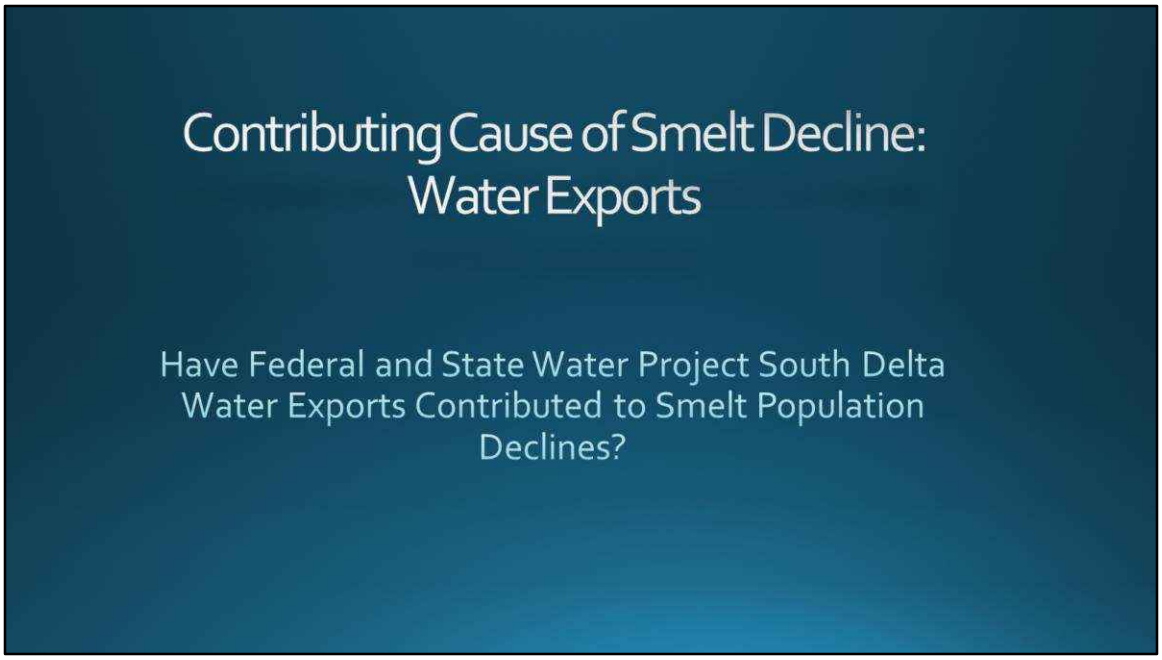
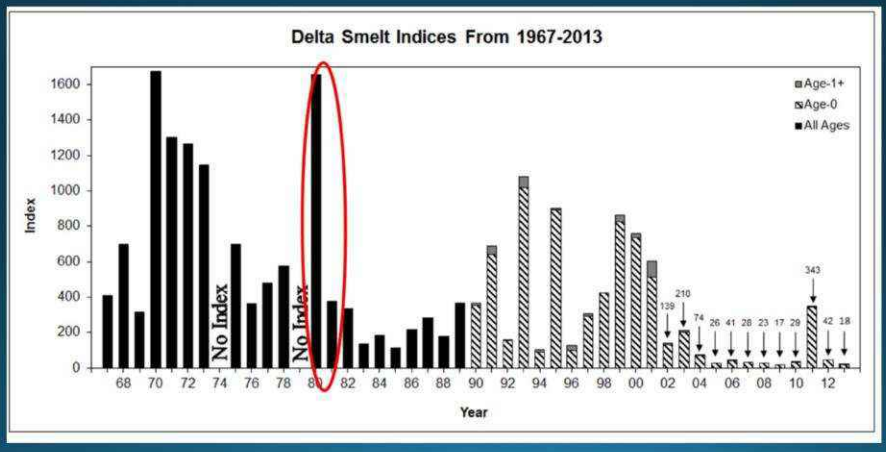


In this presentation, I will make the case that the major cause of the decline of Delta Smelt has been entrainment of smelt into the South Delta export facilities. Since 1980, there have simply not been sufficient protections during the winter spawning season and spring-summer rearing period to maintain this species. From 1980 to 1994 under D1485 standards there were very limited winter-spring protections. After 1995, D1641 standards, CVPIA actions, VAMP, and OCAP biological opinions improved winter-spring protections but reduced summer protections, leading to the Pelagic Organism Decline or POD in the first drought period of this century. During the recent four years of drought already limited protections were relaxed causing the species to become virtually extinct.

Fall Midwater Trawl Index



The largest one year decline in smelt abundance occurred between 1981 and 1982. **RED CIRCLE**

This led to the poor population levels observed from 1983 to 1988.

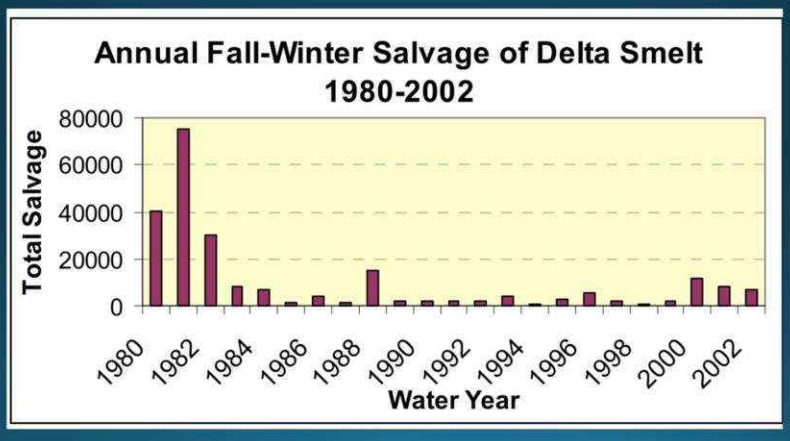
This was followed by a recovery period from 1991 to 2001. The recovery was spurred on by low exports from 90-92 from low storage available in years 4-6 of the 87-92 drought.

