

***Data and Modeling Analyses of the Possible Effects from Entrainment of Delta Smelt on the Population Decline***

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***Collaborators:***

***Salvage/ Flows***

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***IEP Biologists***

***Modeling***

***John Donovan, USGS***

***Henry Wong, USBR***

***2006 EWA Workshop  
November 28, 2006***

# Outline

- Delta smelt salvage data
- Old and Middle River flow as a predictor of salvage
- Adult entrainment estimates from salvage data
- Adult entrainment estimates from 3D particle-tracking model
- Checking estimates of entrainment against the SKT data



# South Delta Fish Facilities

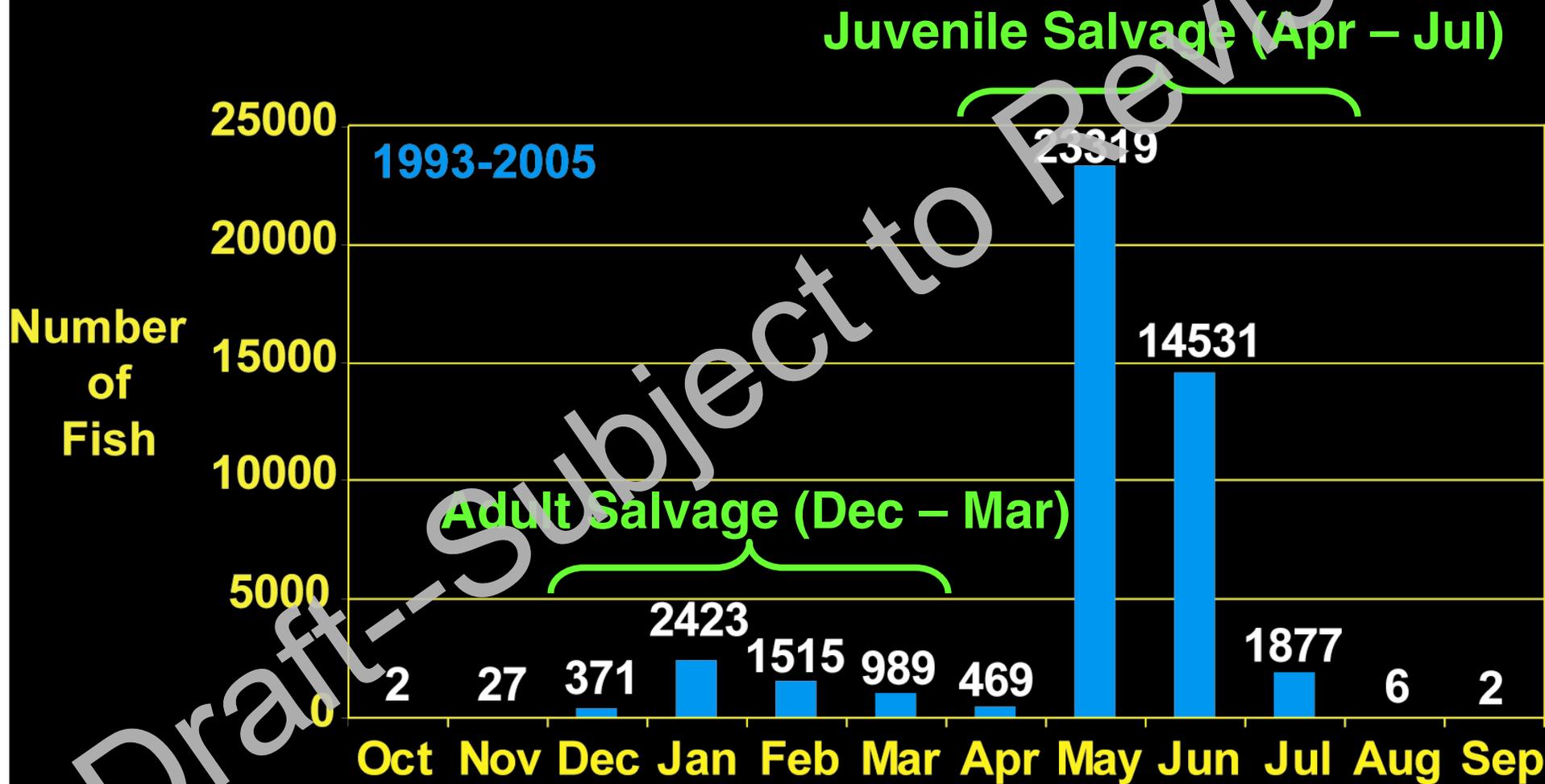
Skinner Fish Facility (DWR)



Tracy Fish Facility (USBR)

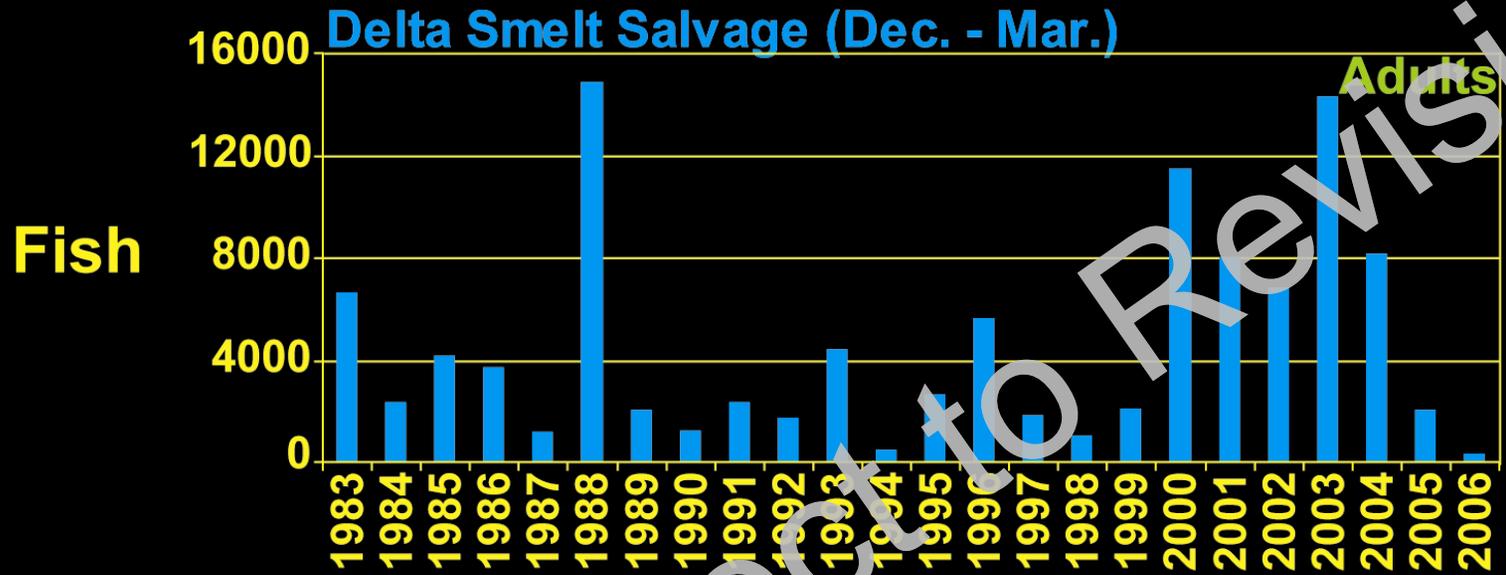


# Average Delta Smelt Salvage by Month



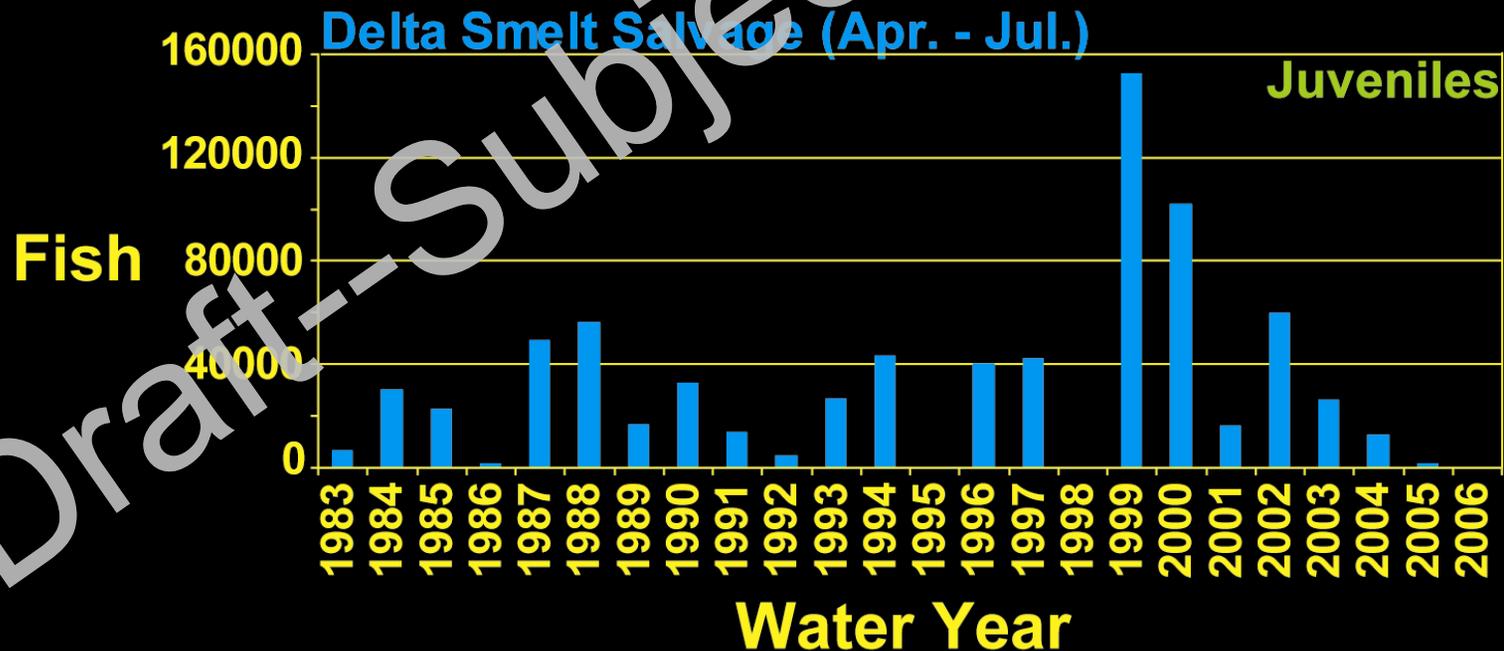
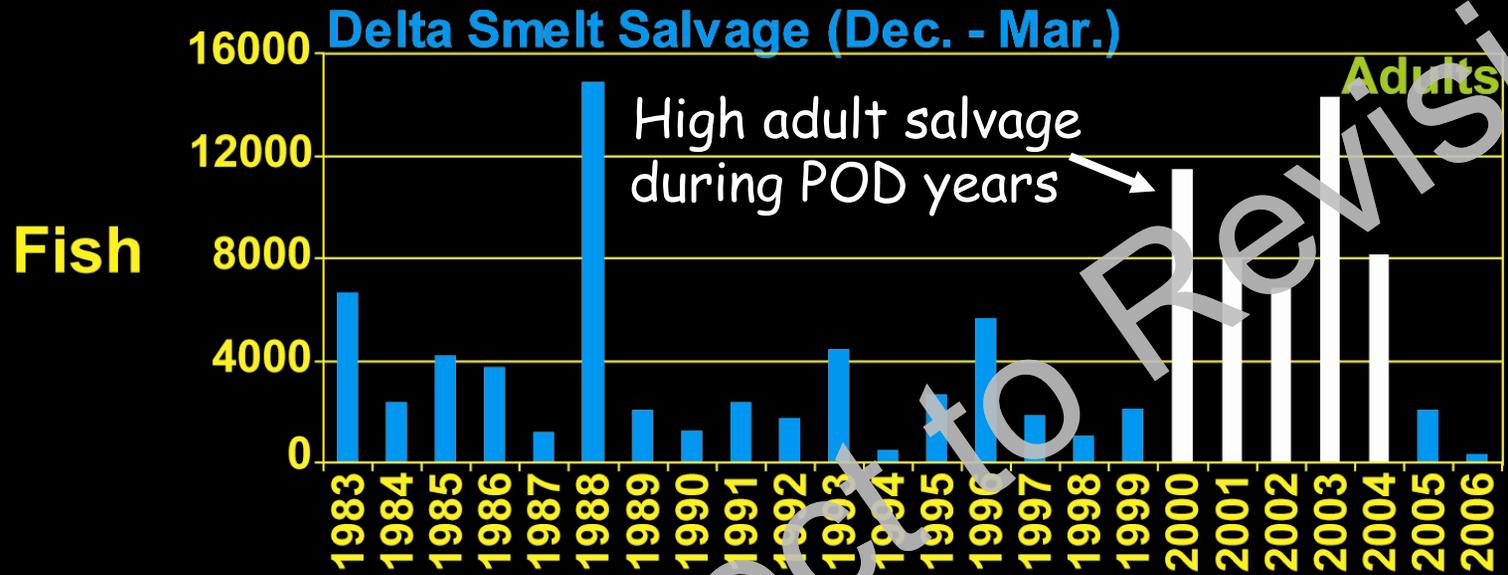
Note: Only fish 20 millimeters or larger are counted in salvage

