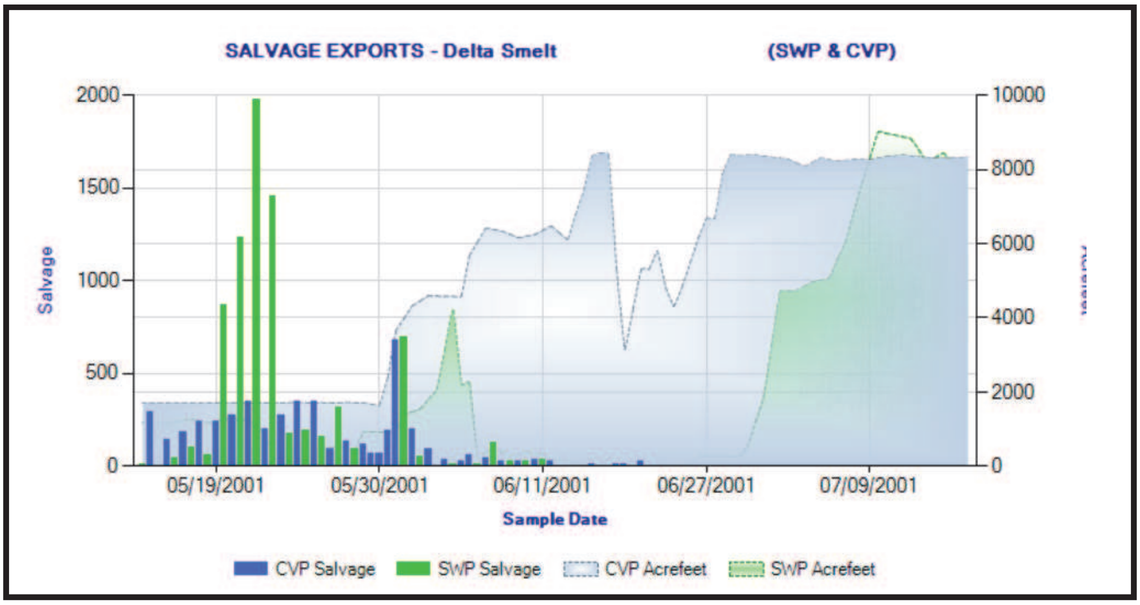


Figure 20. Delta smelt salvage from mid May through mid July 2001.

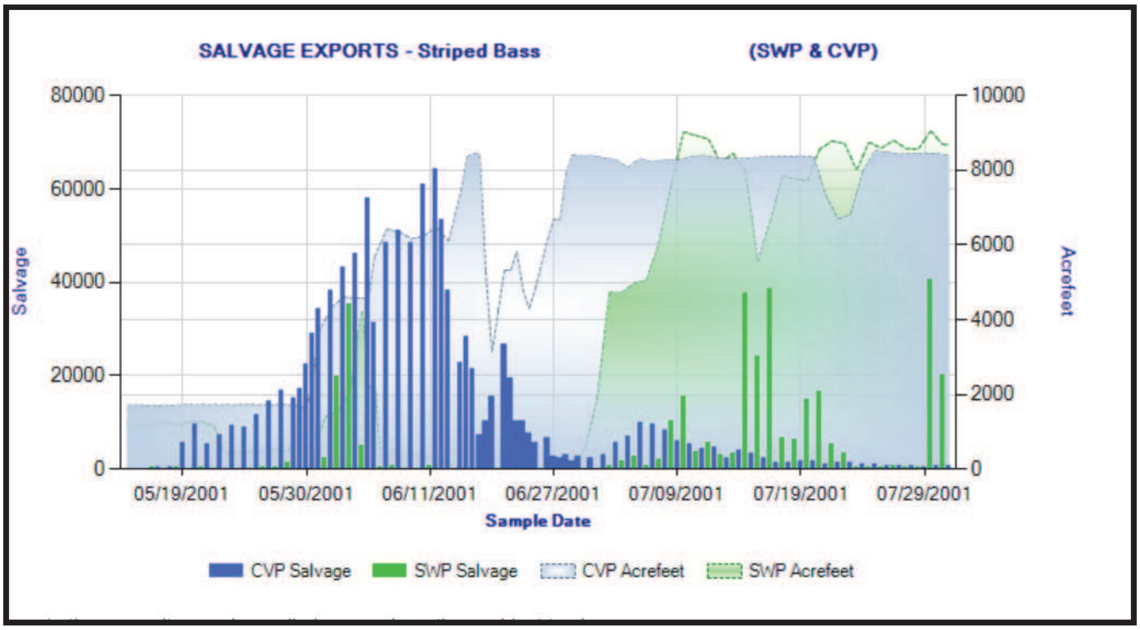


Figure 21. Striped bass salvage from mid May through mid July 2001.

Year 2002

Year 2002 was the third straight drier year of the post-D1641 period. It was the second Dry year following five wet years. As in 2000 and 2001, May-June conditions were poor because of low outflow and increasing exports exacerbated by DCC closures. July outflows were very low (4000-6000 cfs), while exports were 10,000-11,000 cfs, which were too high for a dry year. My recommendation for May of a maximum of 2,000 cfs export limit and 12,000 cfs minimum outflow (Table 2) would have provided protection to delta smelt and striped bass, as well as their food supply. Similarly, June-July criteria for a Dry year of a 2,000 cfs export limit and 10,000 cfs minimum outflow (Table 1) would have provided protection.

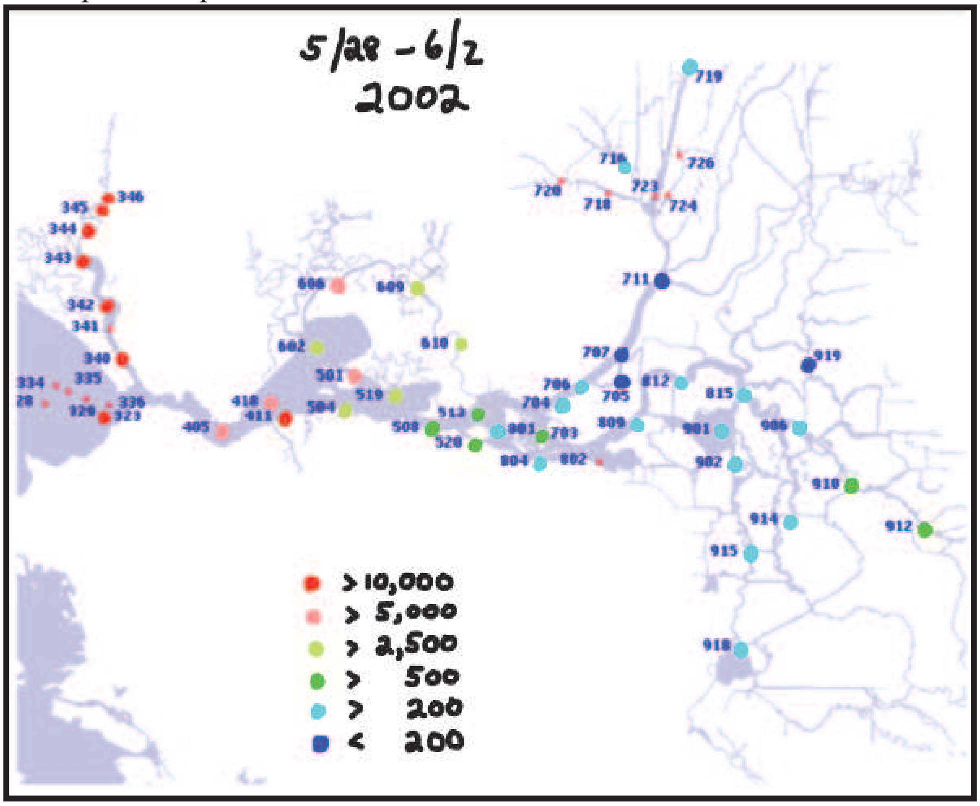


Figure 22. EC data from the 5/28-6/2 2002 20-mm survey.

- During this survey period, outflows were dropping from 11,000 cfs to 7,000 cfs and exports were rising from 2,000 cfs to 4,000 cfs. My recommendations for June are higher outflow (10,000 cfs) and lower exports (2,000 cfs) for this Year Type in June (Table 1).
- The location of the LSZ and slightly brackish water caused delta smelt to be highly vulnerable to exports during the period (Figure 23).
- High salvage rates (Figure 24) and probable high entrainment rates exacerbated by closure of the DCC the week before probably caused severe reduction in the delta smelt population. Simply multiplying the 24 May salvage by its efficiency would yield 2,000,000 juvenile smelt lost at the SWP pumps.