Poor yearclasses in 94 and 96 were also a result of high export entrainment.

A decade of decline after 2001 was followed a weak recovery in 2011.

Since 2012 indices have been at record lows.

Adult Delta Smelt Winter Salvage



This is a Chart from my 2004 paper:

Fall-Winter 1981 marked the peak in Fall-Winter Delta salvage of 30,000 to 75,000 adult smelt in fall-winters of 1980-1982.

In contrast are the 8 adult Delta Smelt salvaged thus far in fall 2015-winter 2016.

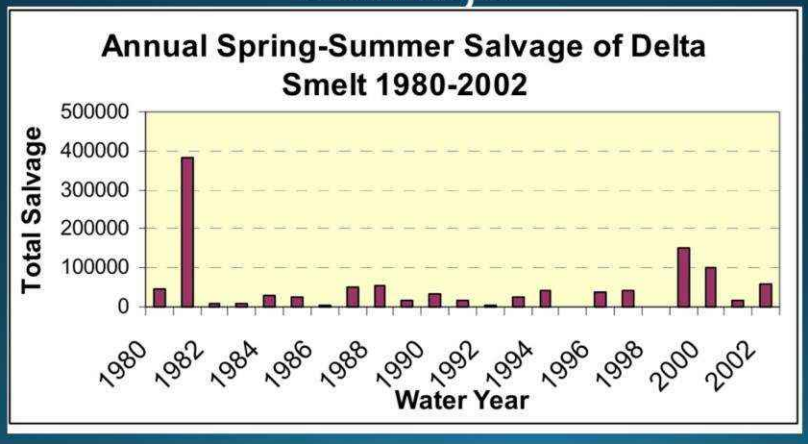
Note: most "salvaged" smelt die, salvage collections are inefficient, and many smelt are preyed upon before reaching the South Delta or entering salvage facilities. Therefore these counts underestimate the numbers of smelt lost from directly and indirectly from exports.

I believe the high winter losses in 1980-82 struck a long-lasting possibly permanent blow to the population.

Subsequent high winter losses in 1988 limited recovery.

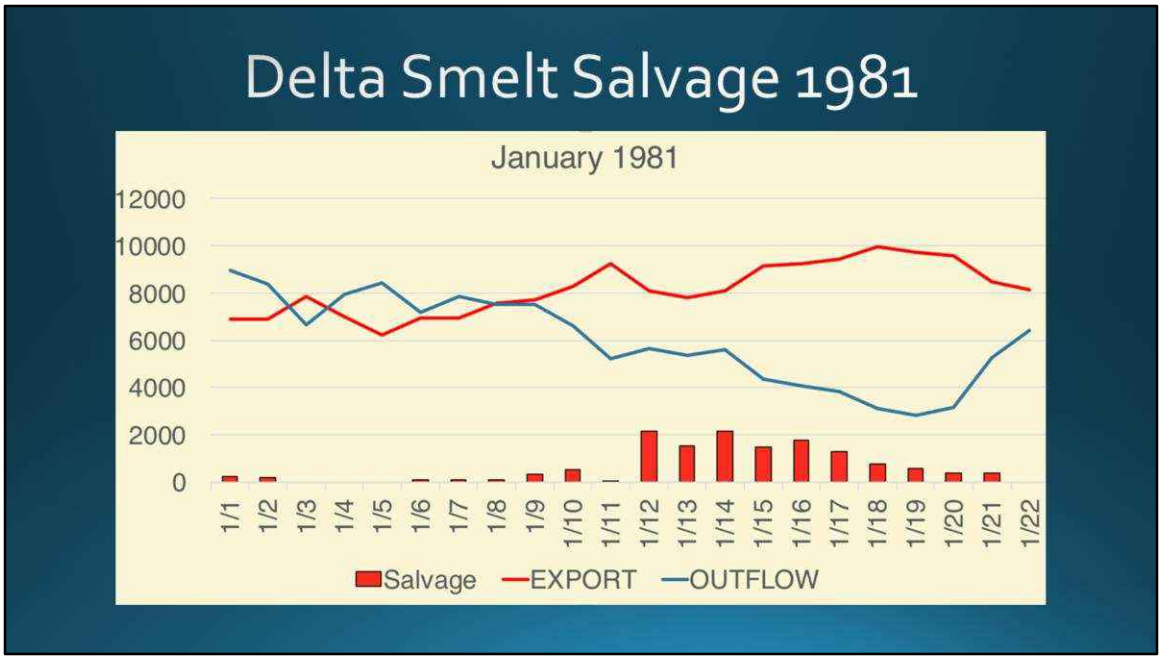
Relatively high mortality in 1988 and from 2000 to 2002 limited recovery in the 90s and contributed to population decline in the early 2000s.

Delta Smelt Spring-Summer Salvage



High spring-summer mortality also occurred in 1981. High losses in spring from 1999-2002 contributed to the end of recovery of the population in the 90s.