# 24-Year Trends in Delta Smelt Salvage

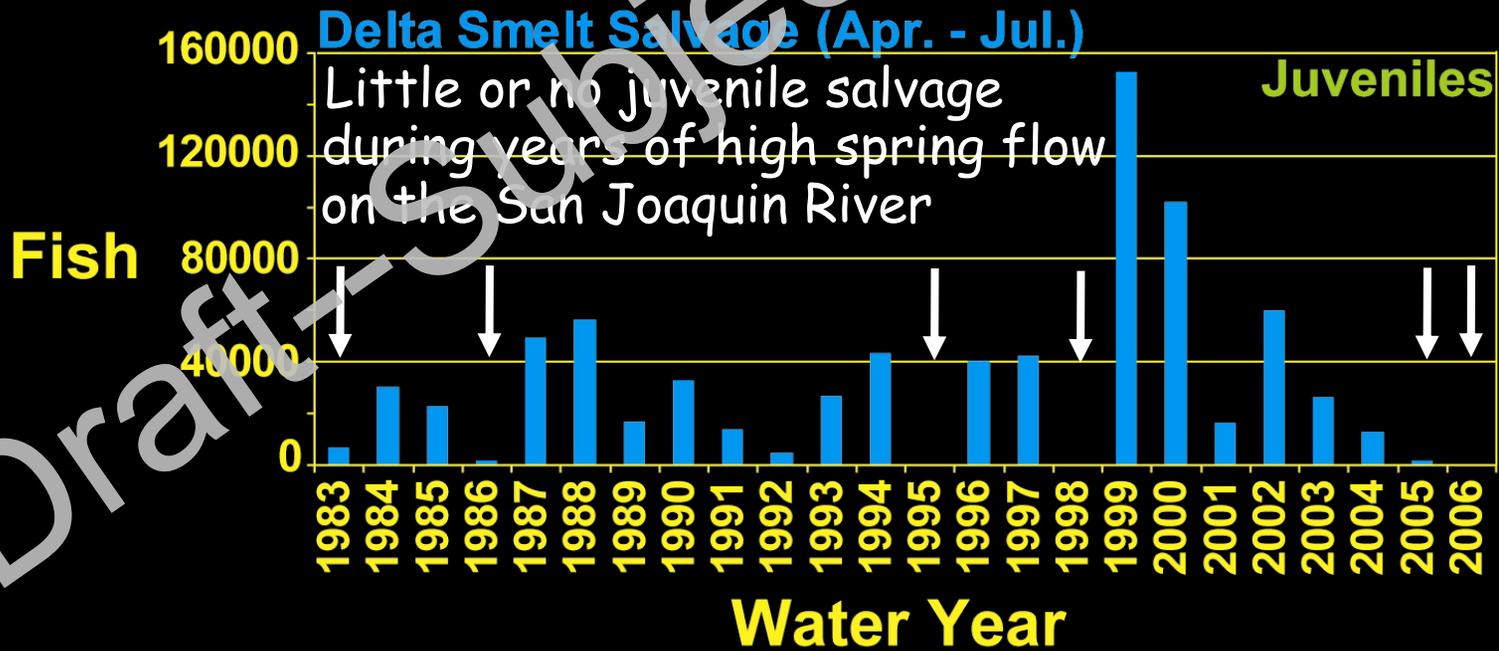
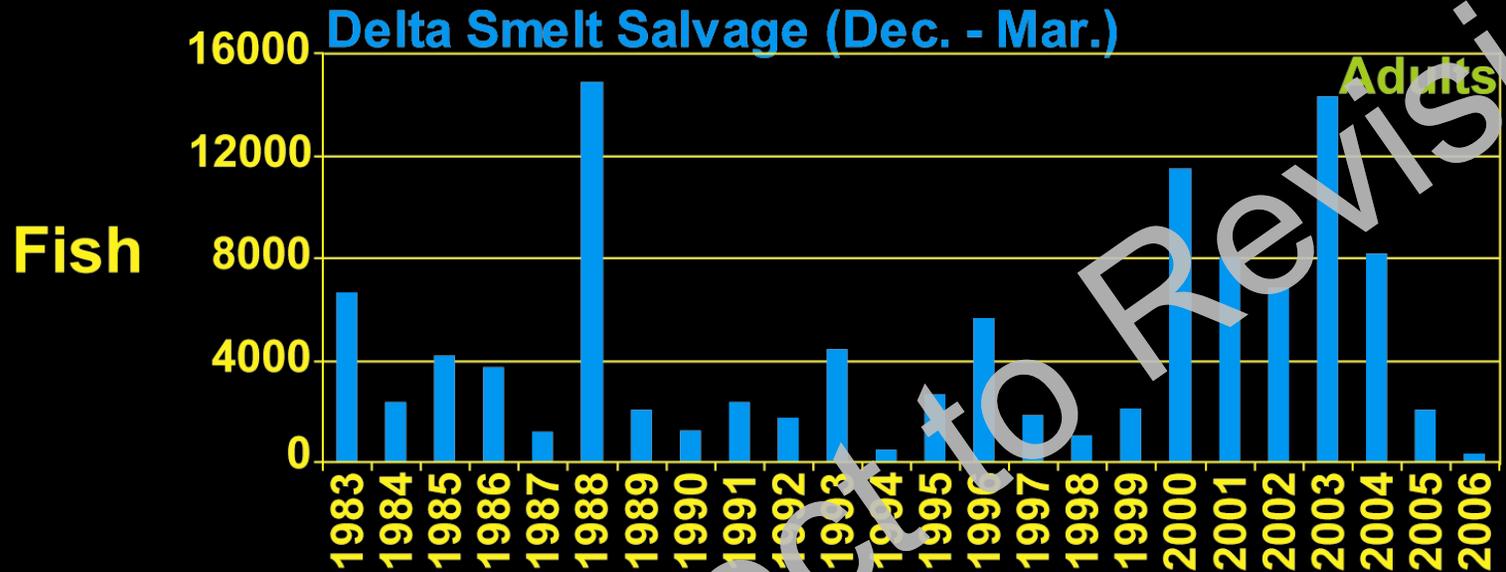