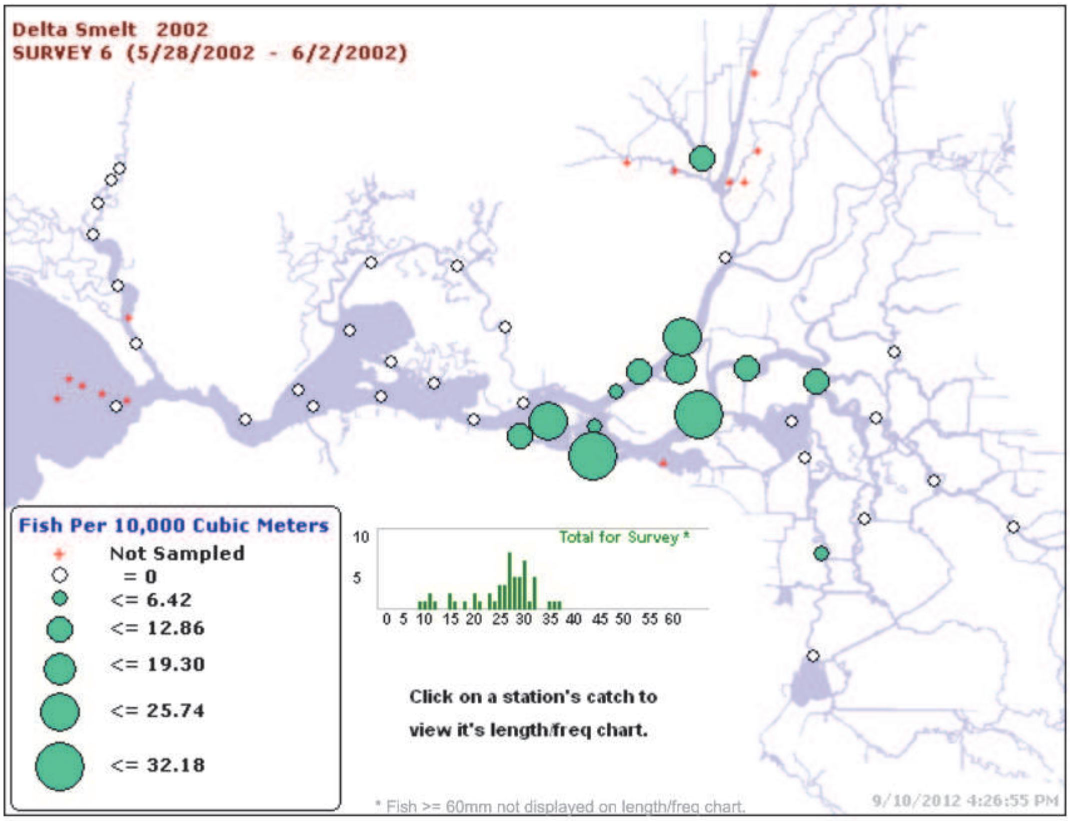


Figure 23. Delta smelt distribution in the 5/28-6/2 2002 20-mm survey. These densities are low for this period of the year.

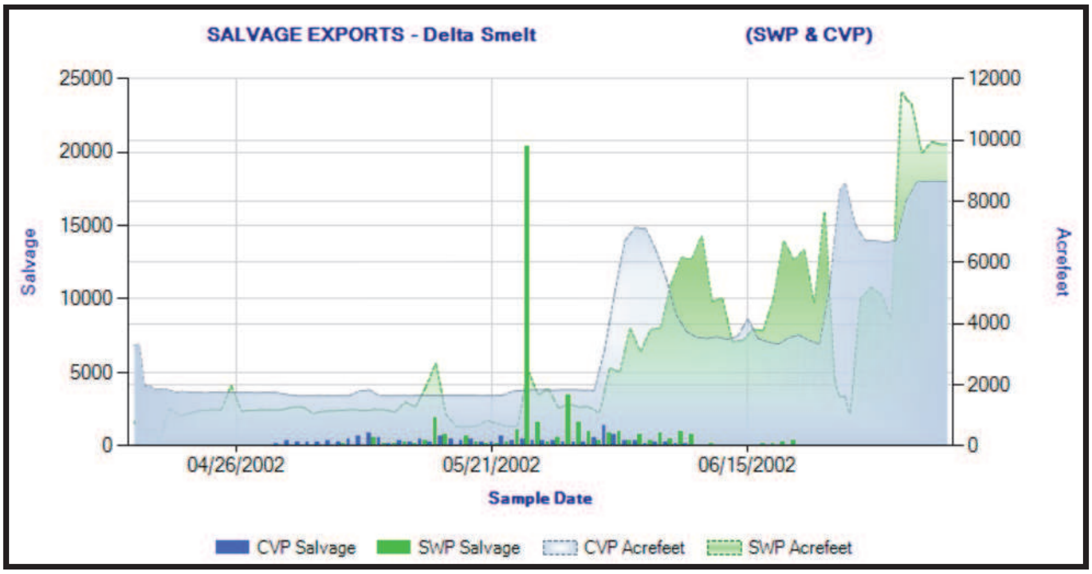


Figure 24. Delta smelt salvage from mid April through mid July 2002.

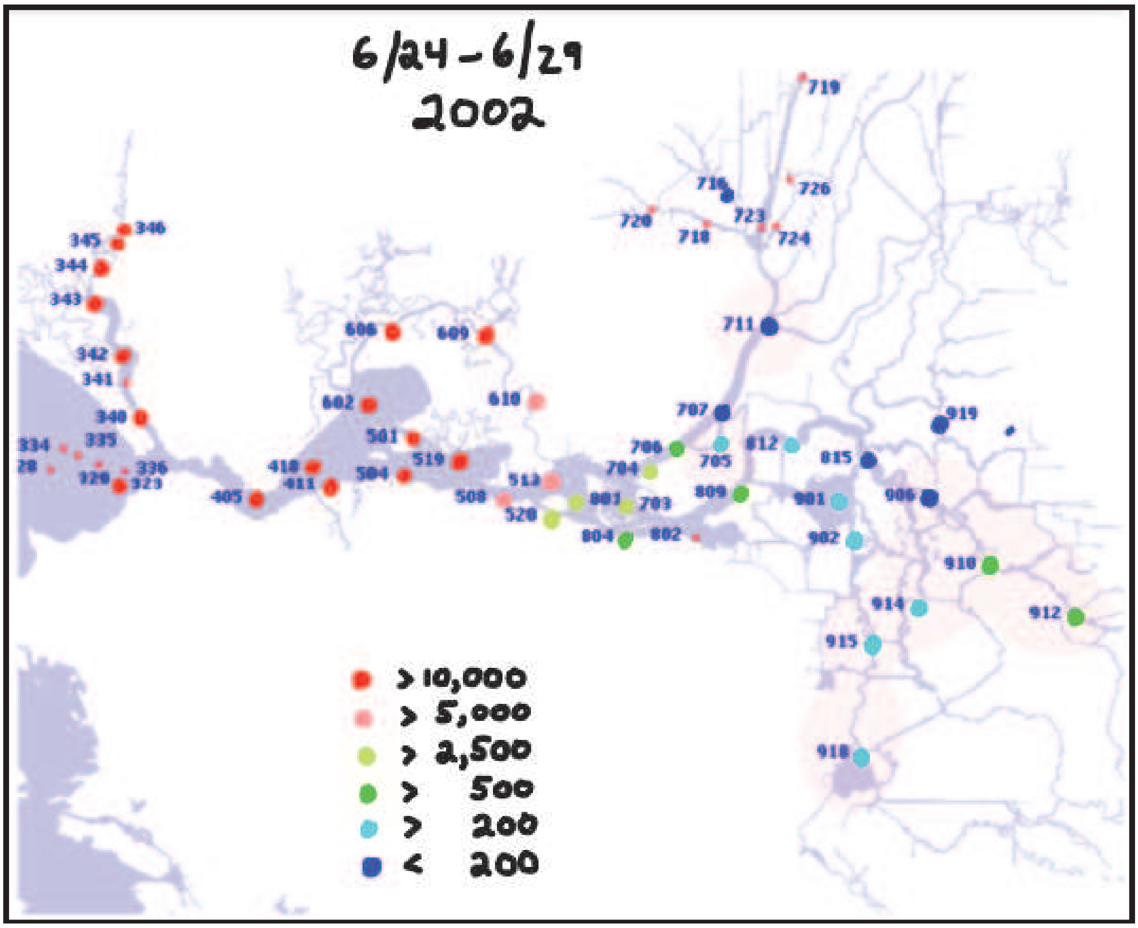


Figure 25. EC data from the 6/24-6/9 2002 20-mm survey.

- During this survey period, outflows were dropping from 9,000 cfs to 7,000 cfs and exports were rising from 5,000 cfs to 7,000 cfs. My recommendations for June are higher outflow (10,000 cfs) and lower exports (2,000 cfs) for this Year Type in June (Table 1).
- The extreme upstream location of the LSZ and slightly brackish water caused delta smelt to continue highly vulnerable to exports during the period (Figure 26). The LSZ extended upstream east of Antioch in the lower San Joaquin channel under these conditions. Despite lack of salvage (Figure 24), given the warm water (pink hi-light) and poor salvage efficiency, it is unlikely that any juvenile smelt moving toward the pumps would have survived to be salvaged.
- Striped bass juveniles were also highly vulnerable to the exports pumps (Figure 27). However, unlike smelt, they can survive such water temperatures and the salvage process, although salvage efficiency and survival is low at the fish facilities.

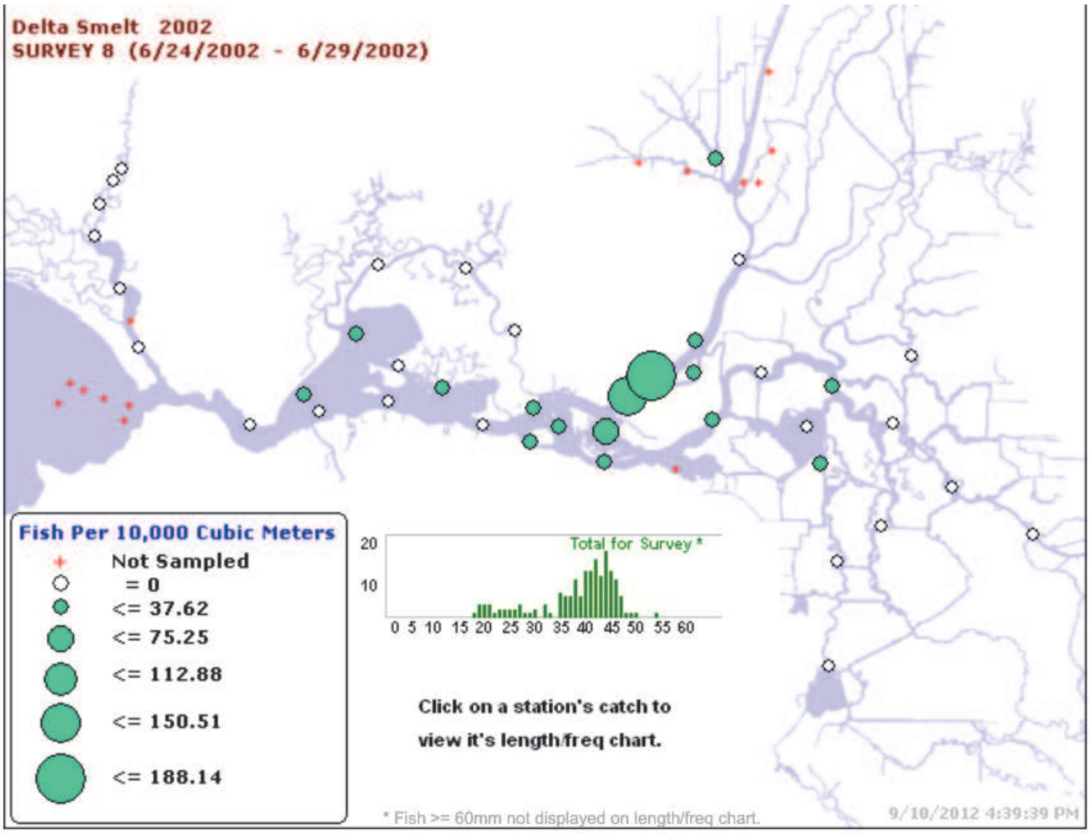


Figure 26. Delta smelt distribution in the 6/24-6/29 2002 20-mm survey.