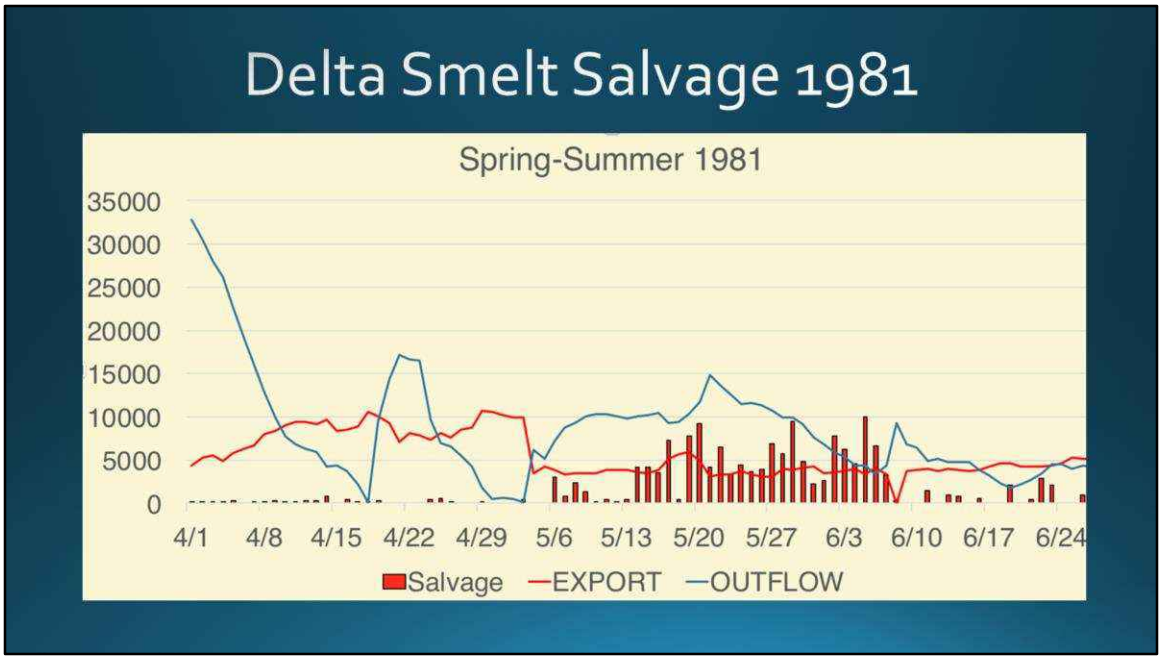
NOTE: salvage efficiency is very low on young smelt and larvae losses are not assessed.



A close look at January 1981 salvage reveals:

- Salvaged varied from several hundred to several thousand adult Delta Smelt per day during latter half of January under high exports (8,000 to 10,000 cfs).

- The salvage increase in mid January was coincident with increased exports and declining outflow.
- Old and Middle River net flows in the Central Delta are -8000 to -10,000 cfs.



A close look at spring-summer salvage in 1981 reveals:

- After a wet March outflow dropped to zero twice in April under high exports. Smelt probably spawned in Central Delta and larvae were in Central and South Delta.

- There was low early spring salvage, but likely high larval entrainment. April is an important month for larvae, when they are typically being carried downstream from the Delta to Suisun Bay and are vulnerable to drifting with flow to South Delta export pumps.

- As outflow declined and exports began increasing in late May, salvage sharply increased as young smelt reached salvageable size.

- High late spring salvage up to 10,000 per day (most at Tracy Fish Facility). Lower at Clifton Court but under lower export rates. I often wondered if they turned off the state pumps in late May because they were taking too many fish. Striped bass salvage was tens of thousands per day at SWP Clifton Court and hundreds of thousands a day at CVP Tracy.

- Note again: These salvage numbers are not representative of the total mortality occurring from exports; larval stage not collected, salvage efficiency is low, and predation is likely high especially in CCF.

These are the outflow standards set by Decision 1485 of the State Water Resources Control Board in 1978 to protect fish and wildlife in the Delta. In reality they were designed mainly to protect striped bass. The standards were appealed as inadequate which led to the Racanelli decision in 1986, stating that outflows had to be based on "beneficial use." This was too late to save delta smelt from the major entrainment events of the early 1980s. I don't have time to talk about these standards in detail, but they did not benefit the smelt.

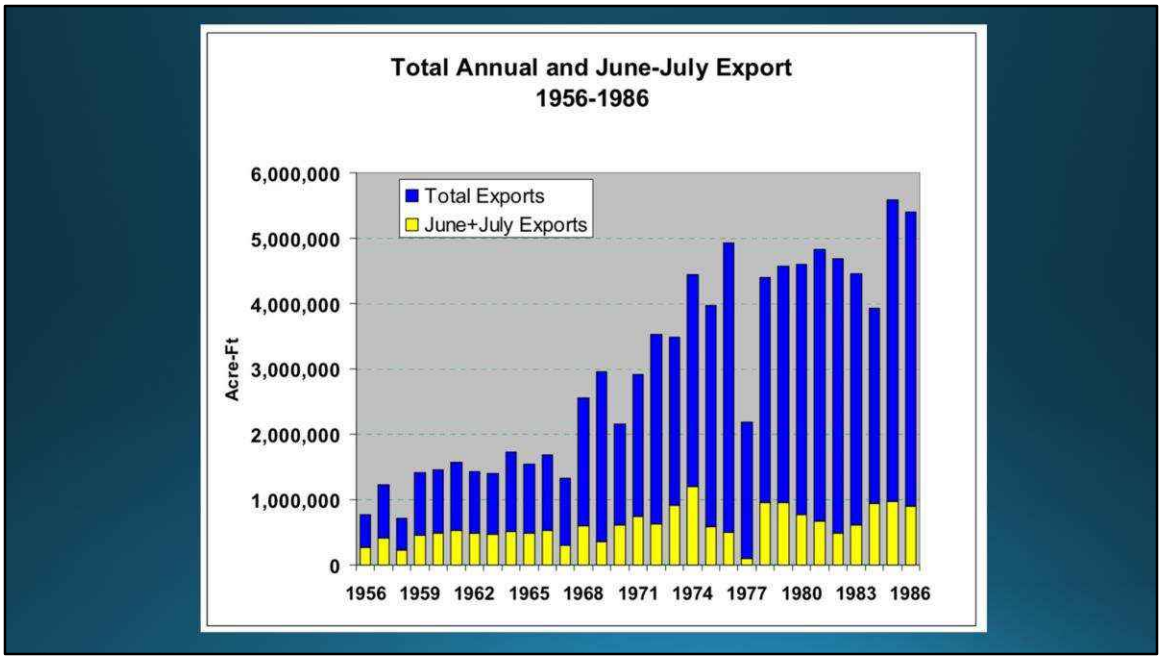
These are winter criteria.