**Water Year**

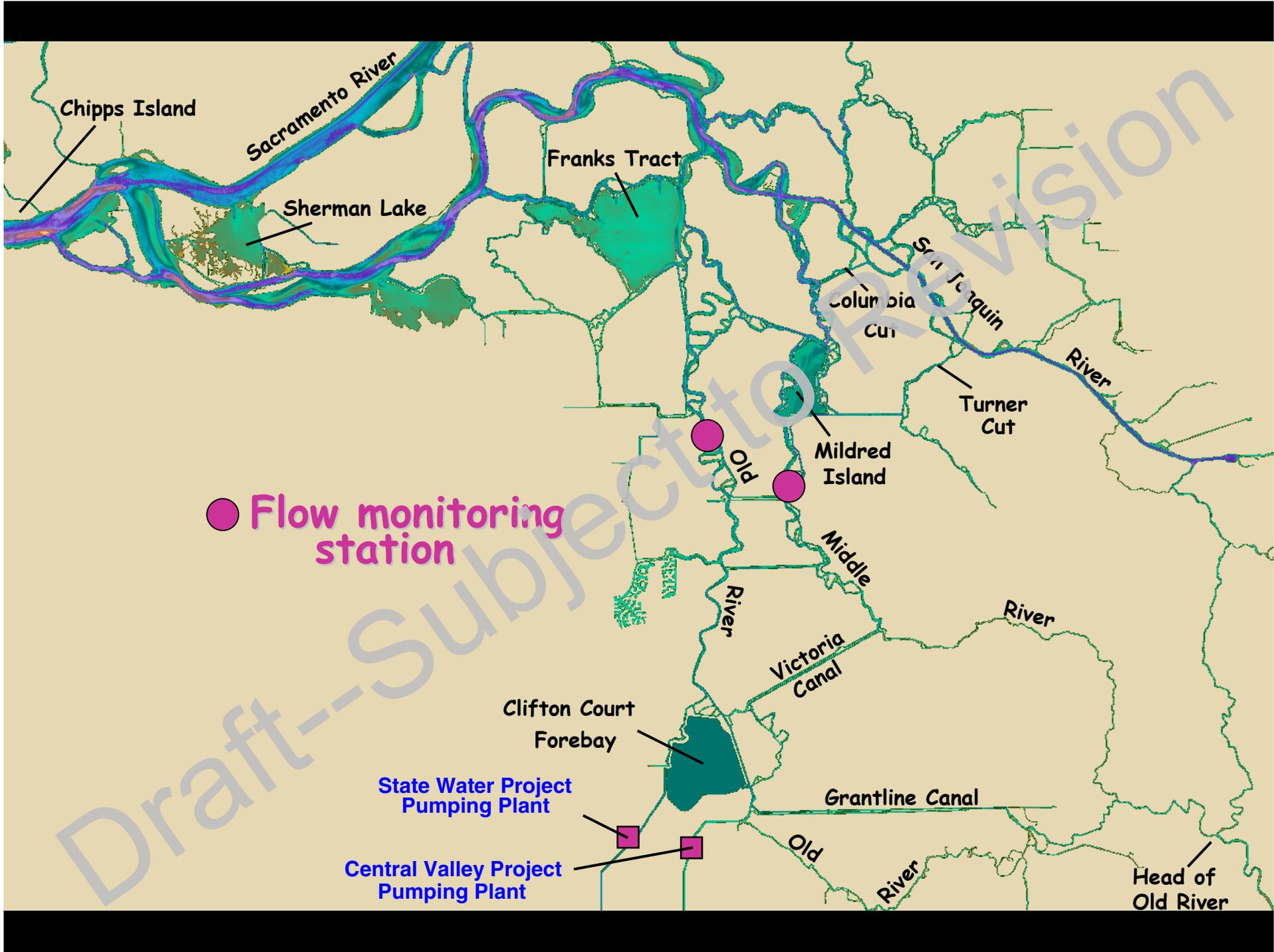
# 24-Year Trends in Delta Smelt Salvage



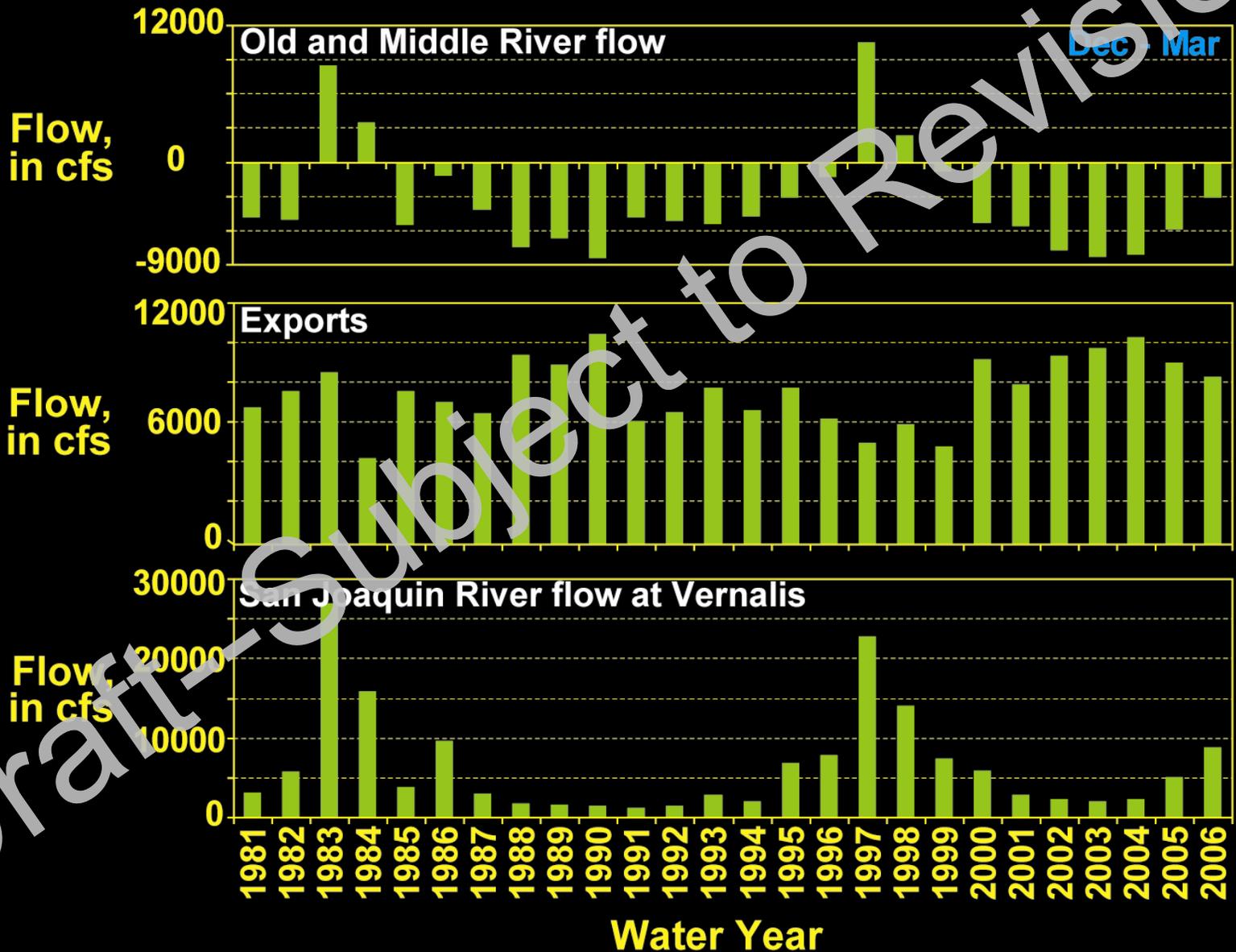
# 24-Year Trends in Delta Smelt Salvage



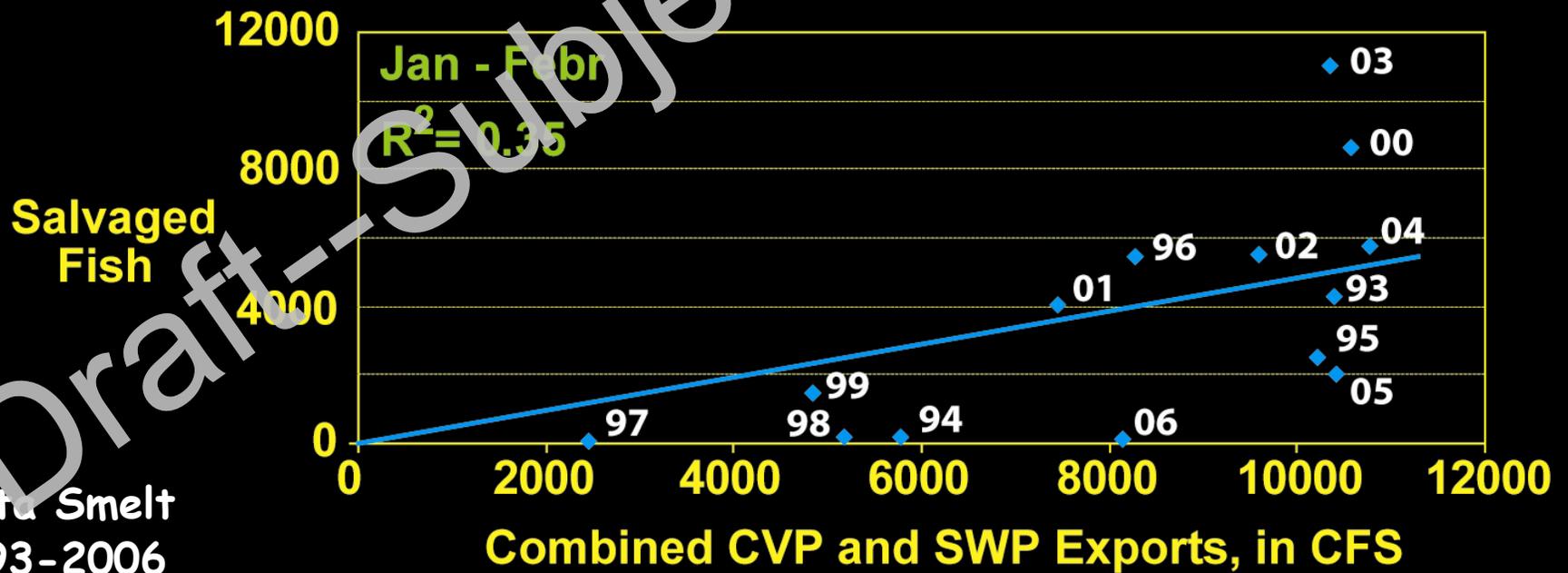
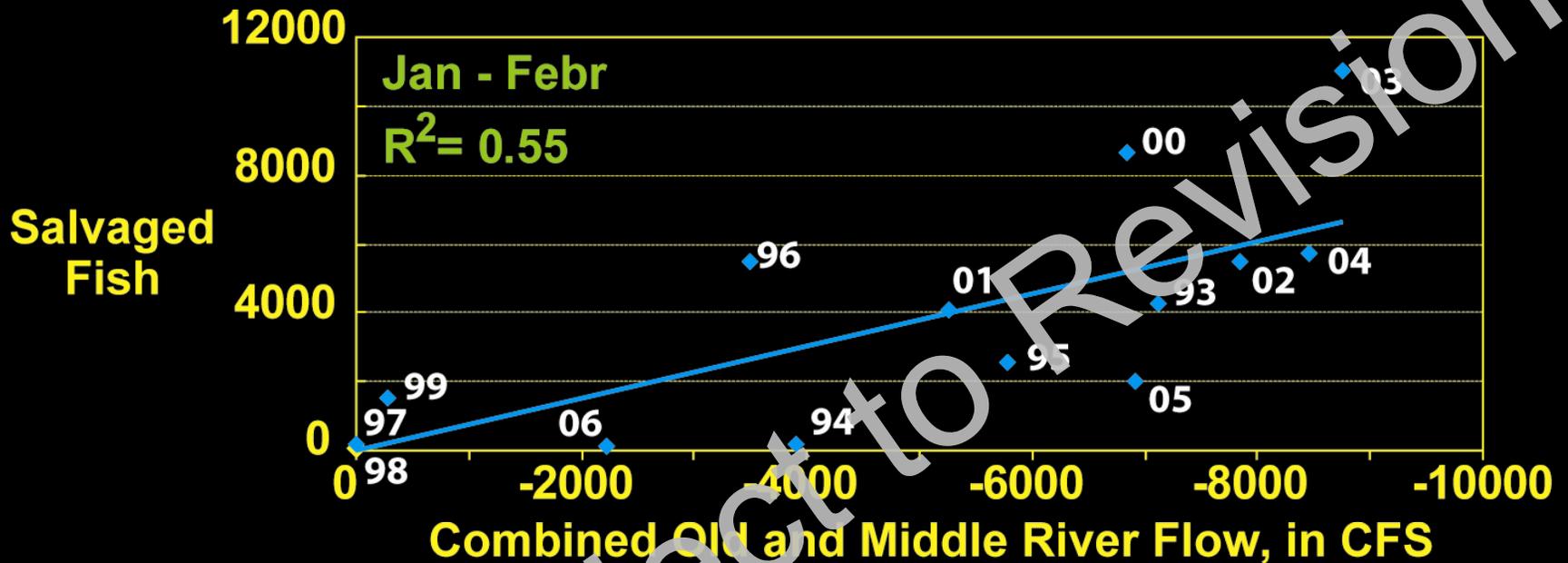
**Water Year**