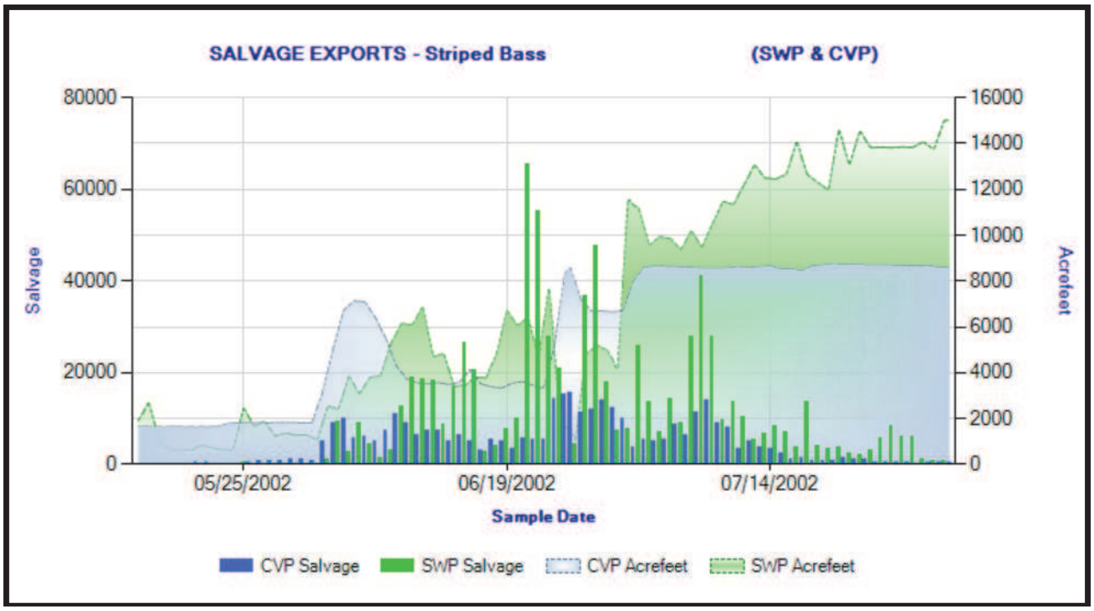


Figure 27. Striped bass salvage from mid May through July 2002.

Year 2004

Year 2004 was the fifth straight non-wet year of the post-D1641 period. It was the first Below Normal year type of the five-year sequence. As in the above-described 2000-2002 years, May-June conditions were good because of adequate outflow and low exports although there were DCC closures. July outflows were low (6000-8000 cfs), while exports were 9,000-11,000 cfs, which were too high for a below normal year. My recommendation for May of a maximum of 2,000 cfs export limit and 12,000 cfs minimum outflow (Table 2) would have provided protection to delta smelt and striped bass, as well as their food supply. Similarly, June-July criteria for a Below Normal year of a 2,000 cfs export limit and 10,000 cfs minimum outflow (Table 1) would have provided protection.

- March and April: despite relatively high outflows (150,000 cfs down to 15,000 cfs), exports over 10,000 cfs (along with DCC closures) through the month of March and over 4,000 cfs through the first half of April were too high to protect smelt larvae generally abundant throughout the Delta in early spring.
- May 24-28: coming out of VAMP under low outflow (11,000 cfs; Figure 28) the smelt were highly vulnerable to exports (Figure 29). However, in 2004 the export and outflow conditions were as recommended in Table 2.
- However, at the end of May and the first week of June outflow dropped to 6,000 cfs and exports increased to 6,800 cfs along with a closure of the DCC leading to high smelt losses (Figure 30).
- Delta smelt remained vulnerable to high exports through July under high exports and low outflow (Figures 31-34).
- The delta smelt, longfin smelt, threadfin shad, and striped bass fall indices were record lows up to that year. The decline in these and other pelagic species from 2000 to 2004 was labeled the "Pelagic Organism Decline" or POD.
- Further declines during the Dry and Critical years of 2007-2009 under similar D1641 conditions brought further record low indices and extended the POD. The patterns described for 2004 and above for 2000-2002 are very similar for 2007-2009.
- After a small recovery in wet year 2011, the indices are expected to decline again in dry 2012.

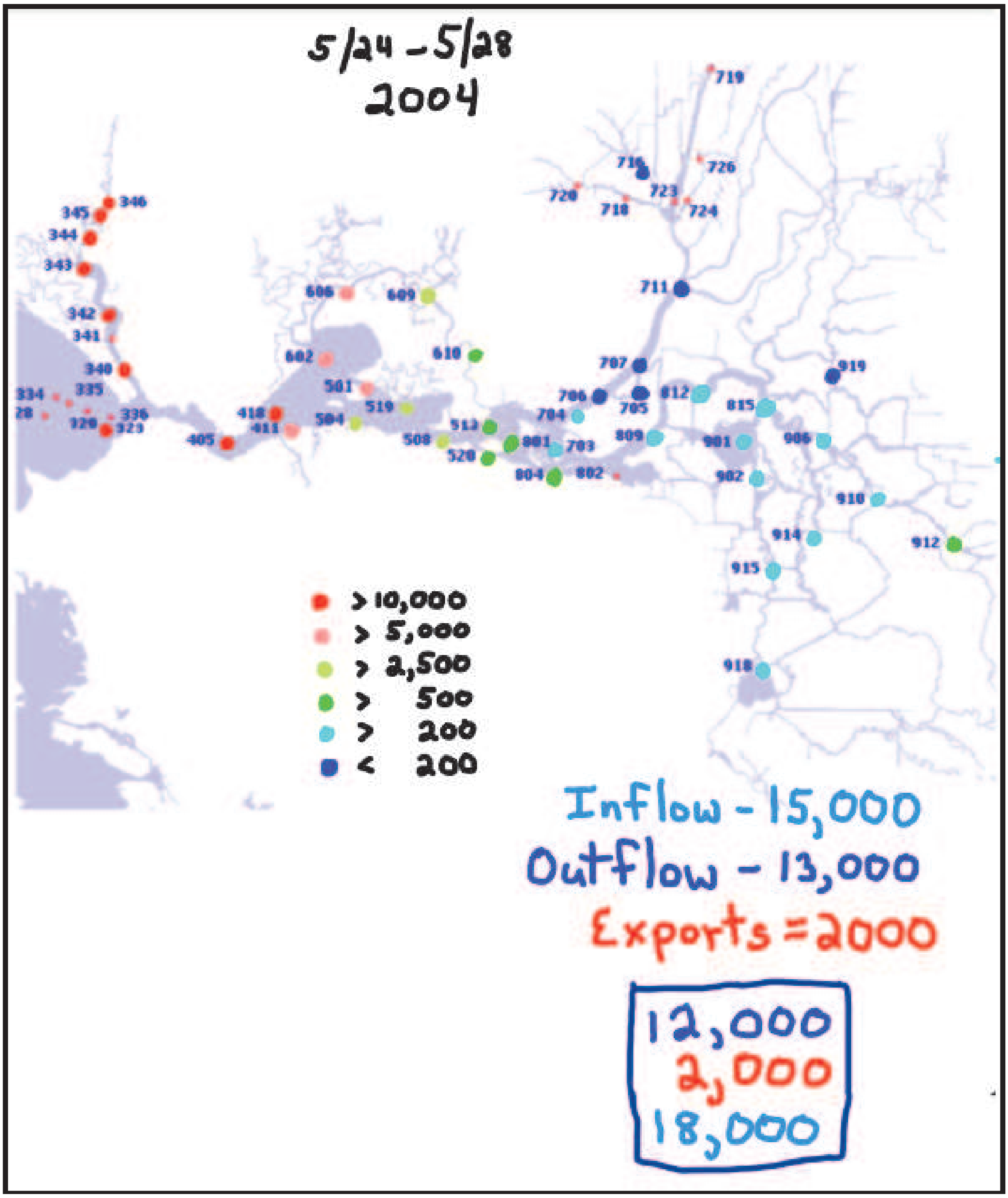


Figure 28. EC data from the 6/24-6/9 2002 20-mm survey.