Spring-Summer Standards - D1485

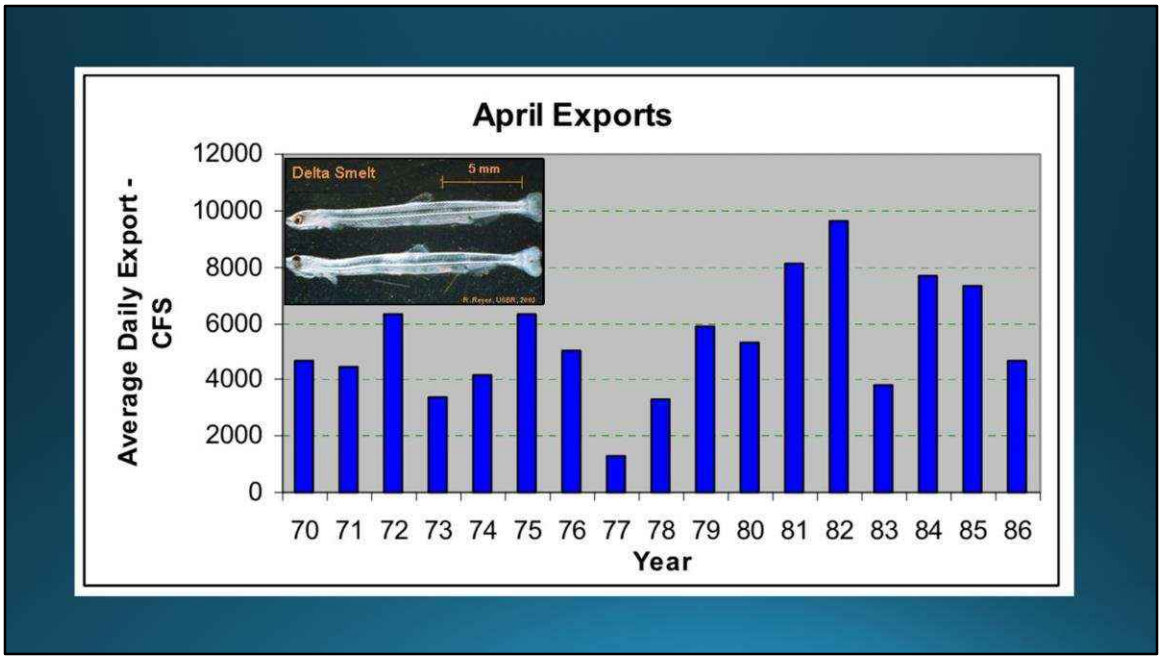
- Apr 1-14 period min average Delta outflow of 6700 cfs all year types
- April – min 12,000 cfs monthly average outflow non-dry years
- April – no export restrictions
- May-June – monthly average 6000 cfs export maximum
- July – monthly average 9000 cfs export maximum
- August – monthly average exports 11,400 cfs (no limit)

Spring and summer criteria were not protective of Delta Smelt either.

- Monthly averages
- No April export restrictions.



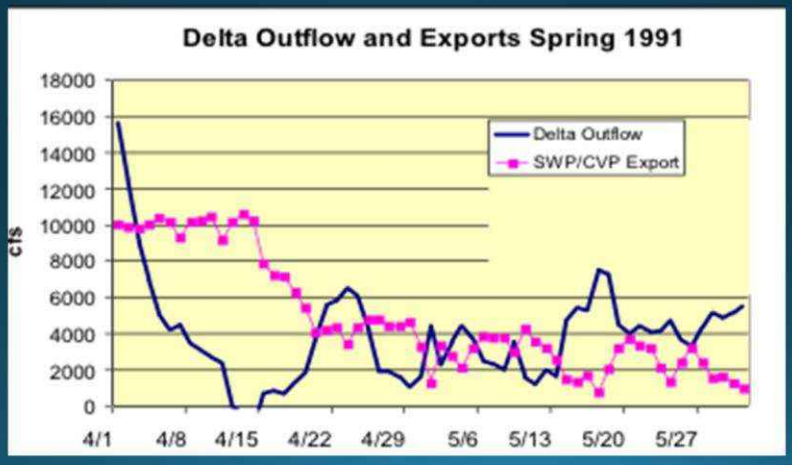
Total exports in 1981 reached nearly 5 million AF.
Sharply higher after SWP came on line in 1974.
Recovery in 1980s was limited by higher exports than the 1970s.



The extreme April exports in 81, 82, 84, and 85 likely resulted in high smelt larvae entrainment, which served to keep the population depressed in the late 80s. Salvage systems only capture smelt > 20 mm.