# Old and Middle River Flows, Exports, and San Joaquin River Flows

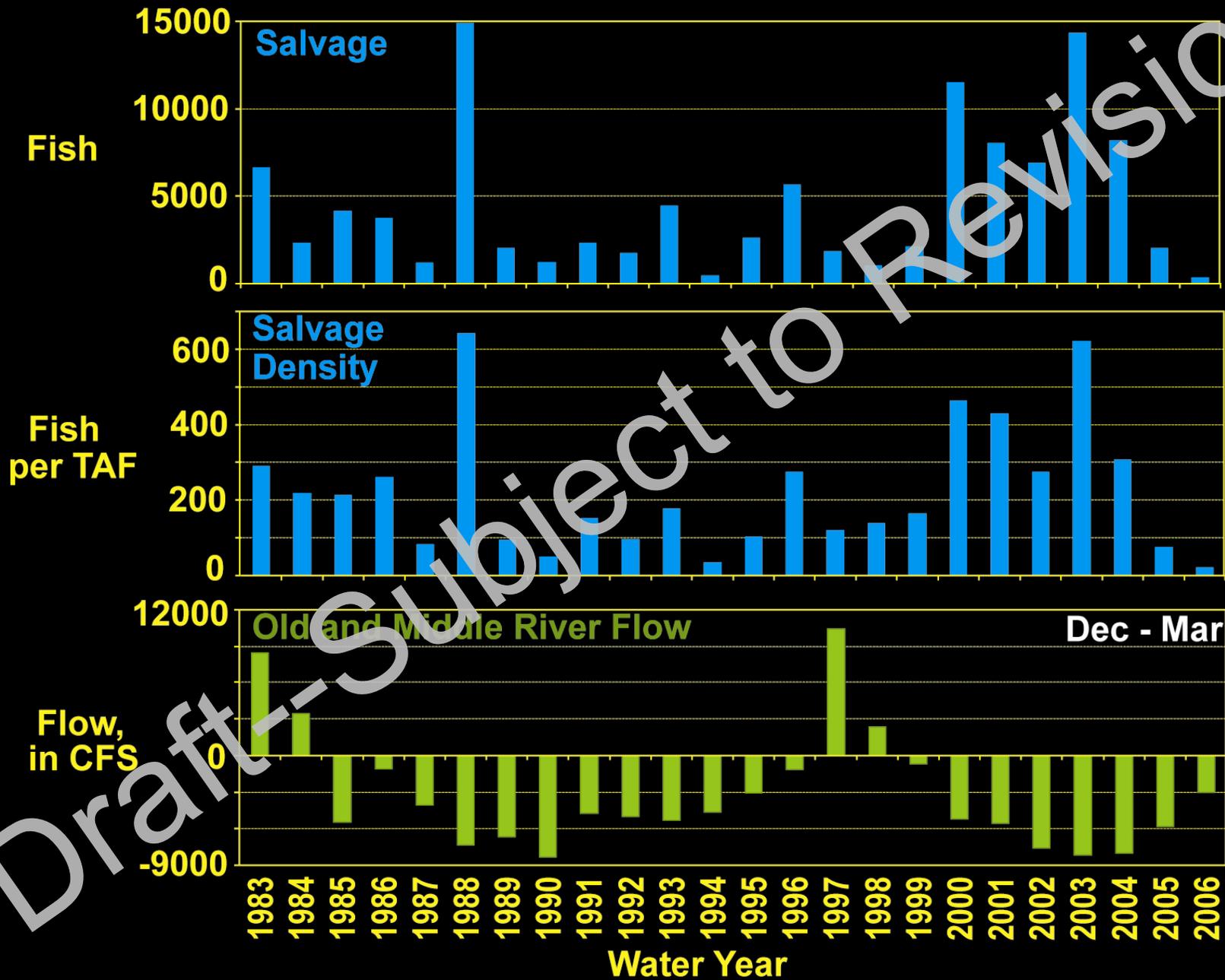


# Winter Salvage versus Flow Regressions

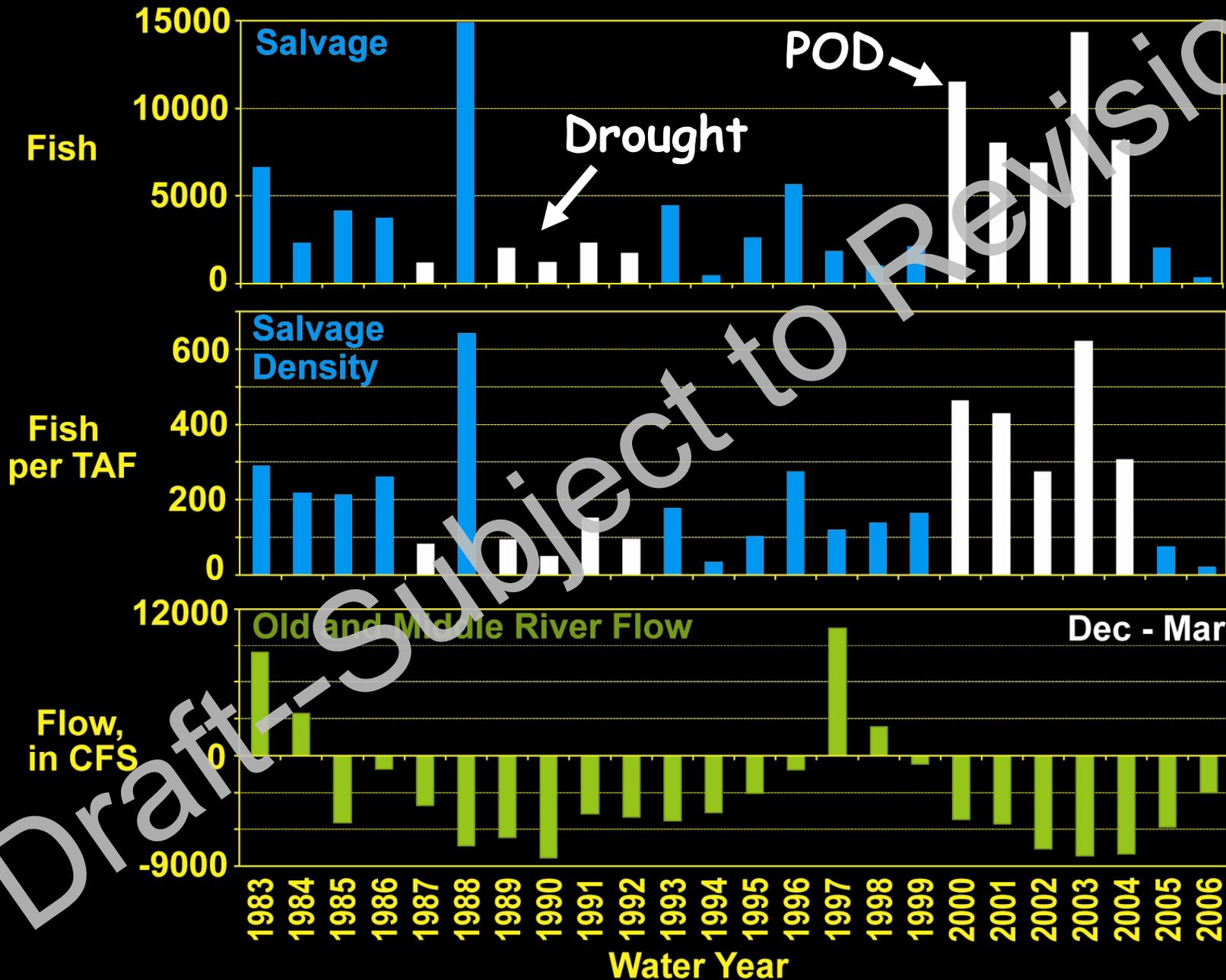


Delta Smelt  
1993-2006

# Winter Delta Smelt Salvage and Flows



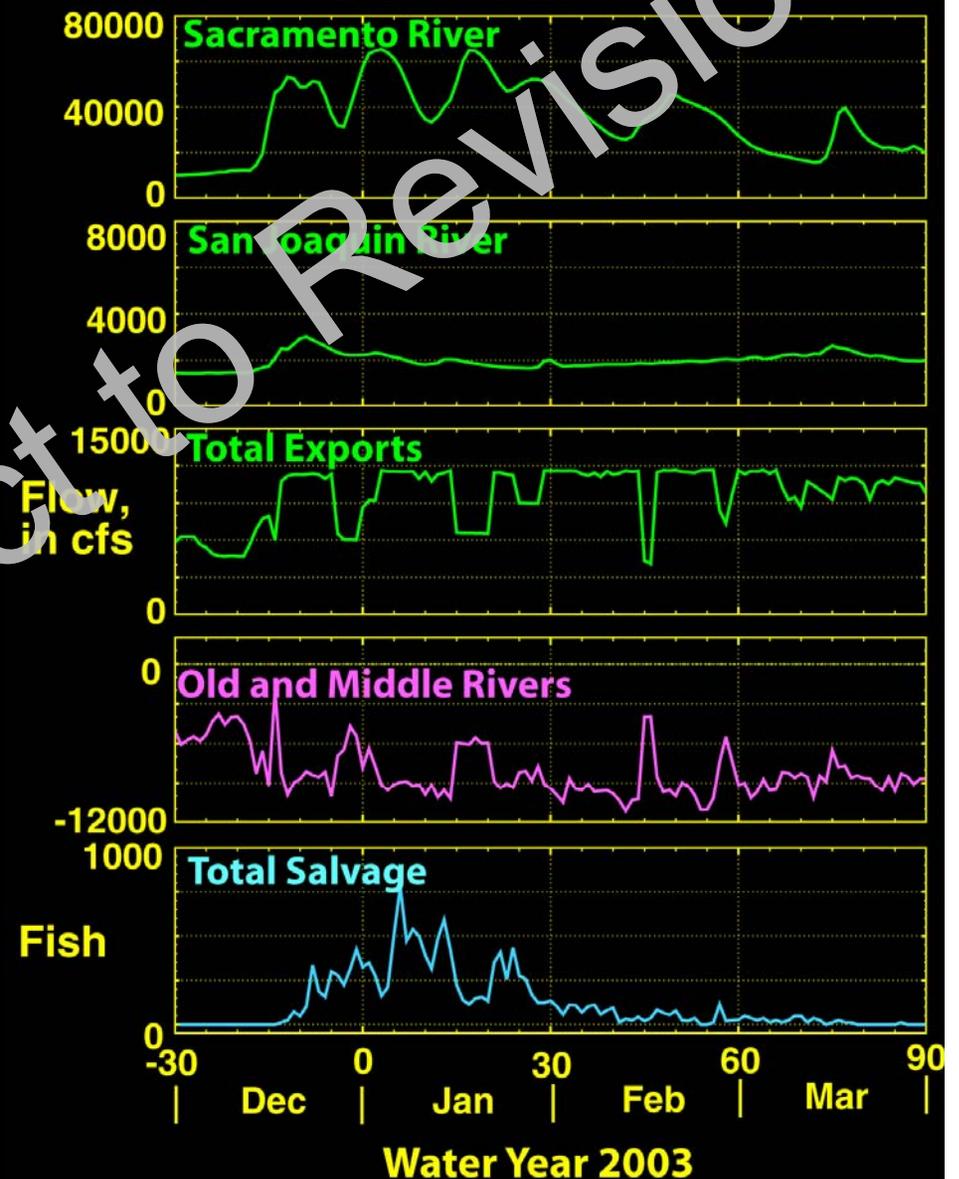
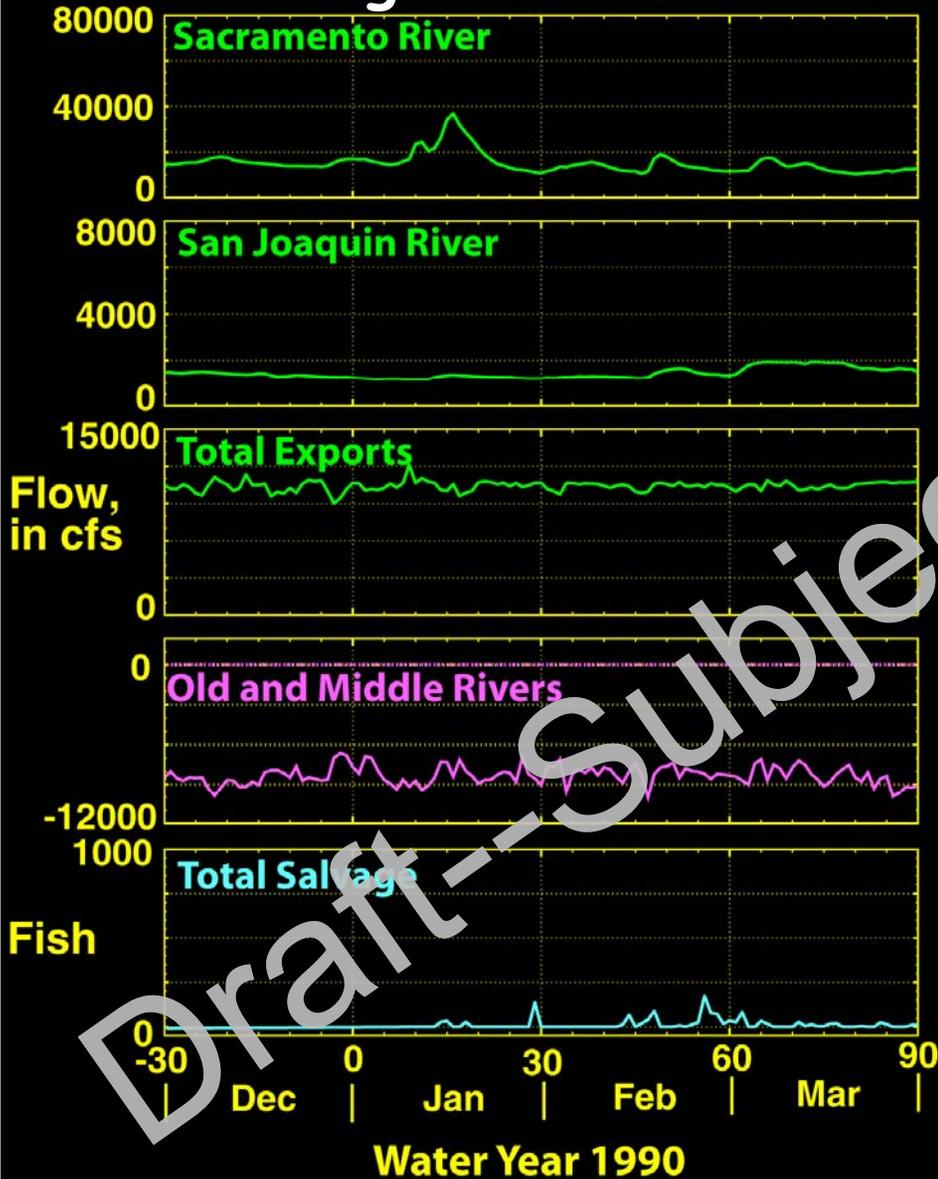
# Winter Delta Smelt Salvage and Flows



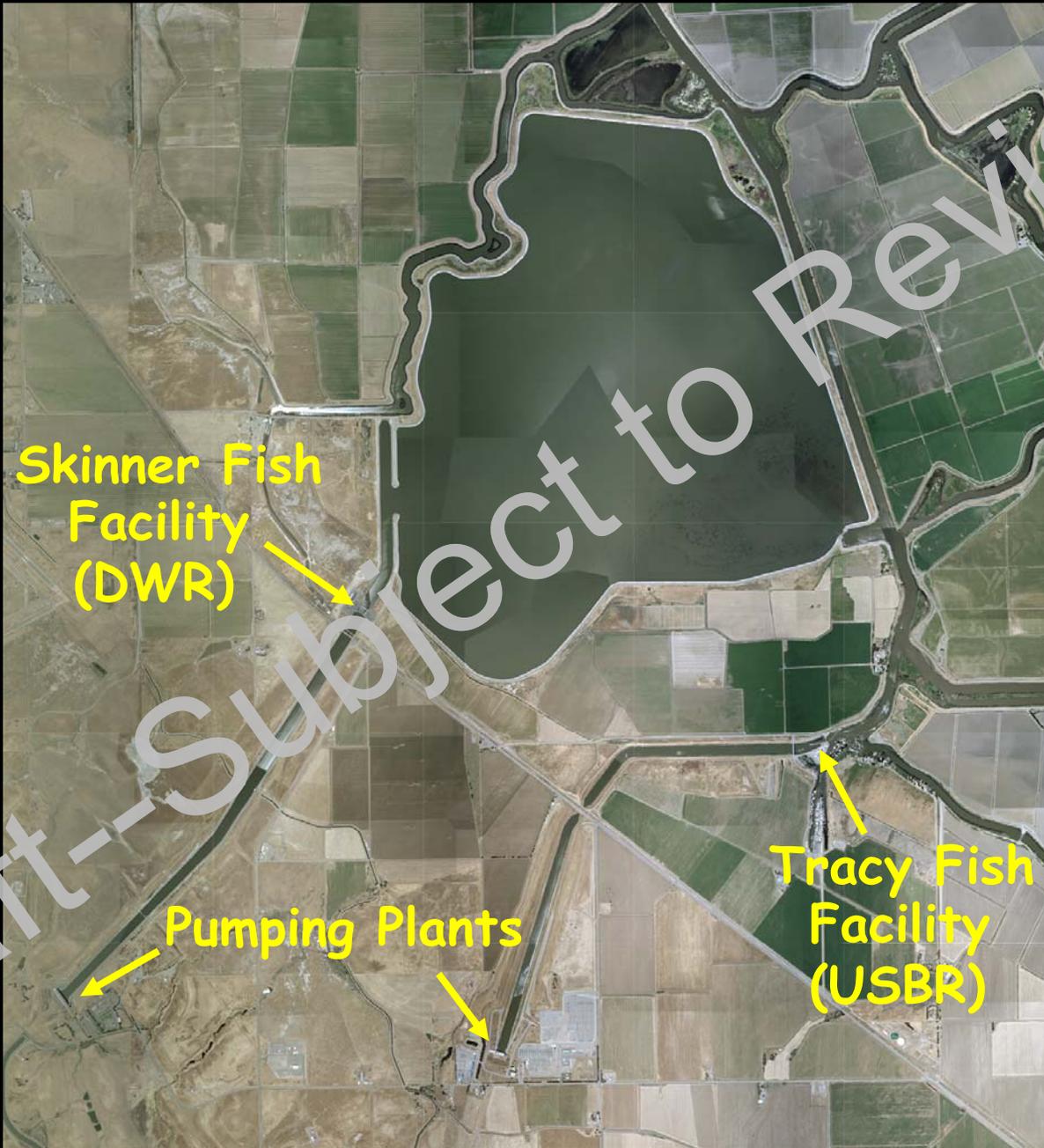
# Comparison of 1990 and 2003

Drought Year--1990

POD Year--2003



# South Delta Export Facilities



Skinner Fish  
Facility  
(DWR)

Tracy Fish  
Facility  
(USBR)