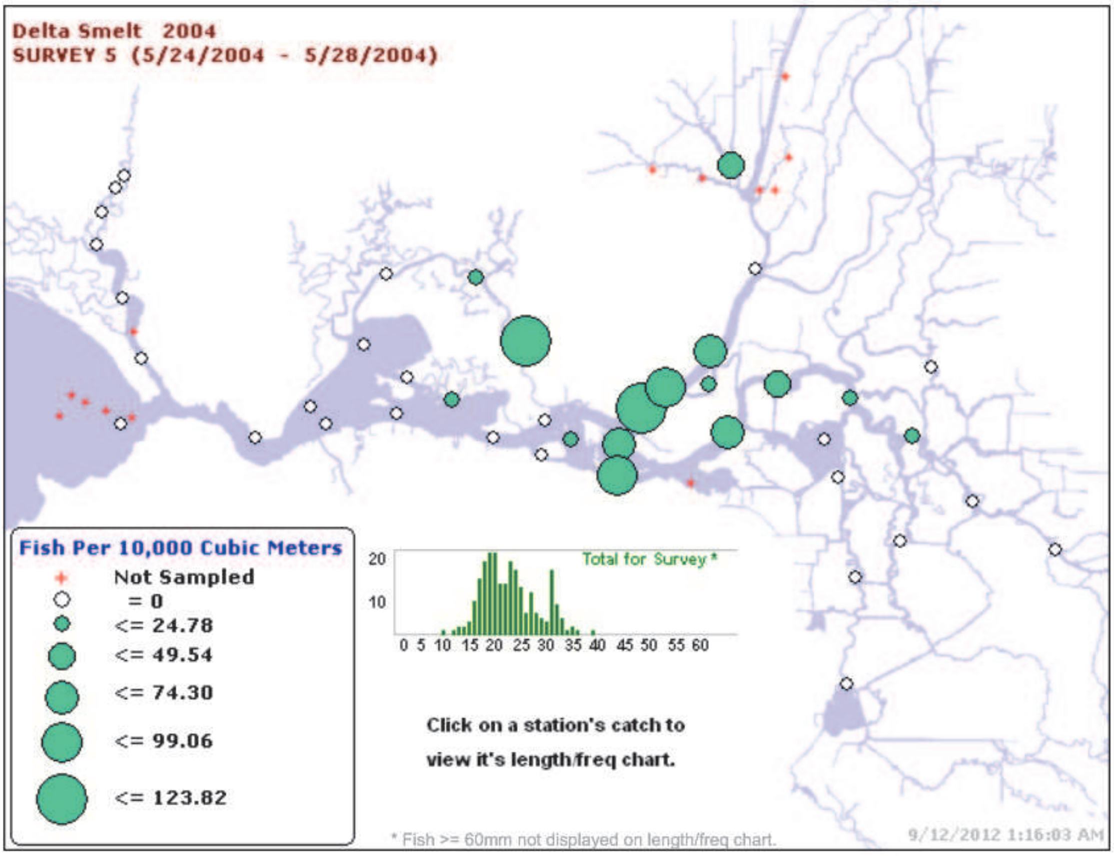


Figure 29. Delta smelt distribution in the 5/24-5/28 2004 20-mm survey.

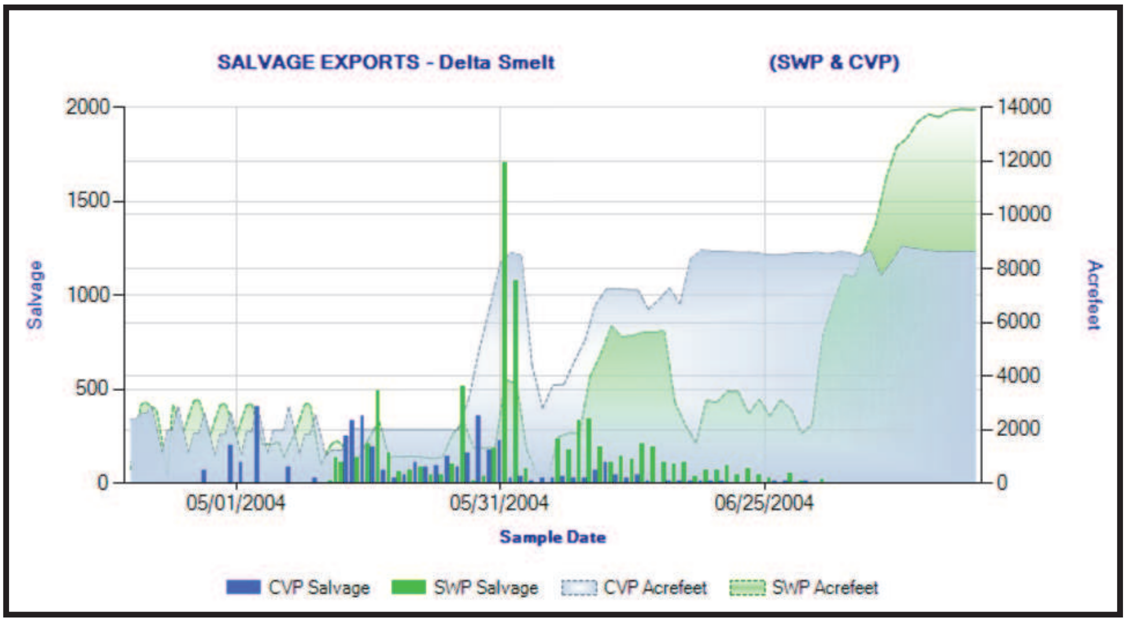
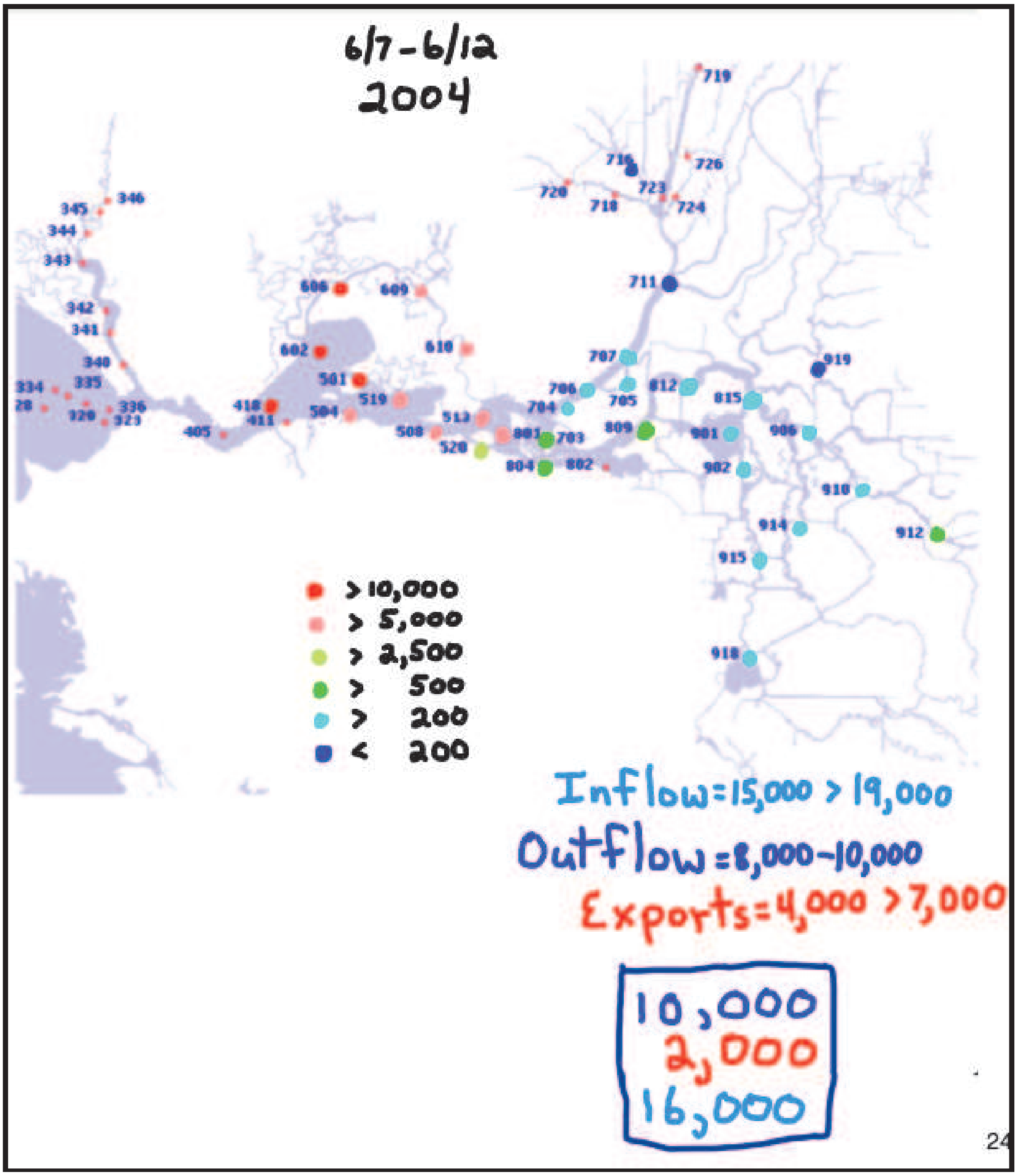
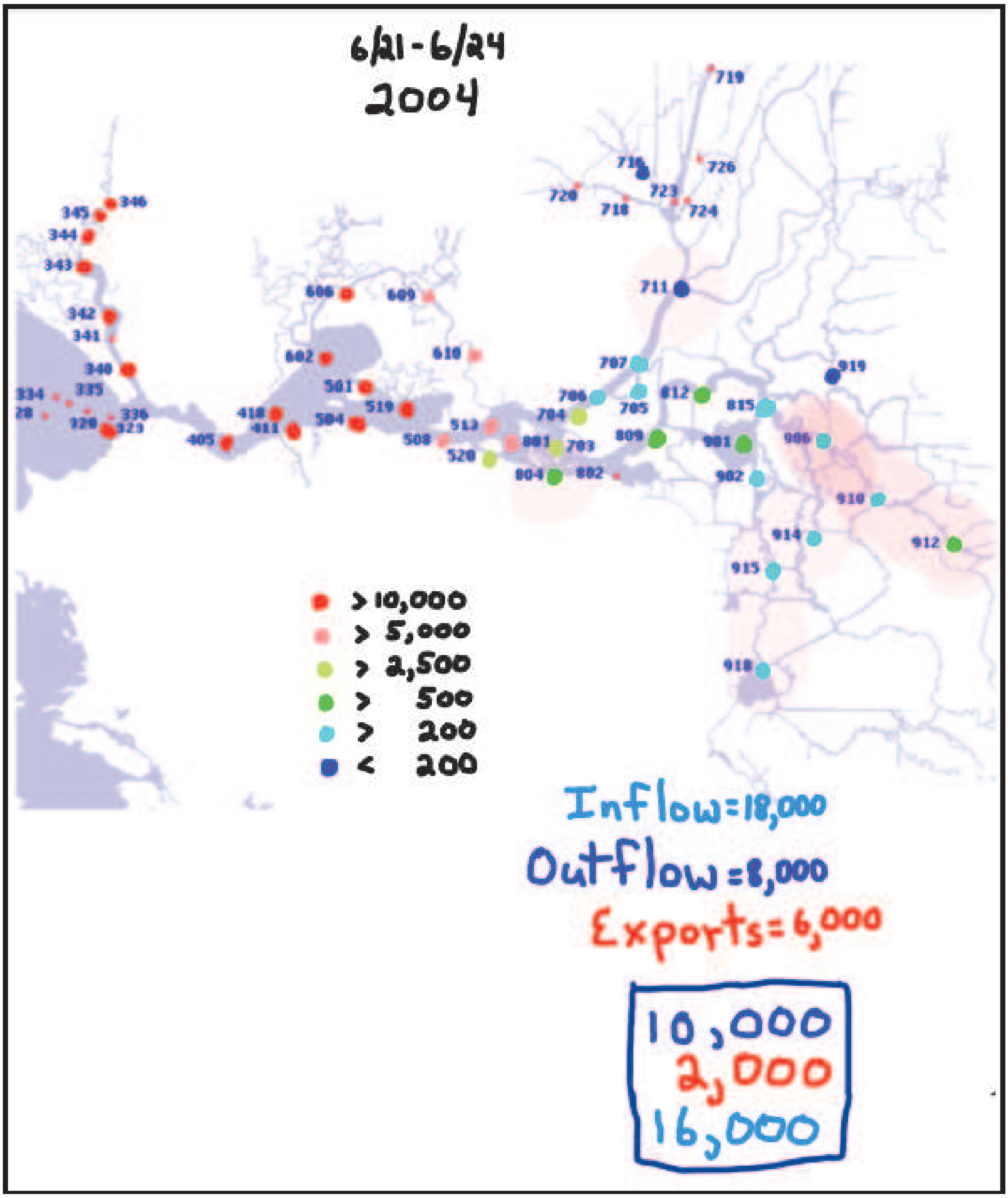