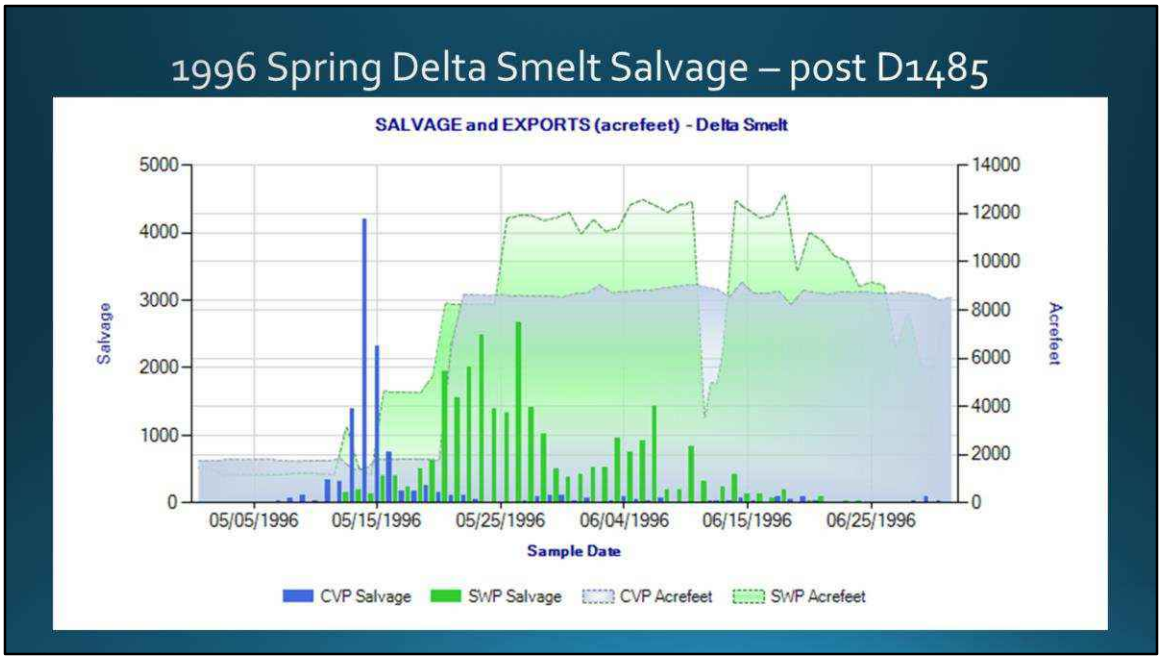
After the 80s, VAMP, CVPIA, D-1641, and biological opinions placed limits on April exports.
You can imagine the risks under these conditions.

Monthly Average Standards



April 1991 is another example of extreme operations under D-1485. Exports were over 10,000 cfs in midApril with zero outflow, which likely led to high larval smelt entrainment. This was a direct result of monthly average standards. Luckily the reservoirs were empty after five years of drought, and exports were low after April. Export and outflow criteria are much stricter today.

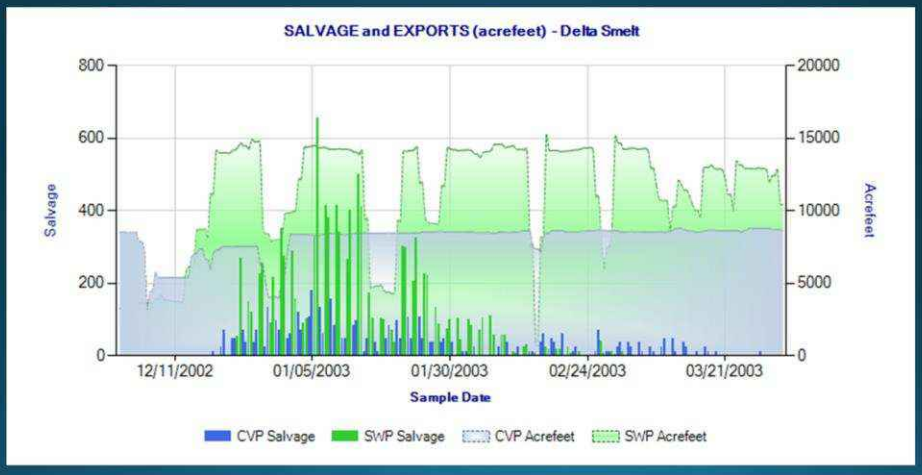
1996 Spring Delta Smelt Salvage – post D1485



AFTER 1994 UNDER D1641 STANDARDS **things changed** – Spring 1996 was typical post-D1485 conditions:

- ❑ VAMP export restrictions from mid April to mid May.
- ❑ CVPIA post VAMP "shelf"
- ❑ Exports near max 9000-10000 cfs after midMay
- ❑ Delta is too warm for smelt after midJune, so salvage tapers off, but does not mean smelt were safe – they died long before salvage facilities.
- ❑ D-1485 May-June 6000 cfs; July 9000, **but 11,400 cfs under D1641.**
- ❑ **No longer today do we have VAMP restrictions from midApr-midMay, so worse today for mid May with OMR -5000 cfs.**
- ❑ **Overall lack of late spring protection. We now have OMR protection through June. There are no July-August restrictions other than E/I of 65% and Delta salinity standards, which were relaxed in recent drought years.**

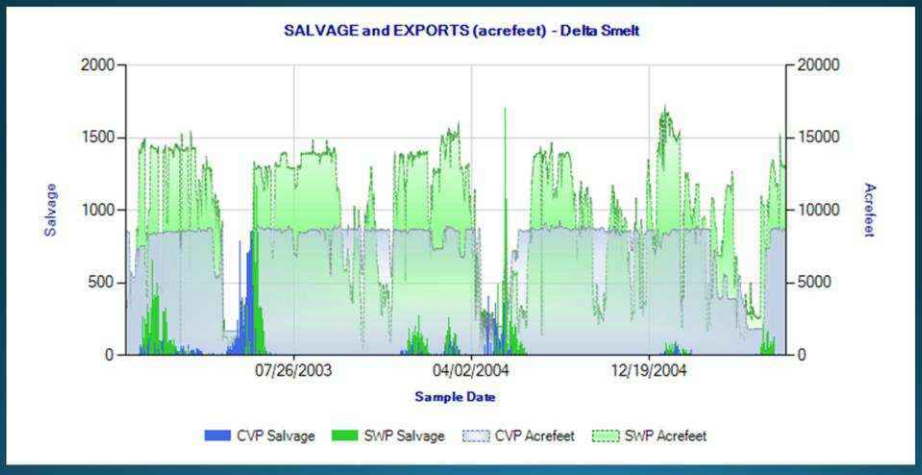
Winter 2003 - Pre OMRs



Winters in dry years 2001-2003 without OMR limits resulted in high adult smelt losses, which ended the recovery and contributed directly to the POD decline.