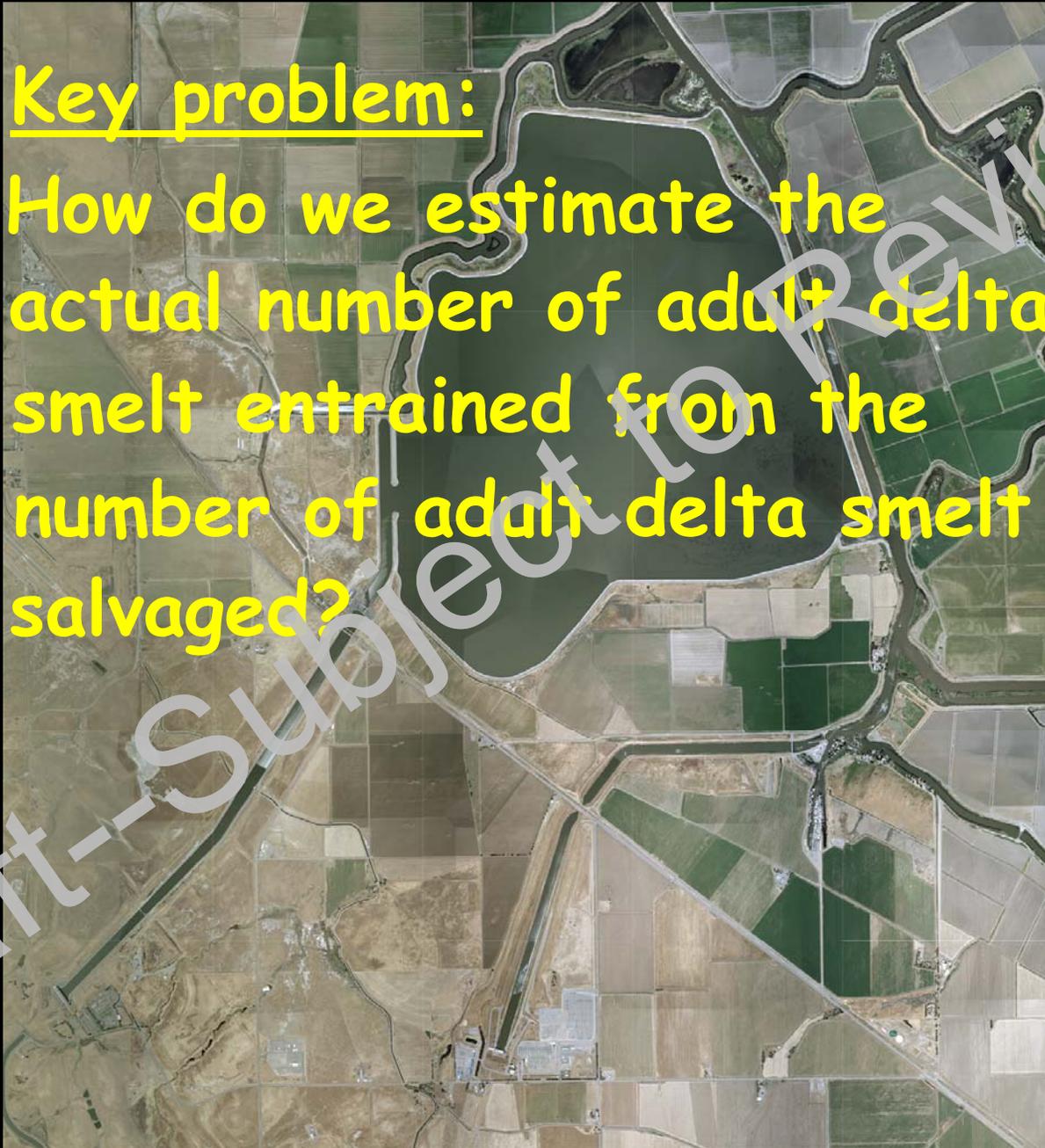
Pumping Plants

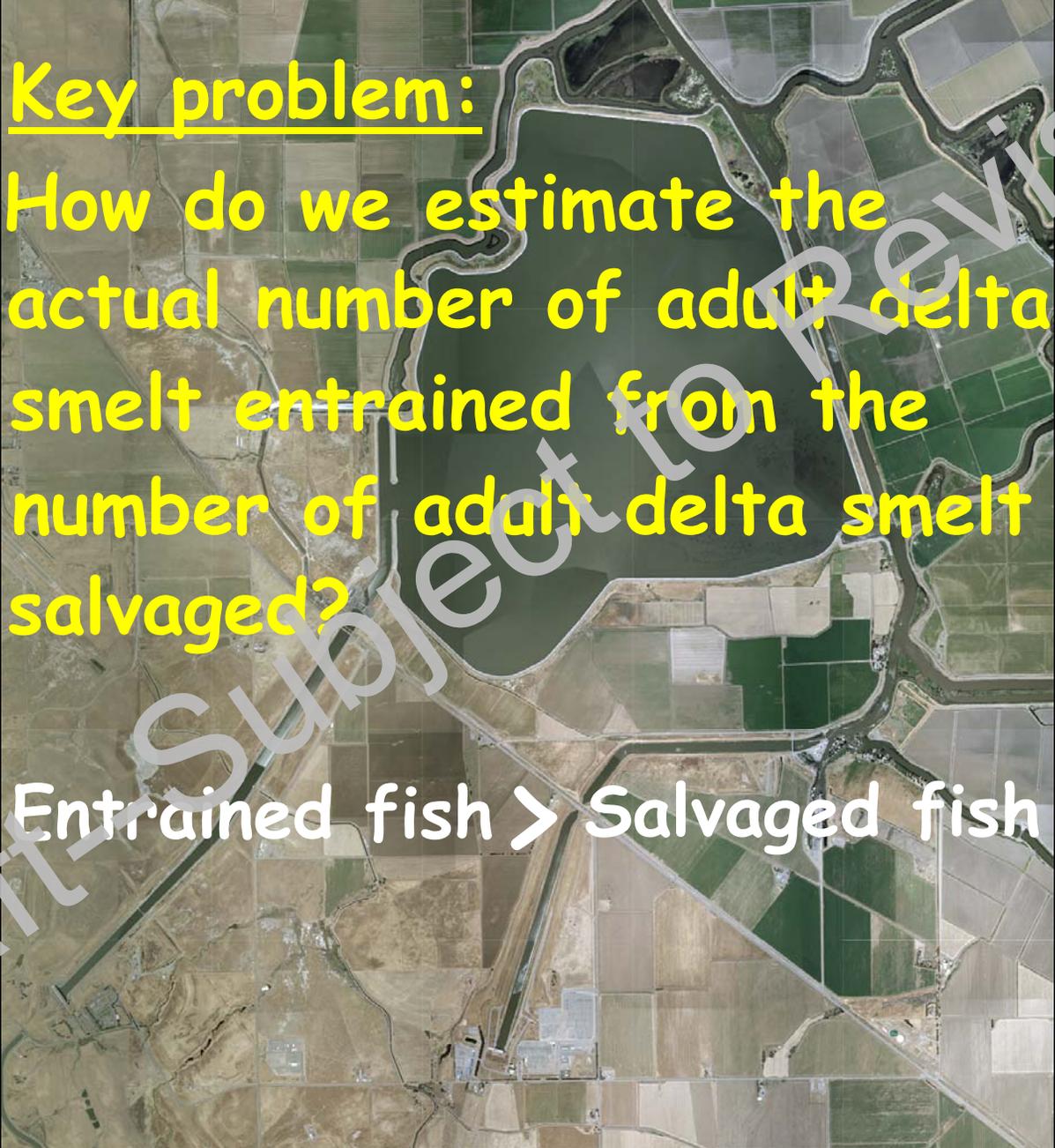
Draft - Subject to Revision

Key problem:

How do we estimate the actual number of adult delta smelt entrained from the number of adult delta smelt salvaged?

Draft--Subject to Revision





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How do we estimate the actual number of adult delta smelt entrained from the number of adult delta smelt salvaged?

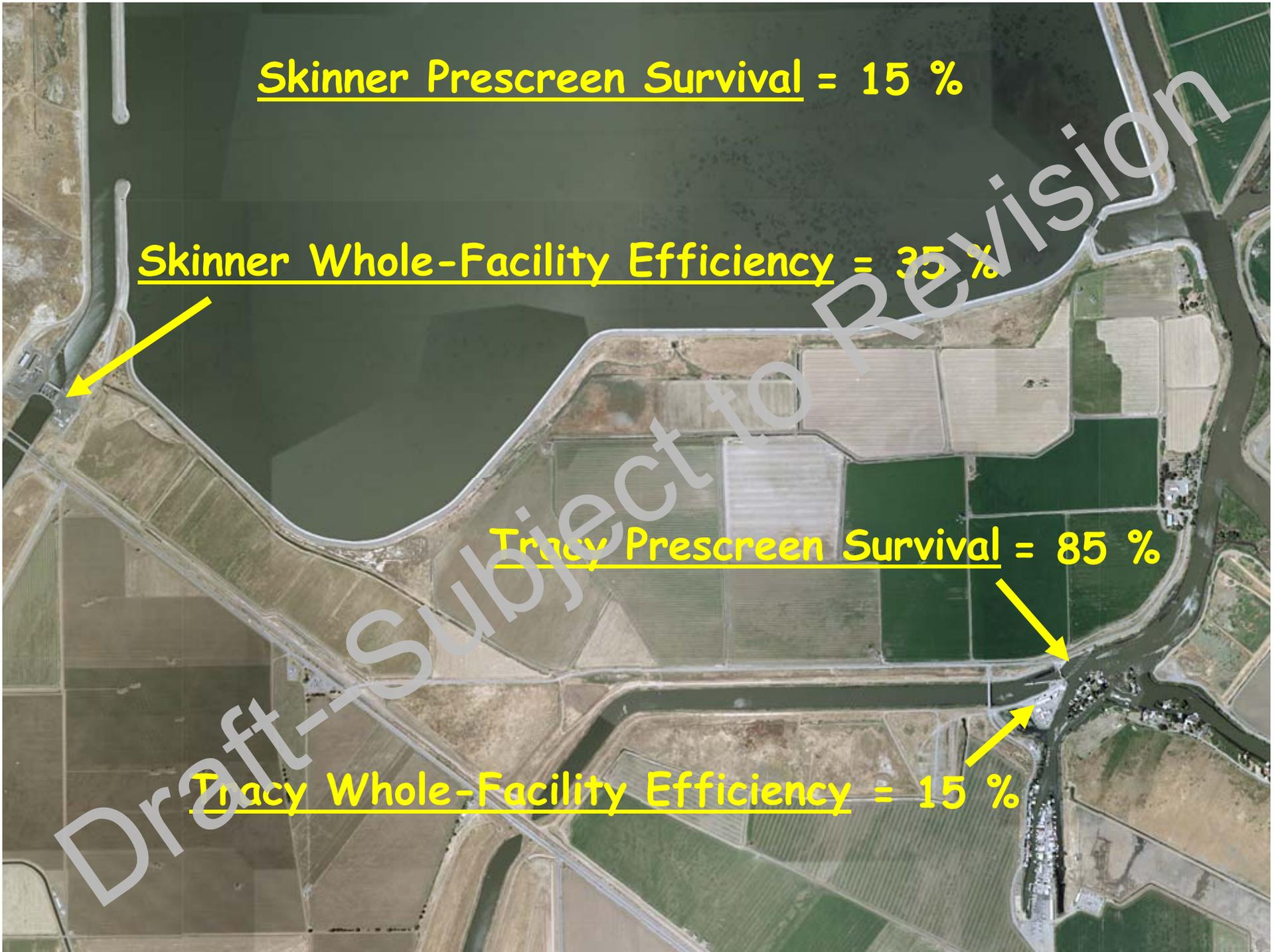
Entrained fish > Salvaged fish

Skinner Prescreen Survival = 15 %

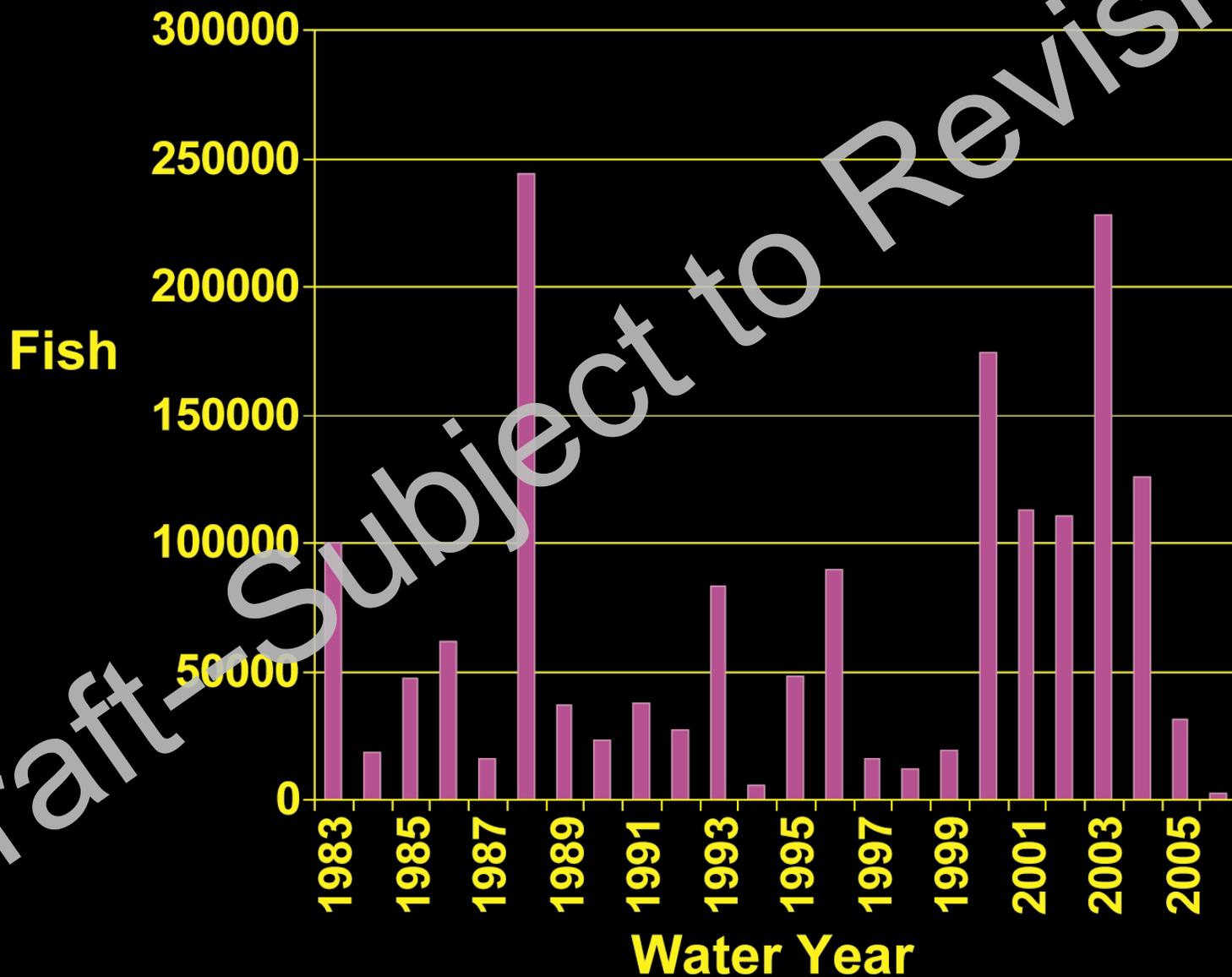
Skinner Whole-Facility Efficiency = 35 %