Figure 30. Smelt salvage May-July 2004.



6/7-6/12
2004
719
716
726
720
723
718
724
345
346
344
343
606
609
711
342
341
610
602
707
919
340
501
334
335
706
812
28
336
418
519
705
815
320
323
411
504
704
405
513
508
801
703
809
901
906
520
804
802
902
910
914
912
915
> 10,000
> 5,000
> 2,500
> 500
> 200
< 200
918
Inflow=15,000 > 19,000
Outflow=8,000-10,000
Exports=4,000 > 7,000
10,000
2,000
16,000
24

Figure 31


6/21-6/24
2004
> 10,000
> 5,000
> 2,500
> 500
> 200
< 200
Inflow=18,000
Outflow=8,000
Exports=6,000
10,000
2,000
16,000
Figure 32

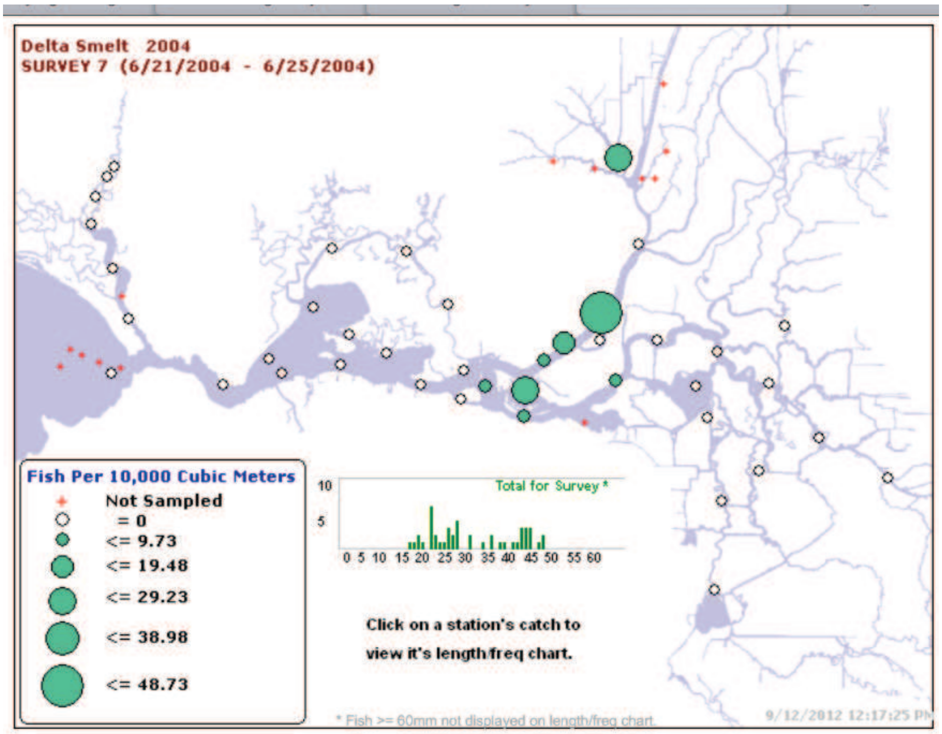


Figure 33.

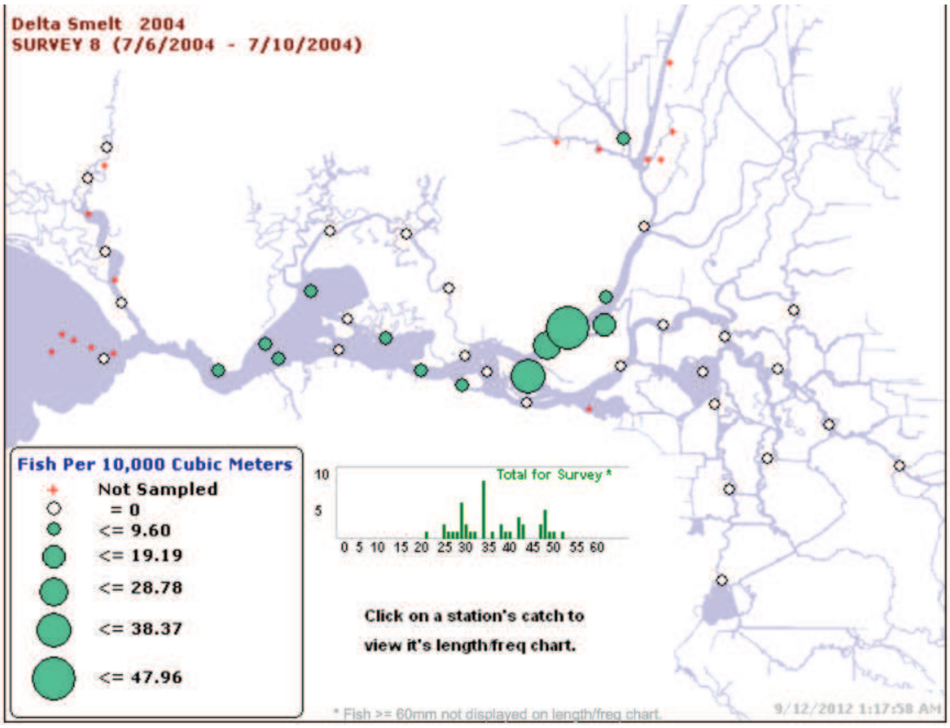


Figure 34.

Population Models

Populations of Delta fish respond to outflow and export conditions as described above. However, the most important factor controlling long-term population trends is the population size itself. Large year classes are generally bred by large year classes, and visa versa. Although individual year class production can be lowered by poor conditions, it generally takes a number of years to pull the population down, as was the case in the POD and the sequence of years 2000 to 2009. Small recoveries like 2011 can come over a couple of years (2005-2006; 2010-2011). Larger recoveries occurred over a longer period (1995-1999). The following are population models I developed for delta smelt and striped bass. The models are some of the strongest stock-recruit models in terms of variance explained that I have seen during my career. The primary driving variable is population size, but water year types explain much of the residual error.

Delta Smelt

Two models were developed for delta smelt using the Summer Townet Index and the Fall Midwater Trawl Index.