- ❑ Here Winter 2003 salvage – risk begins in December
- ❑ Periods of Max exports,
- ❑ No OMR limits, E/I of 65% in Dec-Jan not protective, nor is 35% in Feb-Mar.

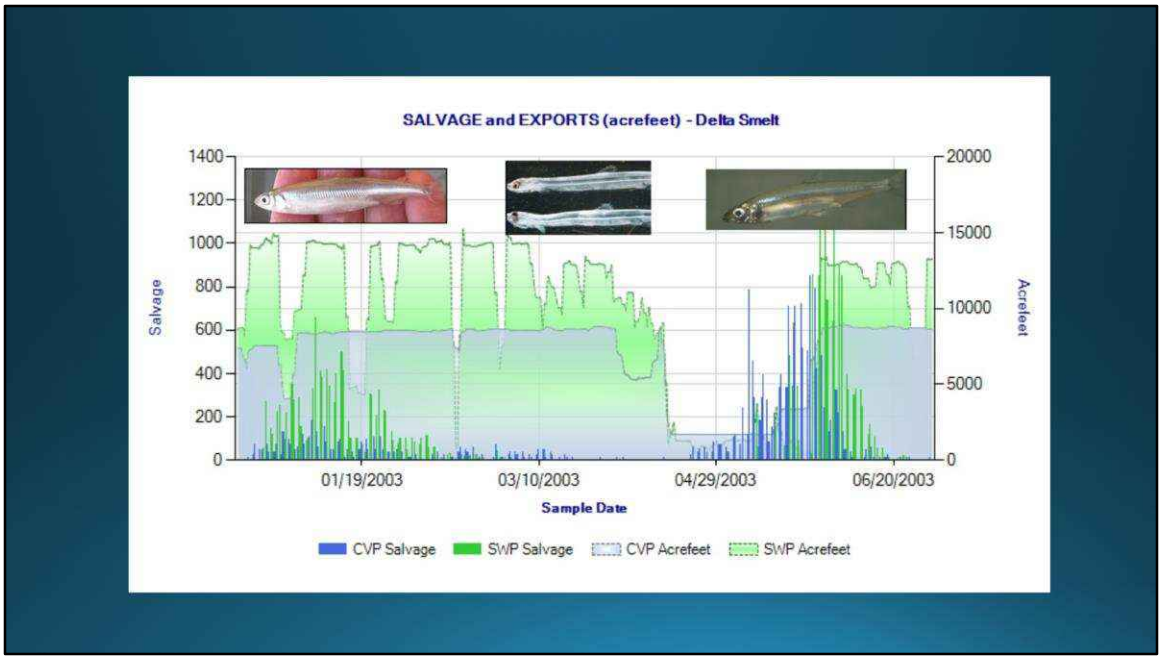
2003-2005

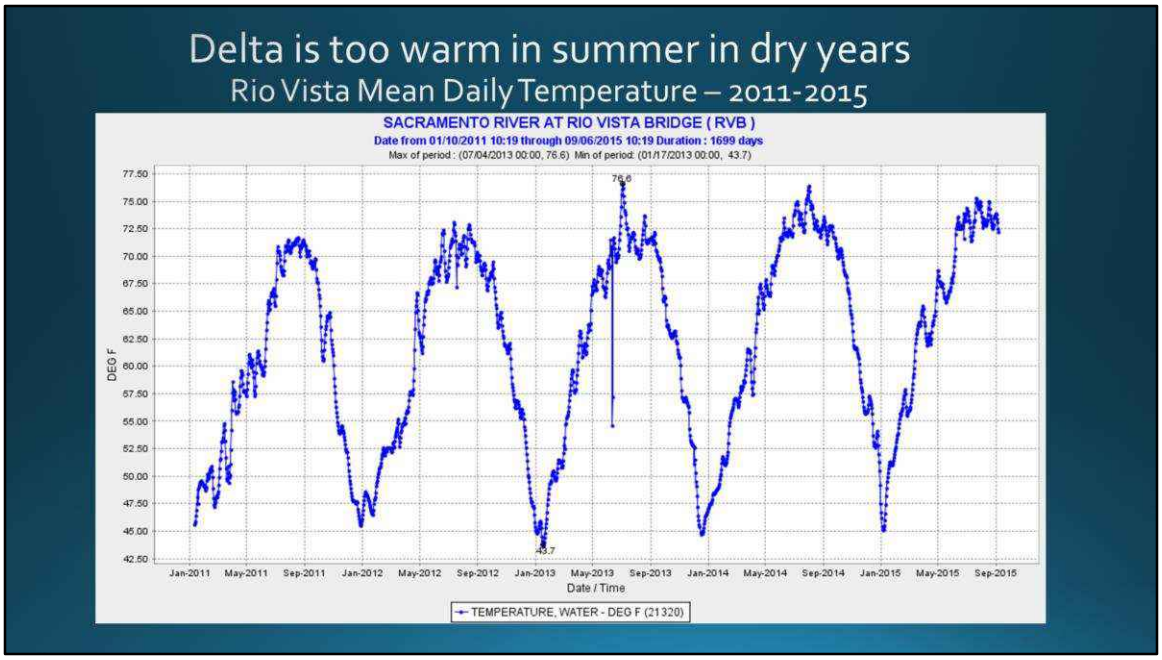


These are POD Years, no OMRs,

- ❑ Note Sharp population decline from winter 03 to summer 05.
- ❑ Large winter adult salvage .
- ❑ Unknown April larval entrainment
- ❑ High young salvage in late Spring.
- ❑ Maybe loss of east Delta population

VAMP but no other protections.
At least D1485 had some protections from May through July. VAMP protections are now gone and replaced by less restrictive OMR restrictions from January through June.