Tracy Prescreen Survival = 85 %

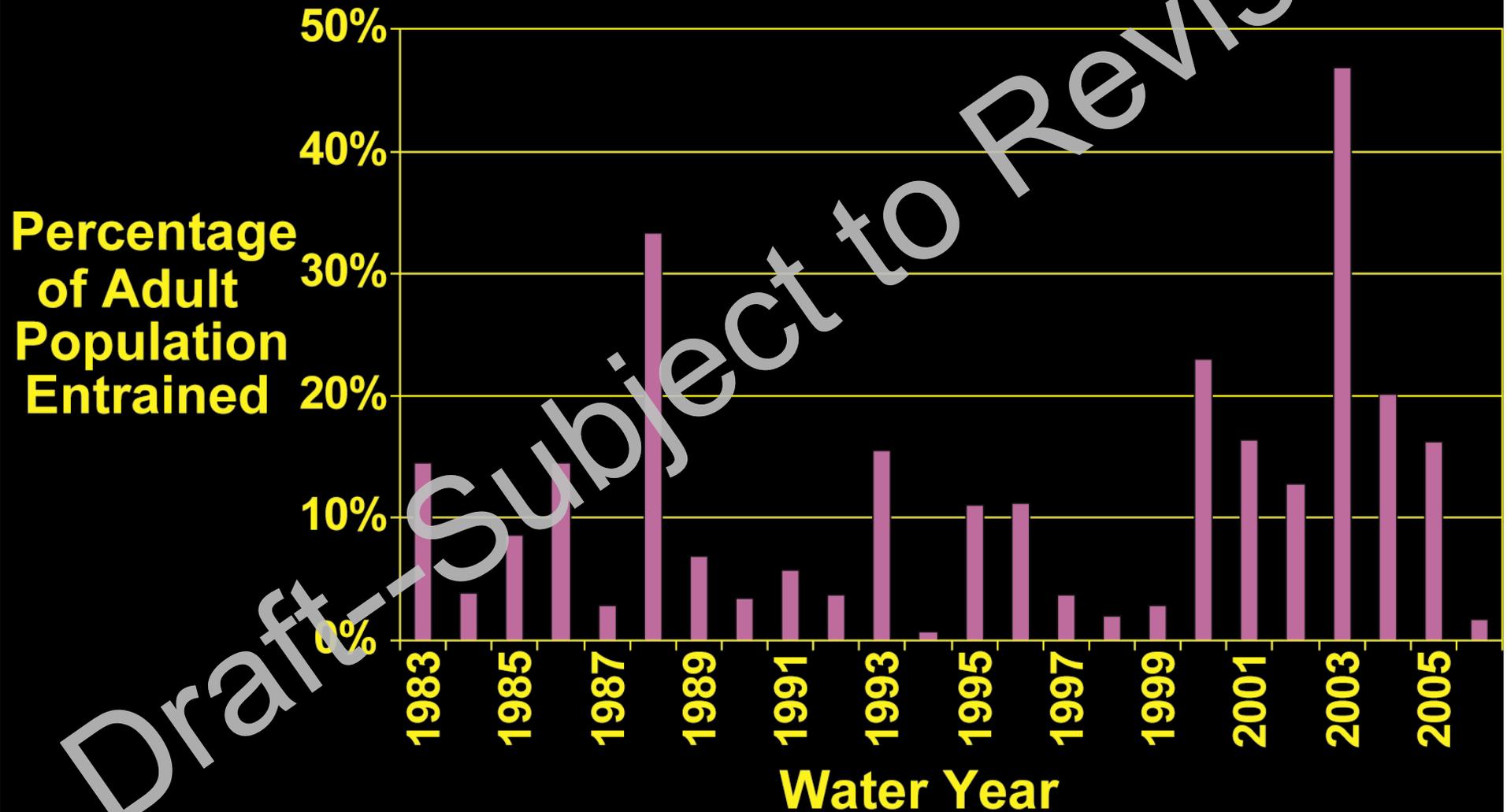
Tracy Whole-Facility Efficiency = 15 %



# Adult Delta Smelt Entrainment Estimates in Number of Fish



# Adult Delta Smelt Entrainment Estimates in Percentage of Population

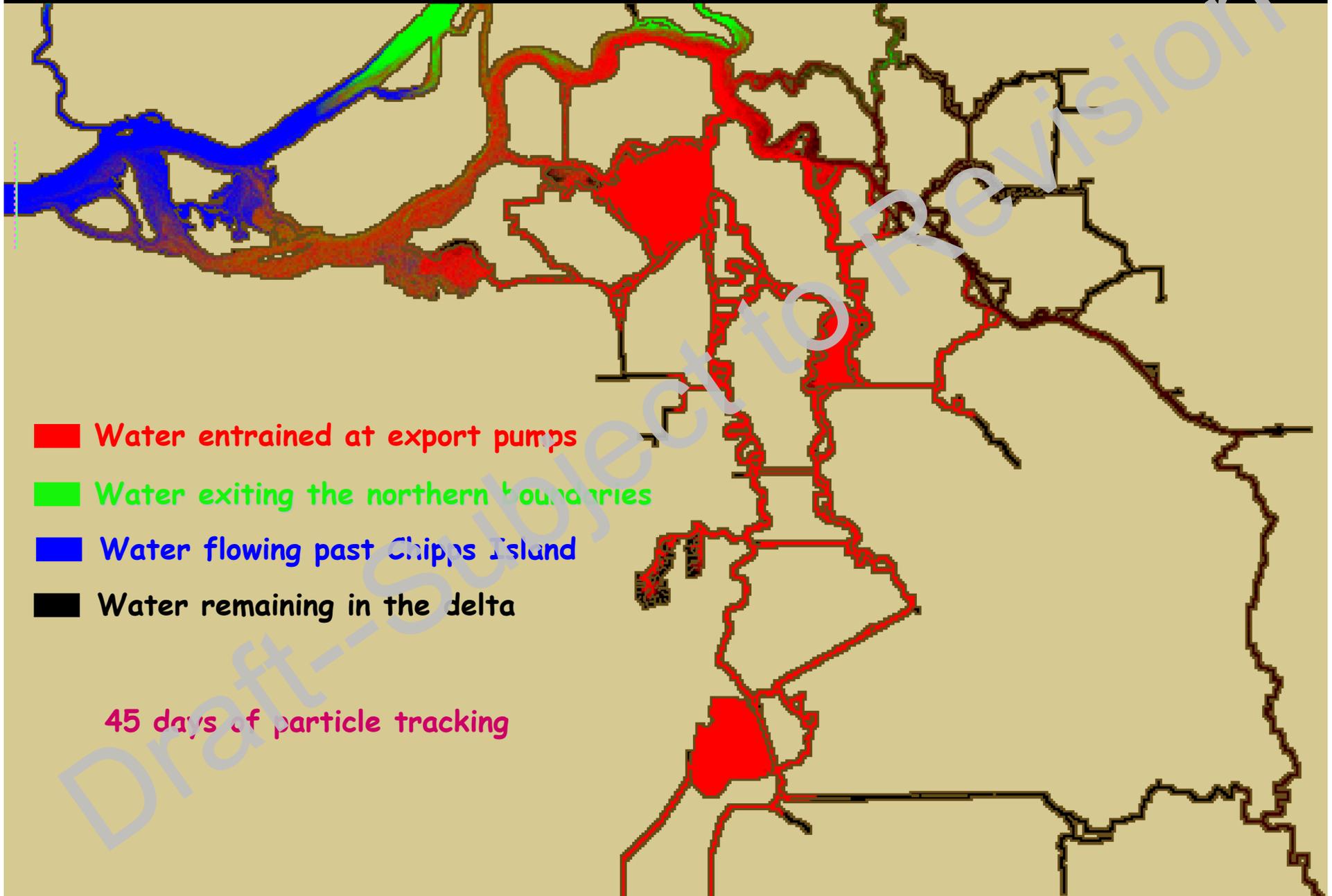


Note: Population estimates taken from Miller(2005)

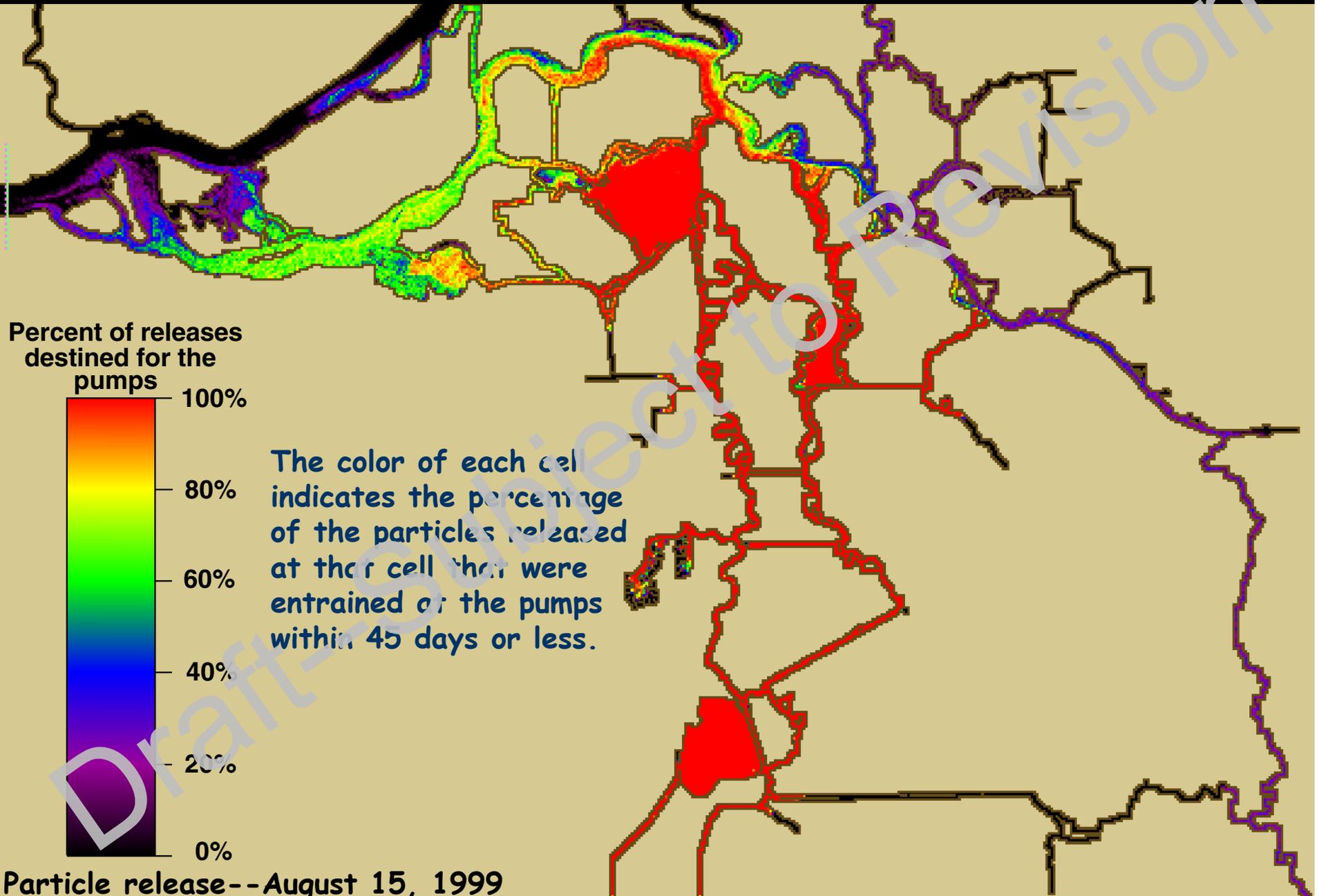
**Are these entrainment  
estimates reasonable?**