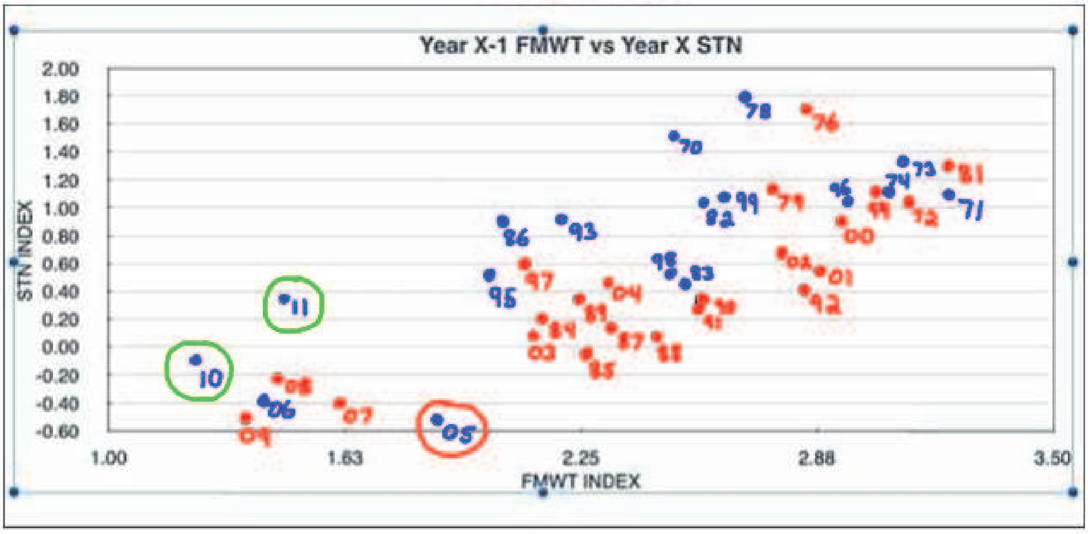
The first model is the Summer Townet Index as influenced by the previous Fall Midwater Trawl Index (Figure 35). Recruits on the y-axis represented by Summer Index and a function of spawners represented by the previous year's Fall Index. Logarithms are used to transform such exponential relationships for numeric indices. As seen in Figure 35 there is a strong positive relationship between spawners and recruits. Recruit production per spawner abundance is also significantly lower in drier year types (red years). Years 2010 and 2011 appears as outliers, but they are actually what can be achieved under good conditions at these very low spawner levels. Years 2005, 2006, and 2012 (not shown) actually achieved far less than their potential abundance had they had good conditions.

The second model is the Fall Trawl Index as influenced by the number of young earlier in the summer represented by that year's Summer Townet Index (Figure 36). Here again there is a strong positive relationship with less fall production in drier summers with low outflow and high exports. Also worthy of note were dry summers with low exports that produced better than expected fall indices.

DELTA SMELT

Young Recruitment Model
1. Driving variable is adult abundance index from previous fall.
2. Significant reduced production in dry springs is also driving.

Plot of Logs



Red years = dry spring/summers
Red circles = max Apr + early summer exports, low X2
green circles = low April- June exports, low X2, no salvage loss

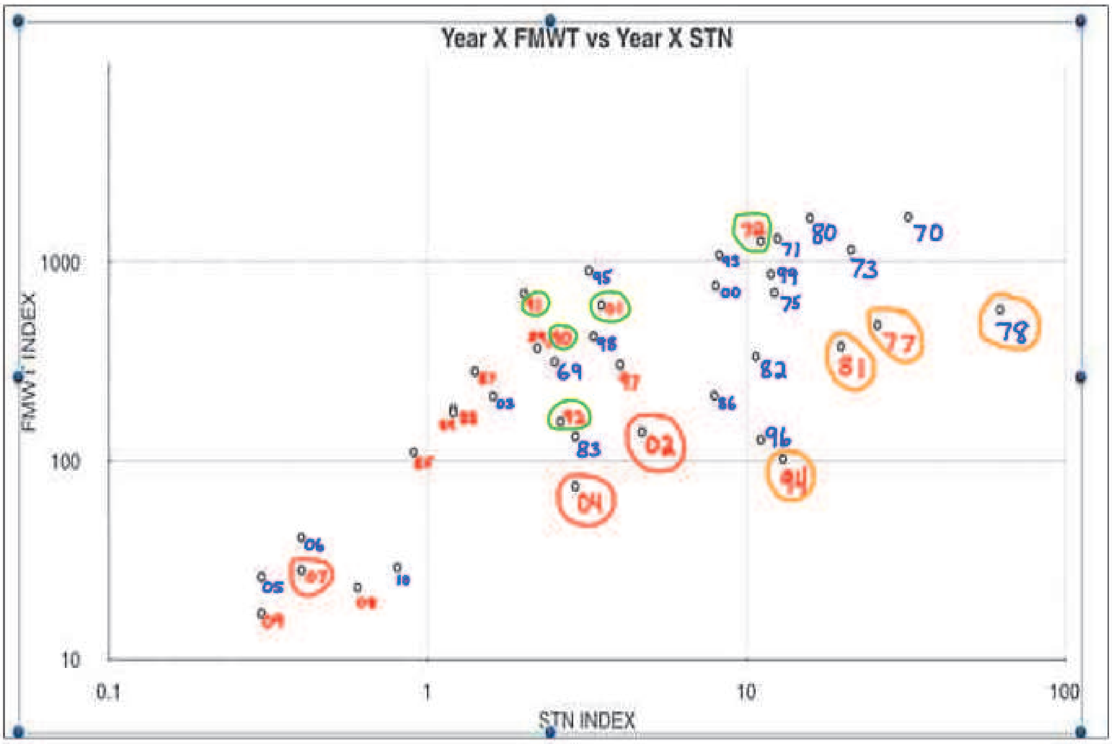
Figure 35

DELTA SMELT

PRE-Adult Production Model

1. Summer young stock abundance is driving variable.
2. Dry spring - summers are secondary factor.
3. Low summer exports in dry years is mitigating factor; 78-95 protected by D1485.
4. High summer exports reduce production

Log-Log Plot



Red years = dry spring/summers
Red circles = also with max summer exports
Green circles = low summer exports
Orange circles = high spring salvage/entrainment (no VAMP)

Figure 36

Striped Bass

Striped bass have a similar population model that shows the influence of dry year conditions. The spawning population in this case was from tag return estimates from three-year and old striped bass as estimated by DFG in the spring of the year. As for the smelt, potential production of young is reduced by dry spring conditions (the YOY index is usually set in June or early July.

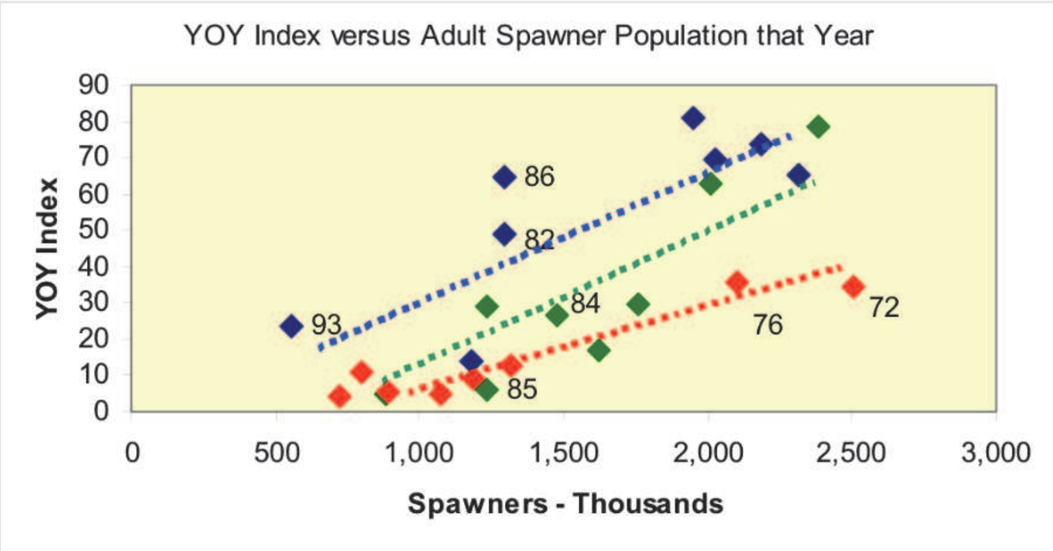


Figure 54. Version of Figure 31 showing spawner to first-summer recruit relationship for different water year types (blue = wet year; green = moderate year; and red = dry year).

Figure 37. (From Cannon 2004)

Chinook Salmon

Chinook salmon use the upper Bay-Delta estuary primarily in winter and spring for migration and rearing. Exports and outflow levels have a strong influence on salmon use of the Bay-Delta and their ultimate survival and success.

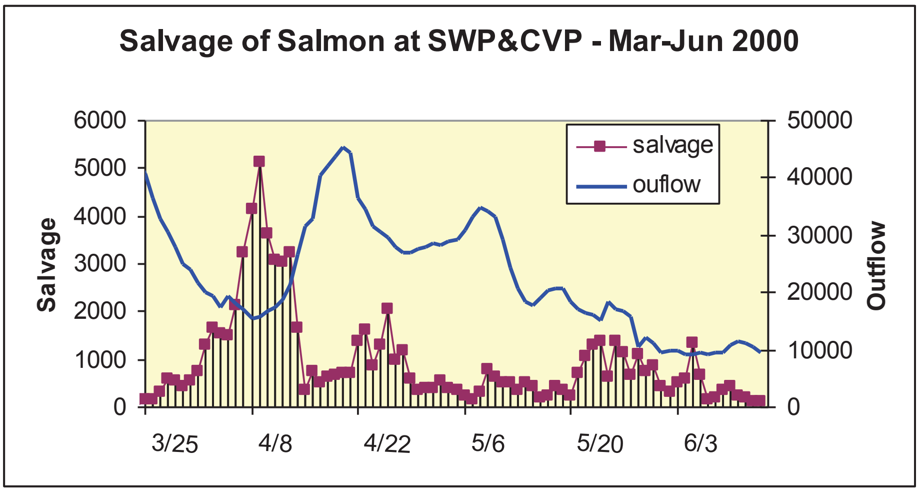
Adult salmon migrate through the Delta in most months of the year, but fall, winter, and spring are the primary migration seasons. Fall run move through as the Delta cools from late summer through fall. They depend on the scent of their natal streams and relatively cool water (generally less than 25ºC). The signatures of San Joaquin and Delta tributary streams are weak in late summer and early fall before the rains because of low late summer Delta outflow (often less than 10,000 cfs) and high exports (often up to 11,500 cfs). Much of outflow is made up of Sacramento River water with little signal coming from the San Joaquin and Eastside tributaries. Exports commonly at 4,000 cfs in summer and fall at the Tracy pumping plant take most of the San Joaquin flow. The proposed outflow and export criteria in Table 3 will provide higher outflow and lower exports to help migrating adult salmon reach their natal streams. Lower exports the remainder of the year will reduce demands on reservoir storage leading to more and cooler water available for the fall season. Carryover storage will also improve for multiyear dry periods.