SALVAGE and EXPORTS (acrefeet) - Delta Smelt
Salvage
Acrefeet
1400
1200
1000
800
600
400
200
0
20000
15000
10000
5000
0
01/19/2003
03/10/2003
04/29/2003
06/20/2003
Sample Date
CVP Salvage
SWP Salvage
CVP Acrefeet
SWP Acrefeet



In the recent drought:

MEAN DAILY RIO VISTA WATER TEMPERATURES 2011-2015:

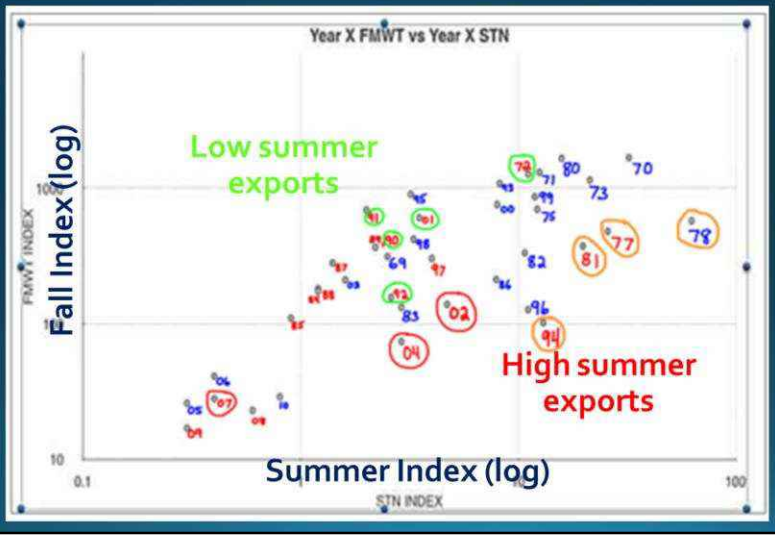
With relaxed Delta outflow and EC standards in 2014 and 2015 the north Delta habitat is too warm for smelt in mid summer. Note 71F in 2011, 72-73F in 2012/13, but 75-76F in 2014/2015 under relaxed standards.

The several degree increase is critical to smelt.

Furthermore, In wetter years nursery area is to the west in cooler waters, in dry years it is closer to Rio Vista with rearing confined to the North Delta in low outflow summers.

Summer exports contribute to the warmer water at low inflow/outflows, as do summer closures of the DCC (prescribed to lower EC at 3-mile Slough to meet TUCPs)

Summer to Fall Recruitment

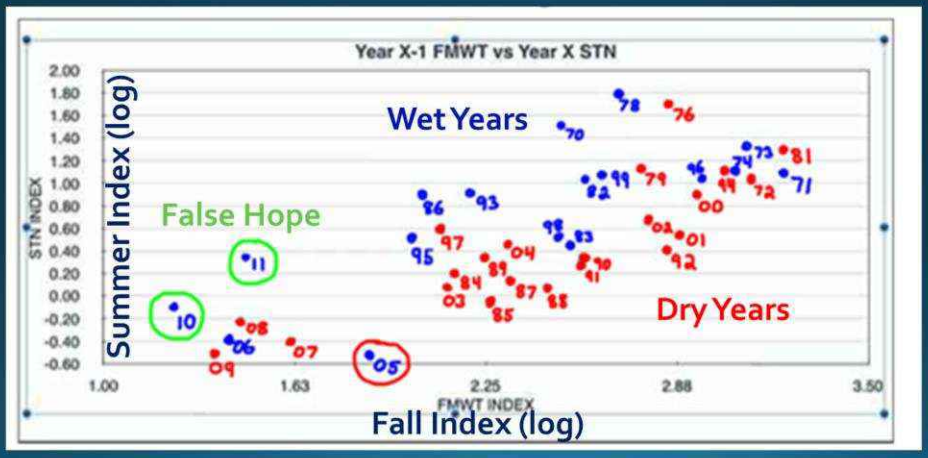


There is a real POPULATION EFFECT:

Strong Stock Recruitment relationship. Summer to fall. **STN Index in June**. FMWT Index in Sep-Dec.

- Strong relationship. Maybe flattens indicating maximum capacity.
- Lower survival in high export/low outflow dry summers like 77, 78, 81, 94, 02, and 04
- Lower in flood years 82, 83, 86, 96.
- High in low export summers 90-92 when they ran out of water for export, and 72 when Andrus Island levee broke.