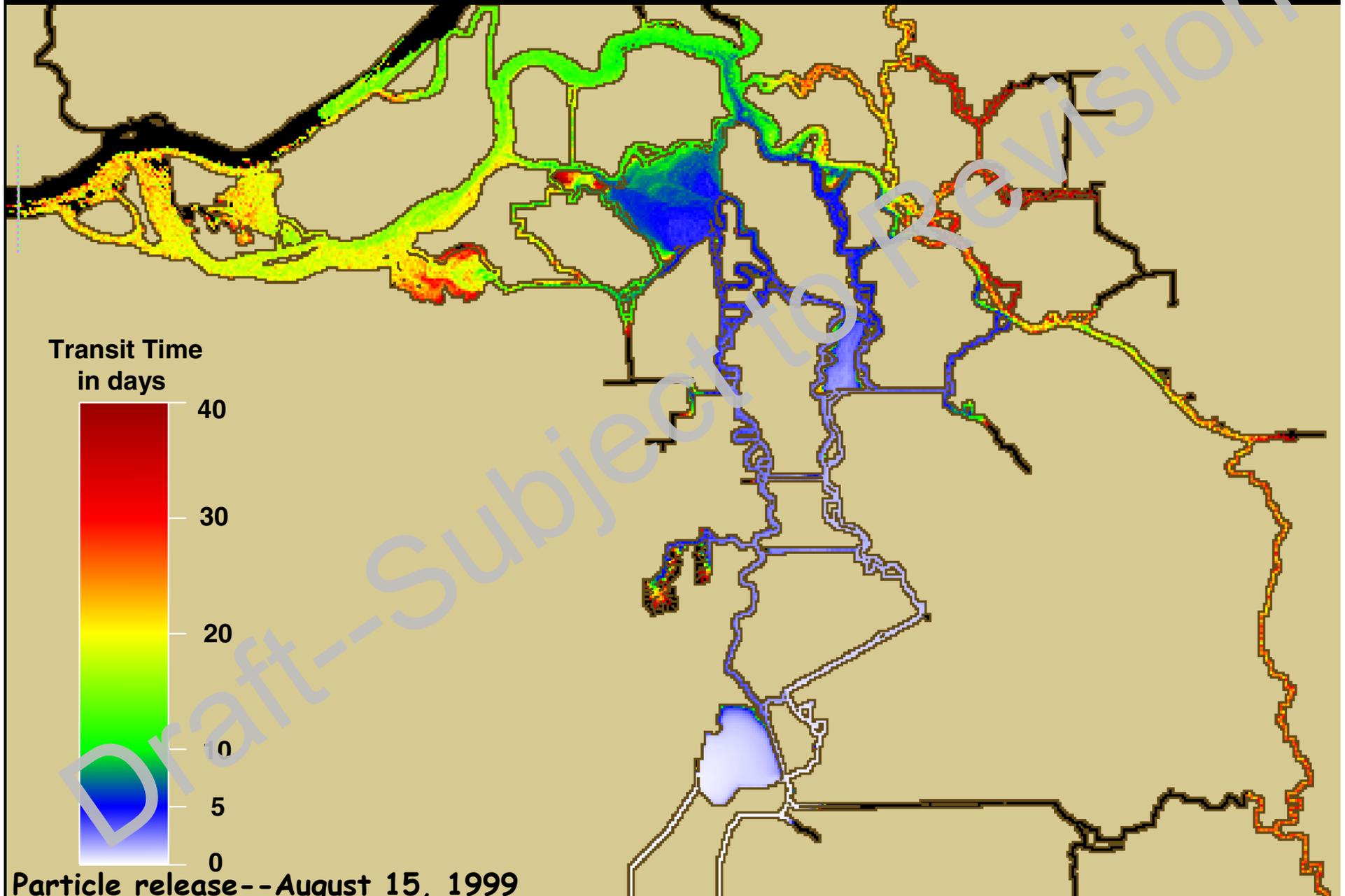
# Zone of Entrainment - Aug 15, 1999



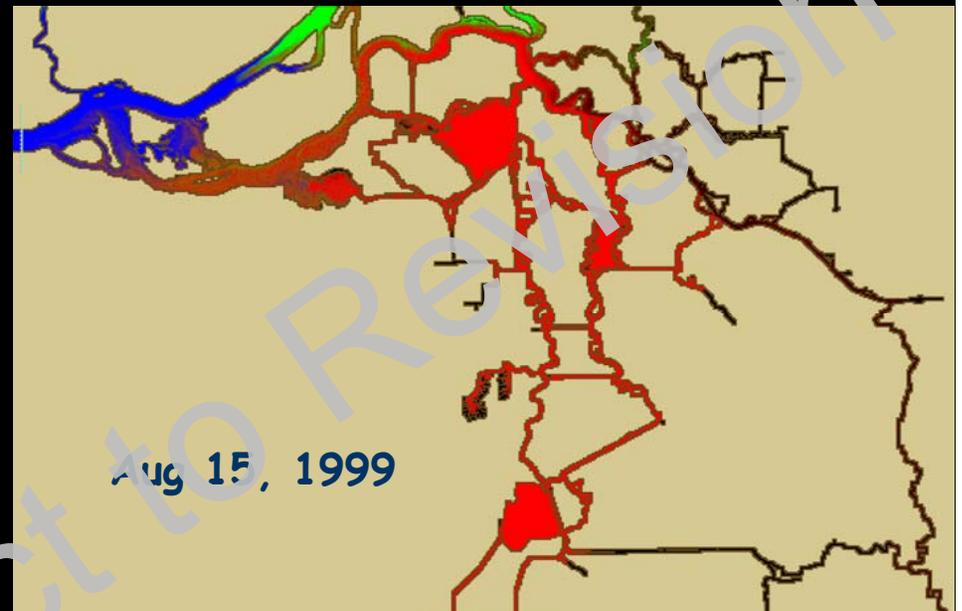
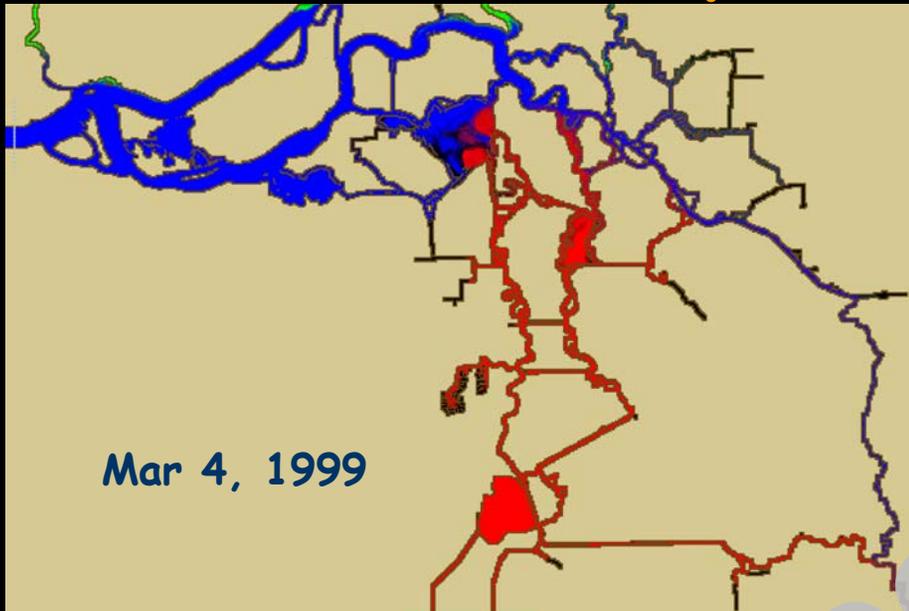
# Percent of Particles Entrained at Pumps within 45 days



# Transit Time of Particles Entrained at Pumps



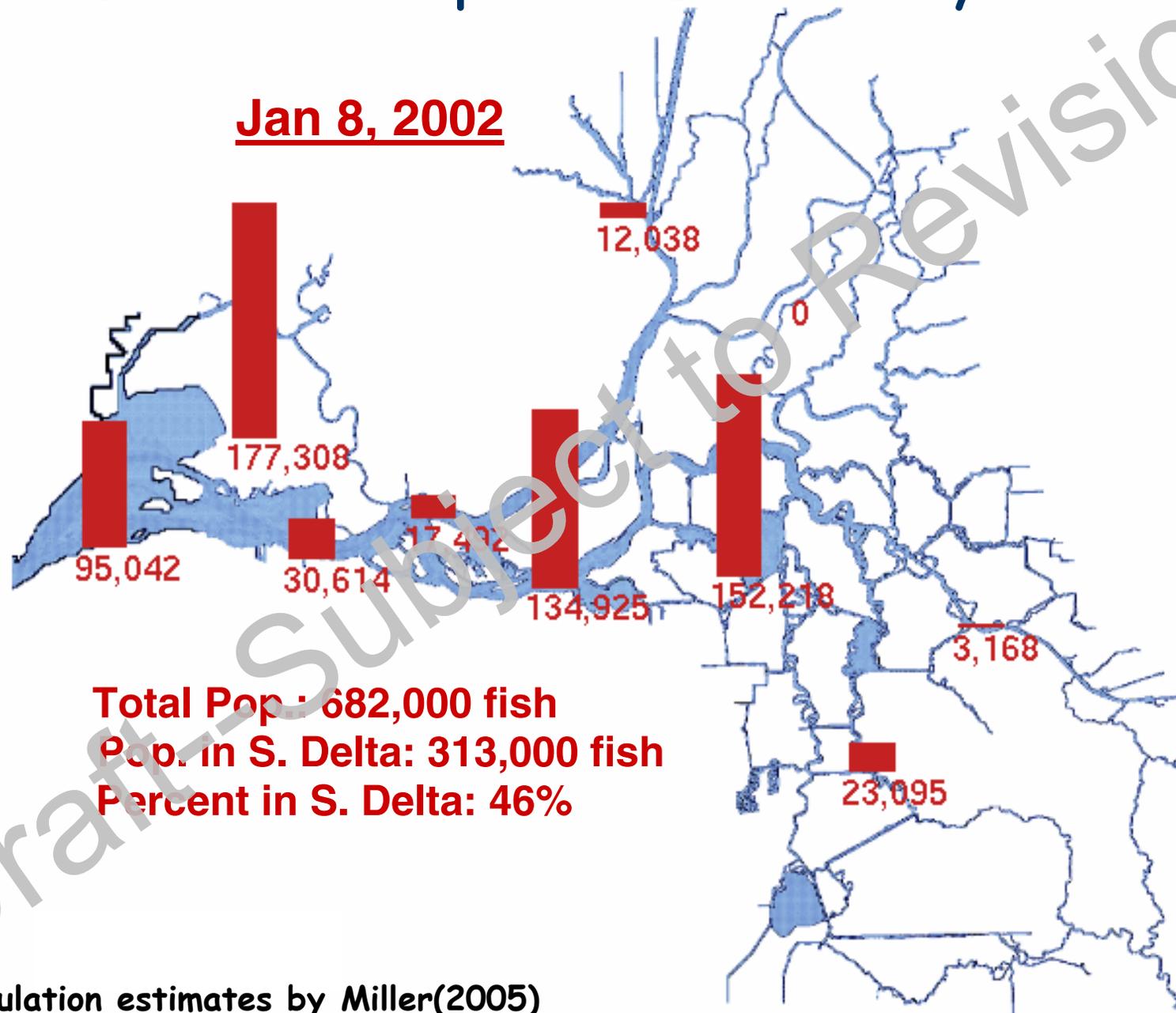
# Compare ZOE<sub>s</sub>



- Water entrained at export pumps
- Water exiting the northern boundaries
- Water flowing past Chipps Island
- Water remaining in Delta

45 days of particle tracking

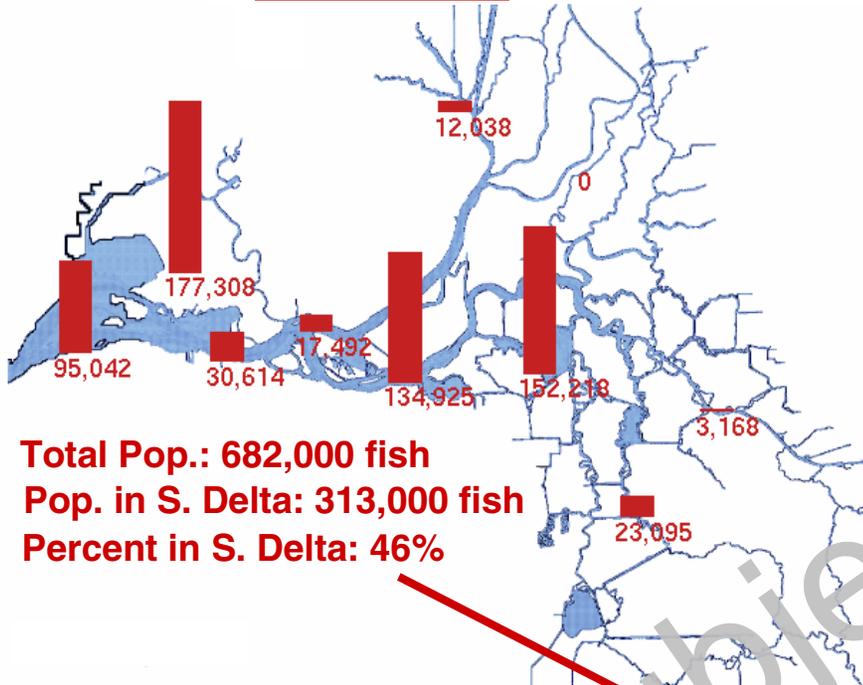
# 2002 Spring Kodiak Trawl Survey Delta Smelt Population Estimates by Area



Note: Population estimates by Miller(2005)

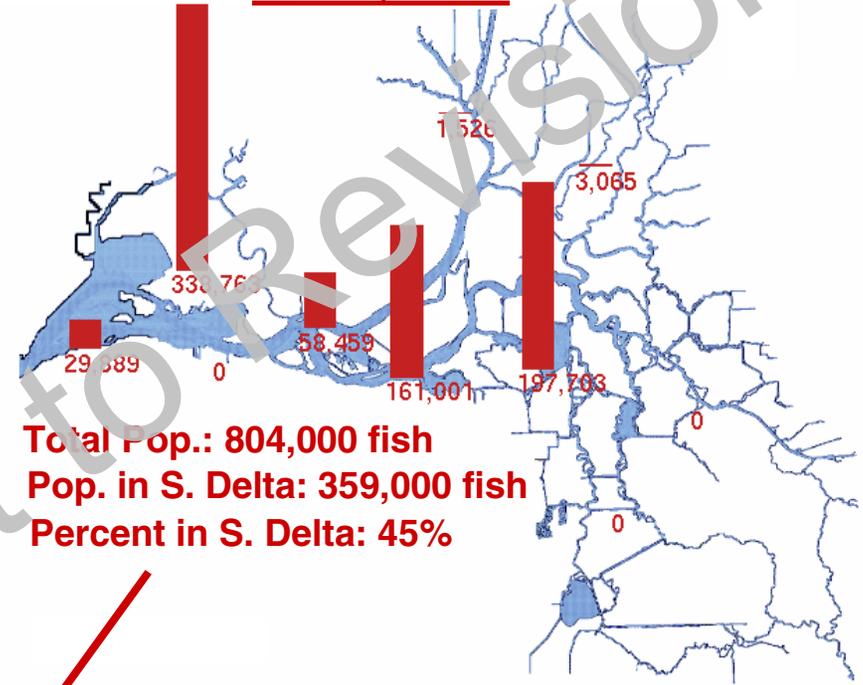
# 2002 Spring Kodiak Trawl Surveys and Salvage