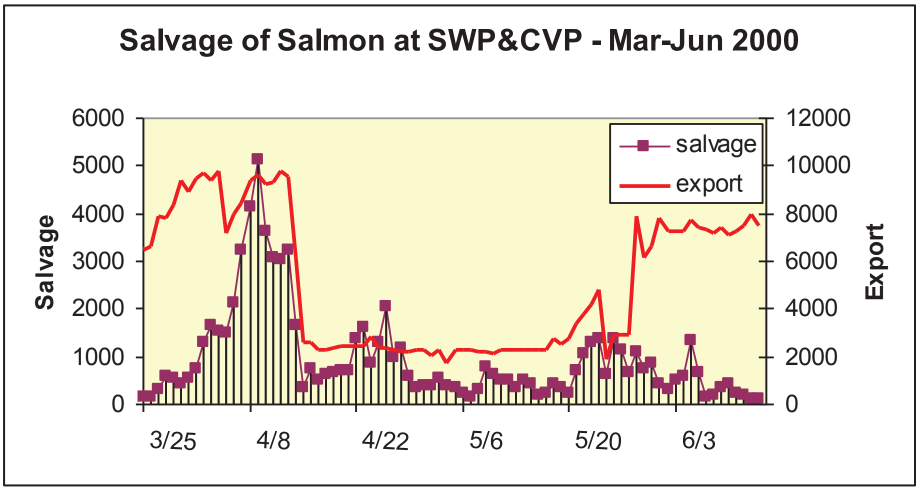
Late fall, winter, and spring run salmon migrate upstream usually during the high flows of winter and spring. However, even they will benefit from higher outflows and lower exports in drier years.

All the run types spend weeks to months as young rearing in the Bay-Delta, where they gain critical growth and energy supply for their eventual entering the ocean. These early life stages will be benefit from improved Delta inflow getting them to the Delta, and lower exports and higher outflow once in the Delta.

Higher outflow, lower exports, and reduced negative Lower San Joaquin River negative flow in the spring generally leads to reduced salvage at the South Delta export pumps (Figures 38-40). Migrating young salmon are wrongly influenced by the negative flow cues caused by the export pumps.

The total San Joaquin salmon production if strongly related to total April-May San Joaquin River inflow to the Delta (Figure 41). Much of the remaining variability is explained by exports two years earlier (Figure 42) with higher exports resulting in lower production and visa versa.





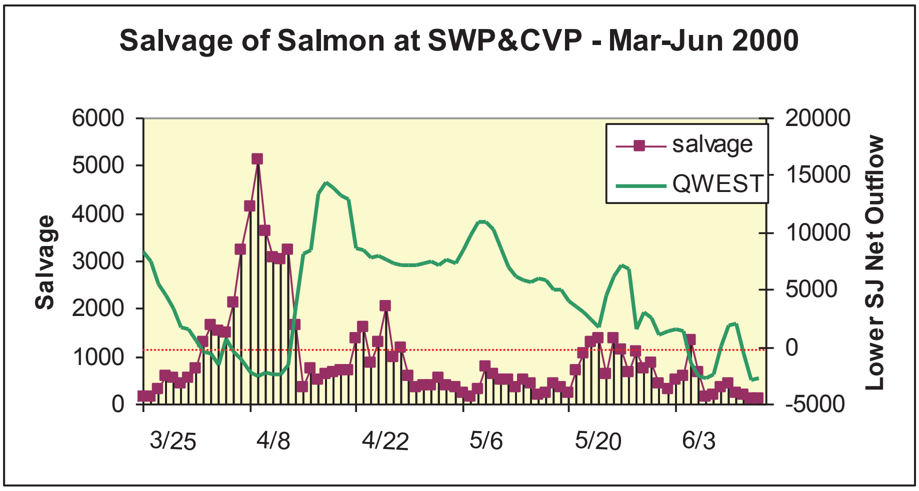


Figure 38. Salmon young salvage in spring of 2000 versus outflow, exports, and QWEST (net direction of lower San Joaquin flow).

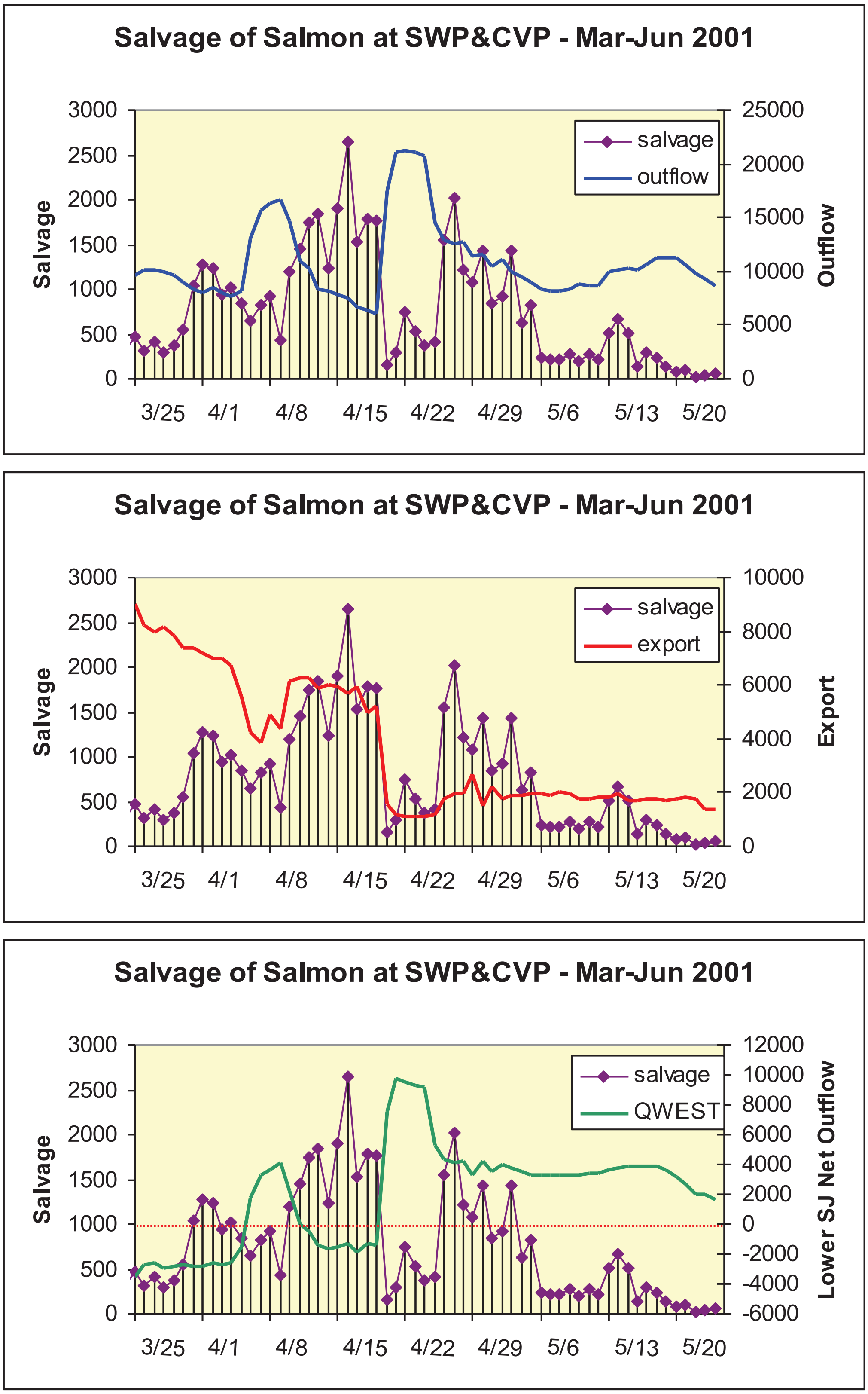
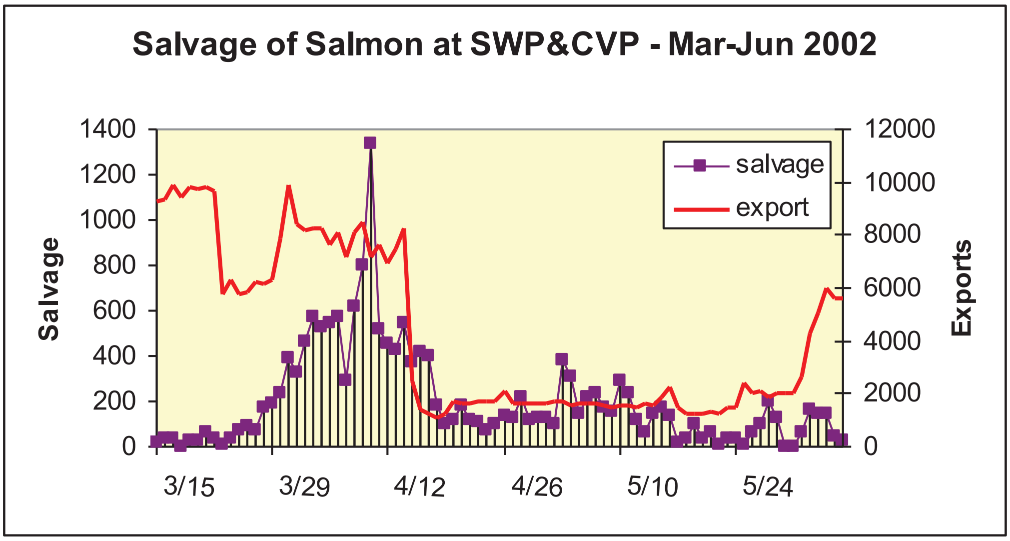


Figure 39. Salmon young salvage in spring of 2001 versus outflow, exports, and QWEST (net direction of lower San Joaquin flow).