Fall to Summer Recruitment

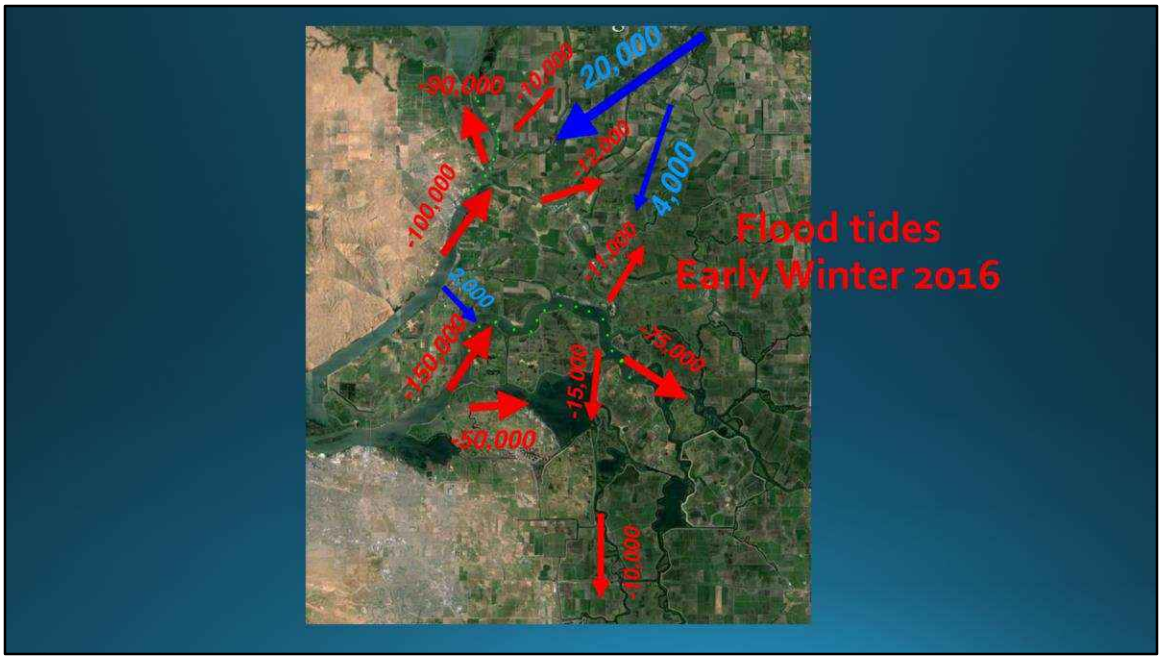


POPULATION EFFECT is also evident in Fall to Next-Summer Relationship:

This too is a Strong relationship. Lower in drier years. Each year has a story.

Years 2010 and 2011 were wetter with low exports under OMR restrictions – gave us some hope, but operations in following 4 years of drought ended that.

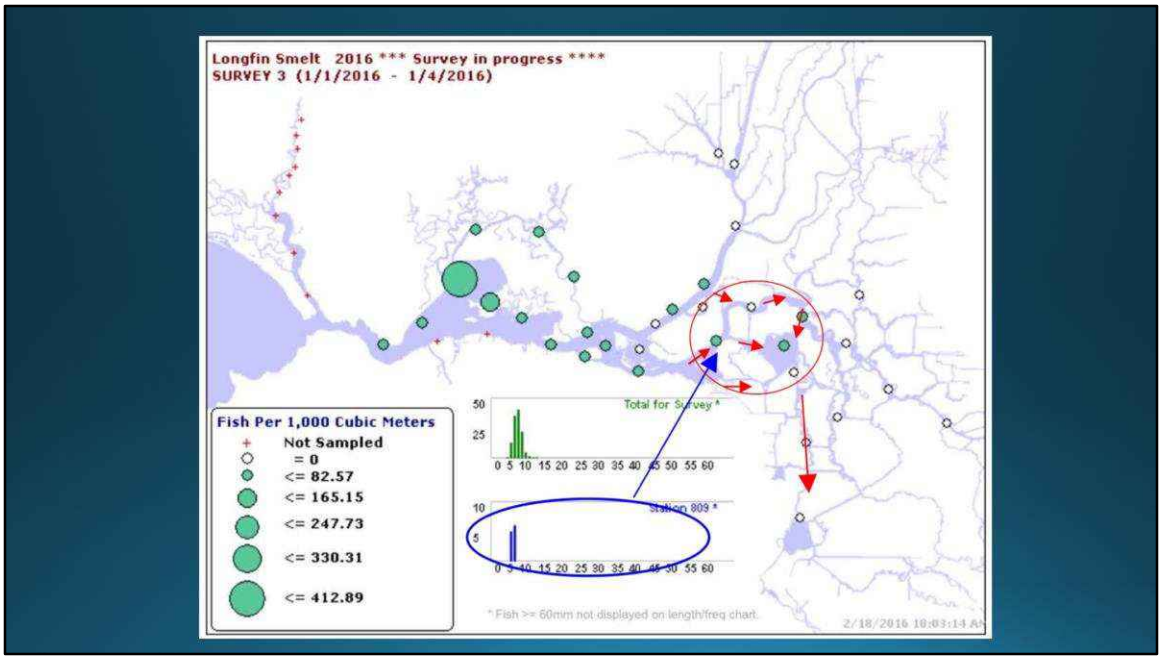
For The past several years points have been at bottom left.



Quick look at RISK MECHANISMS:

- ❑ Spawning smelt ride the flood tides into Central and North Delta.

- ❑ Difficulty in ascending Sacramento River as it carries most inflow in a confined channel.
- ❑ Main spawning areas
- ❑ JERSEY PT TO PRISONERS PT (***Show green Dots)***
- ❑ RIO VISTA TO CACHE SLOUGH Region



RISK MECHANISM: Present for Delta Smelt and Longfin Smelt

Low outflow and high exports put young smelt at risk to exports in winter, spring, and summer.

In this chart of January Longfin smelt, the risk is there even in dry winters. The red arrows show net negative daily flows toward South Delta exports of 6000 cfs, with -5000 cfs OMRs.

PTM shows 20% of lower San Joaquin at -5000 OMR. MUCH HIGHER WITH NO OUTFLOW AND -10,000 OMR.

OPEN DCC, FR BARRIER

Conclusions

- Exports are a major cause of the Delta Smelt decline
- Decline started in 1981 with high entrainment
- Continued export entrainment and low Delta outflow prevent recovery
- Protections are inadequate.

READ