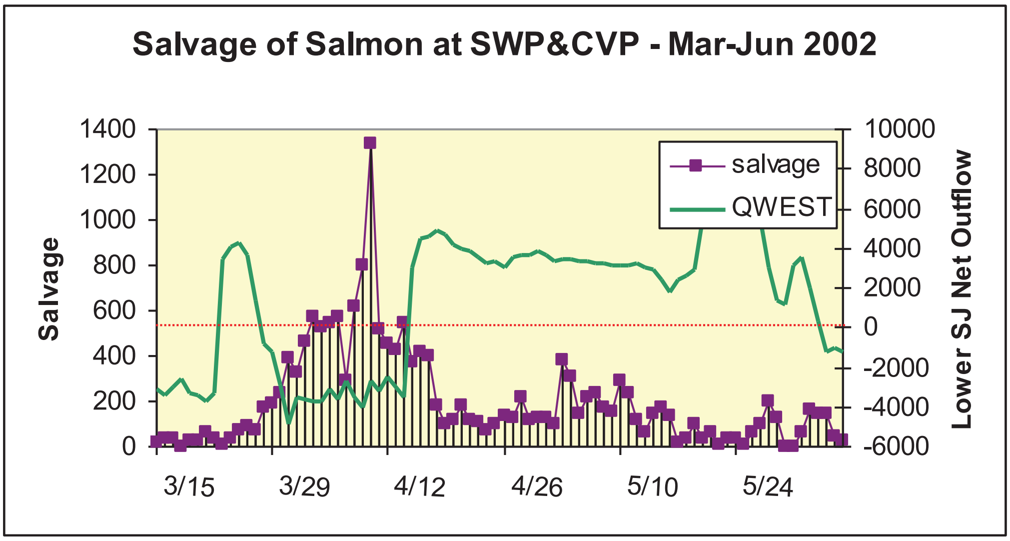


Figure 40. Salmon young salvage in spring of 2002 versus exports and QWEST (net direction of lower San Joaquin flow).

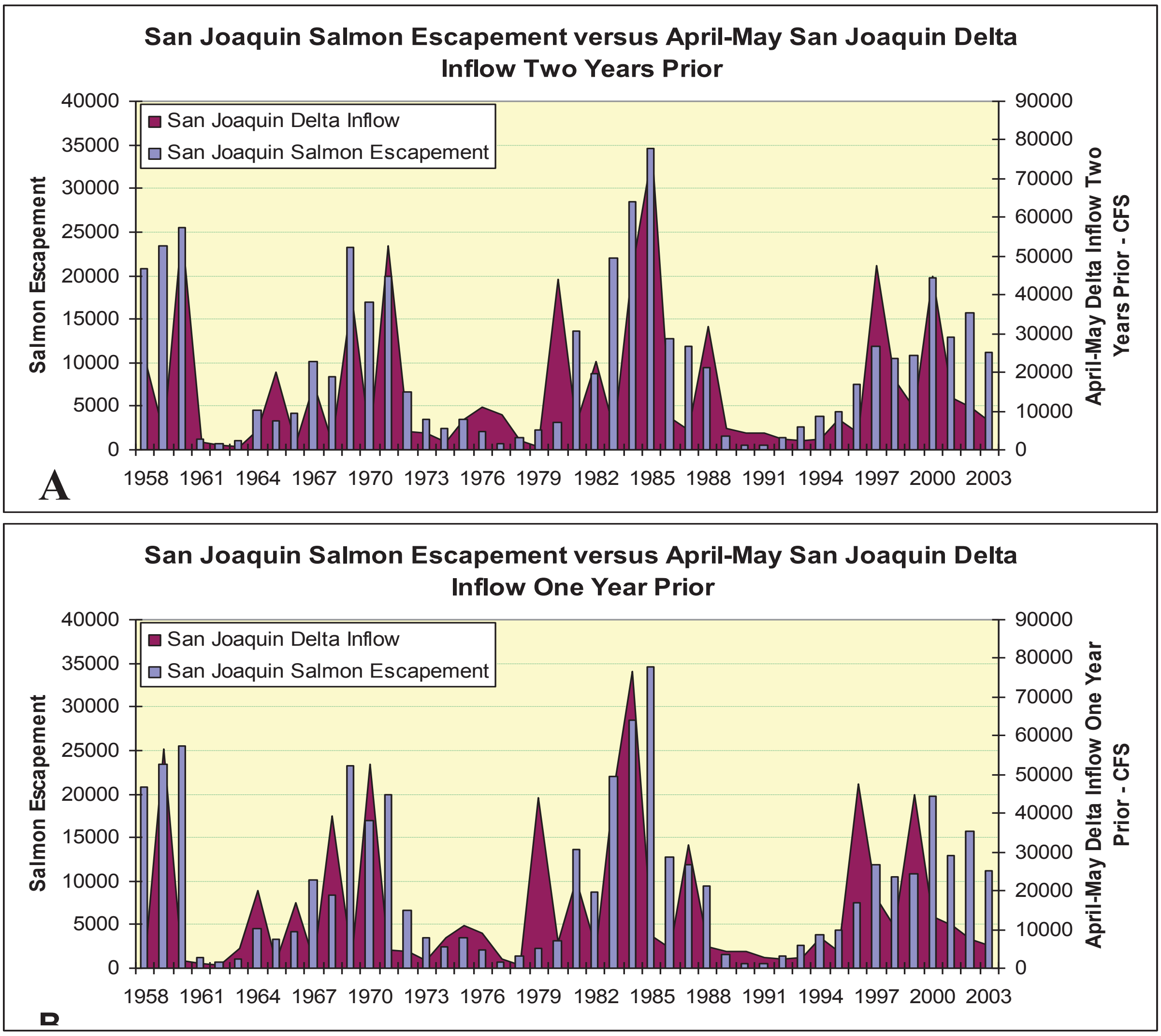


Figure 41. San Joaquin salmon escapement from 1958 to 2003 versus average San Joaquin River Delta inflow in April-May: A - two years prior; and B - one year prior.

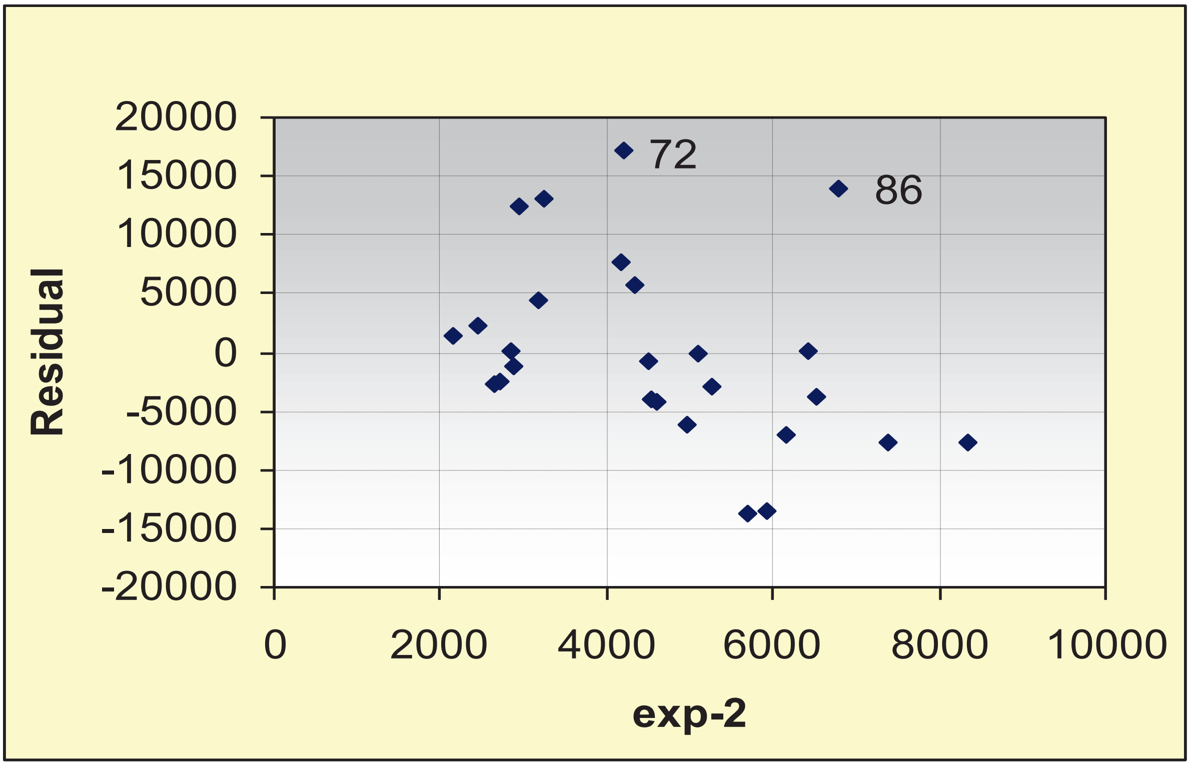


Figure 42. Residuals of regression of escapement, flow, and escapement two years earlier versus export level in April-May two years earlier for only low flow years. The relationship is marginally significant with 1972 and 1986, and highly significant without these years. Both years followed several years of high escapement, which may have contributed to the higher than predicted escapement in 1972 and 1986. The unusually high flows in the fall of 1986 may have also contributed to the large spawning run in the San Joaquin River that year.

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