**Jan 8, 2002**

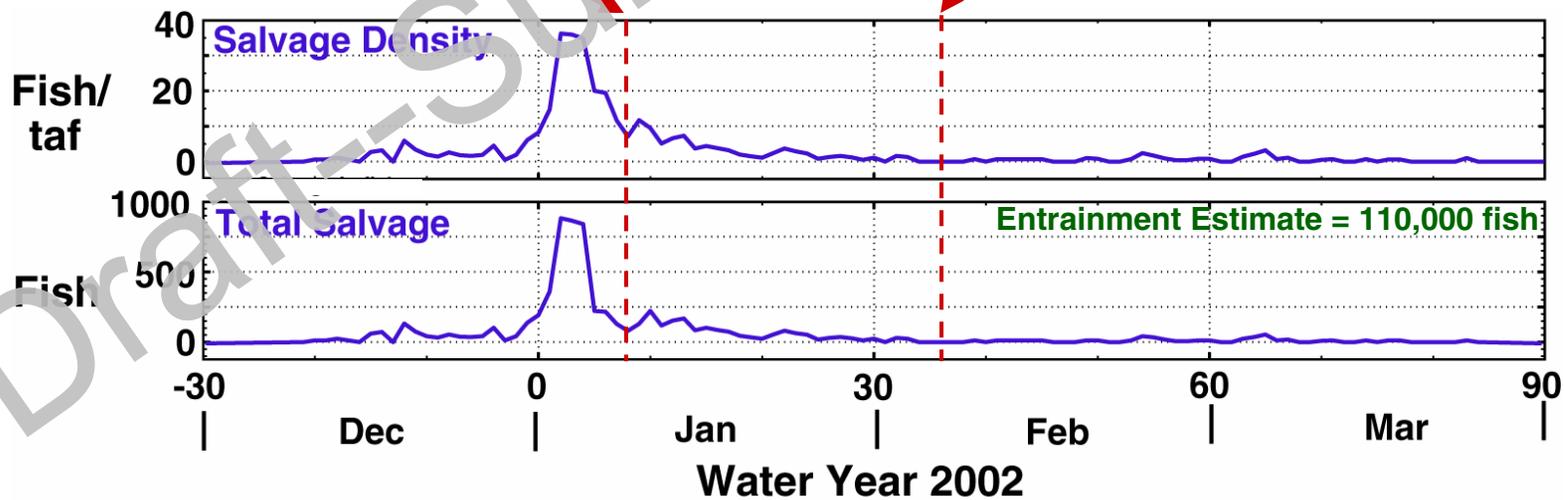


**Total Pop.: 682,000 fish**  
**Pop. in S. Delta: 313,000 fish**  
**Percent in S. Delta: 46%**

**Feb 6, 2002**

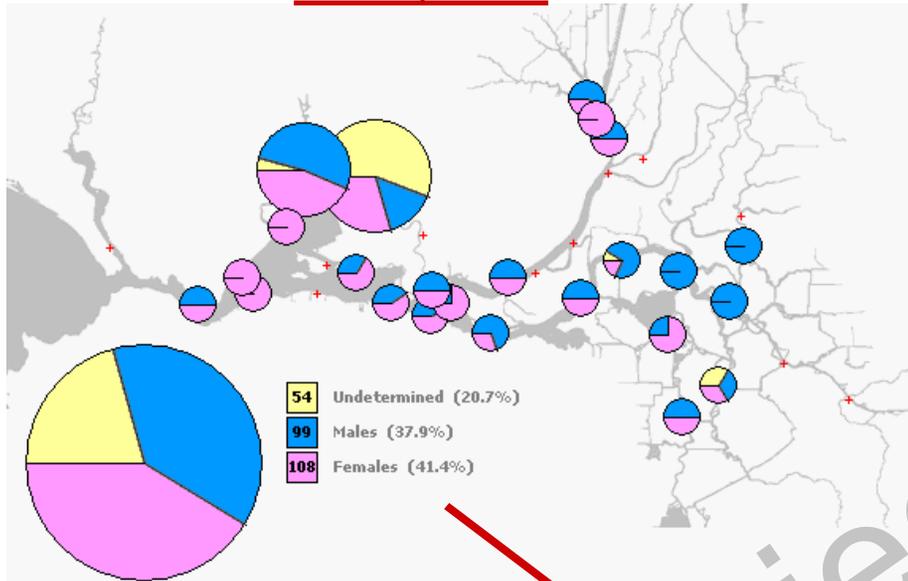


**Total Pop.: 804,000 fish**  
**Pop. in S. Delta: 359,000 fish**  
**Percent in S. Delta: 45%**

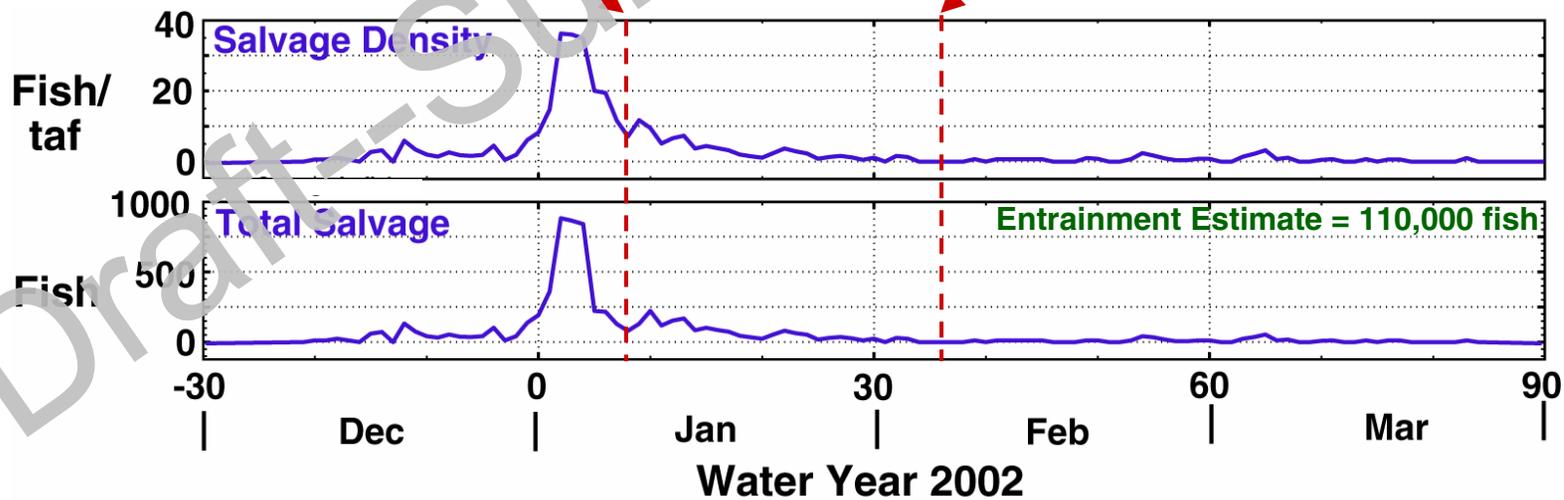
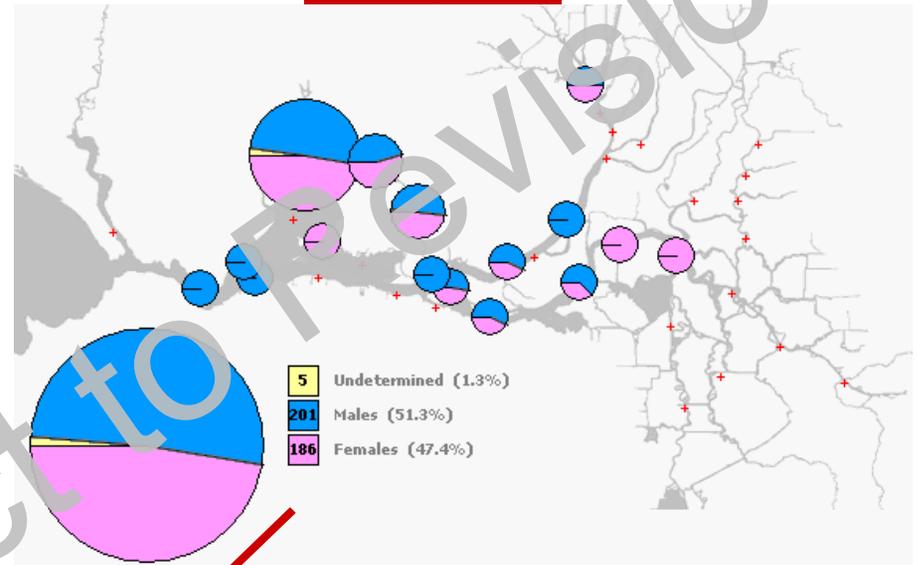


# 2002 Spring Kodiak Trawl Surveys and Salvage

**Jan 8, 2002**

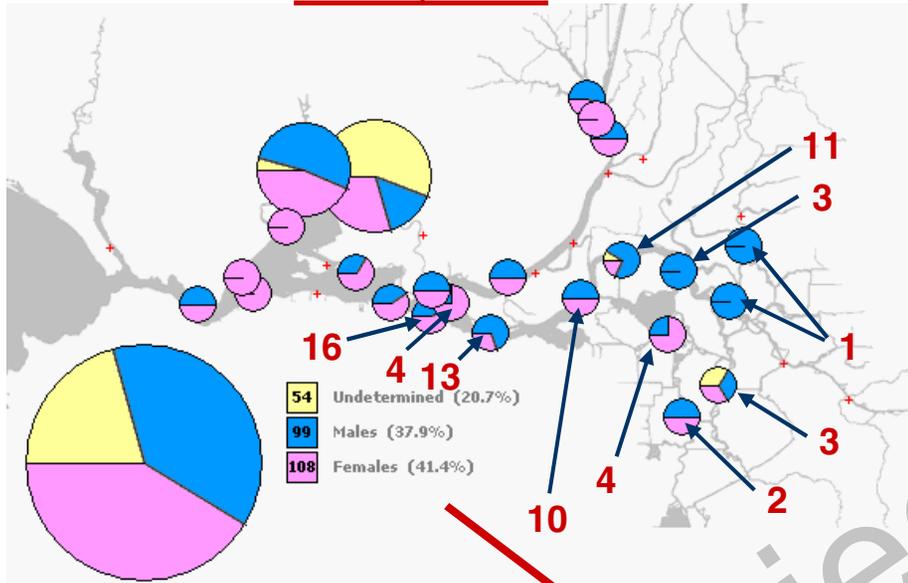


**Feb 6, 2002**

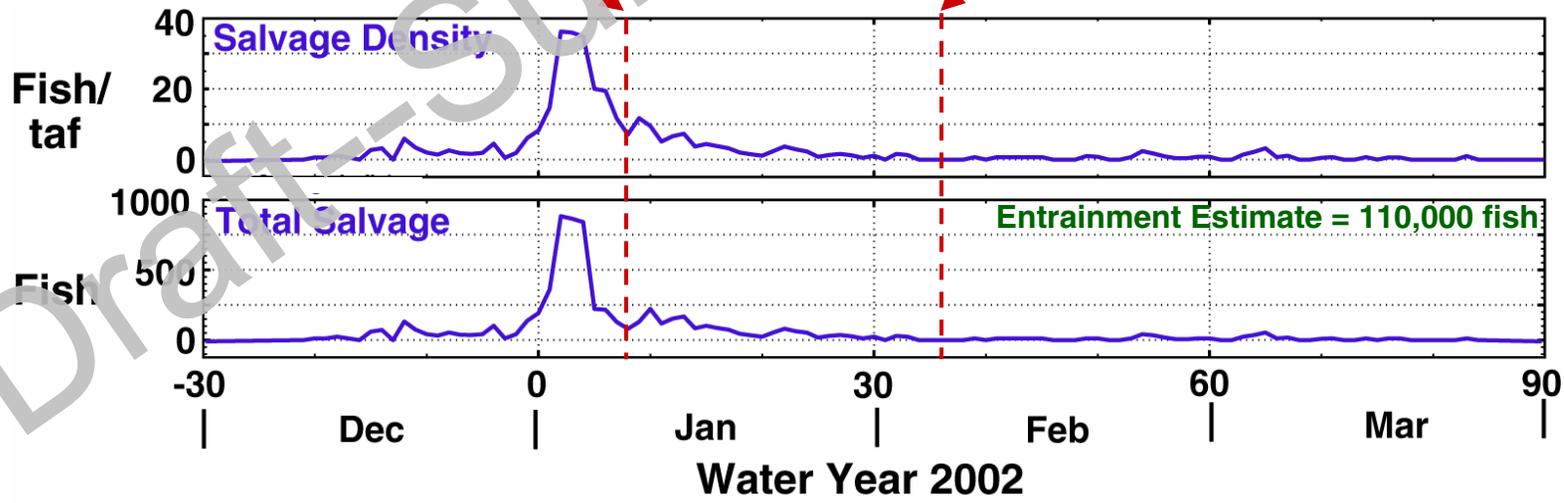
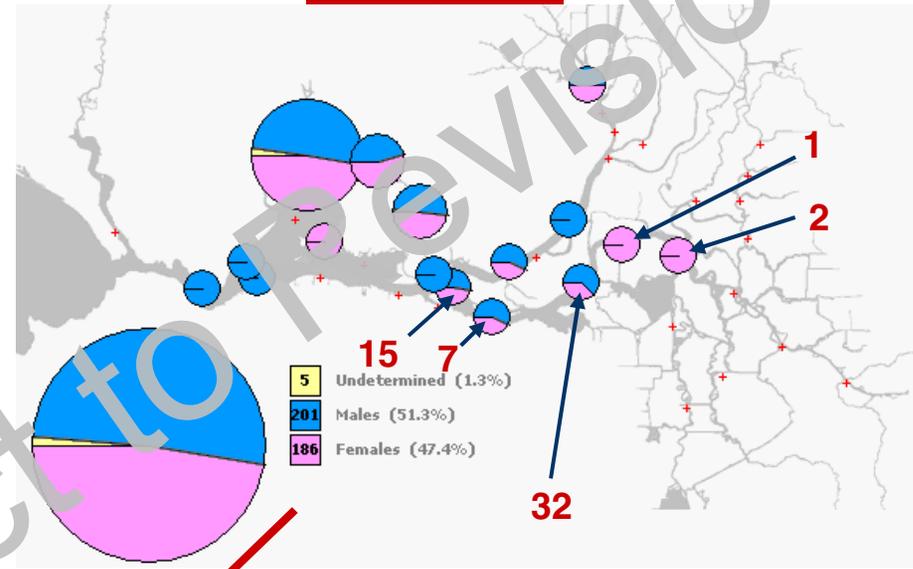


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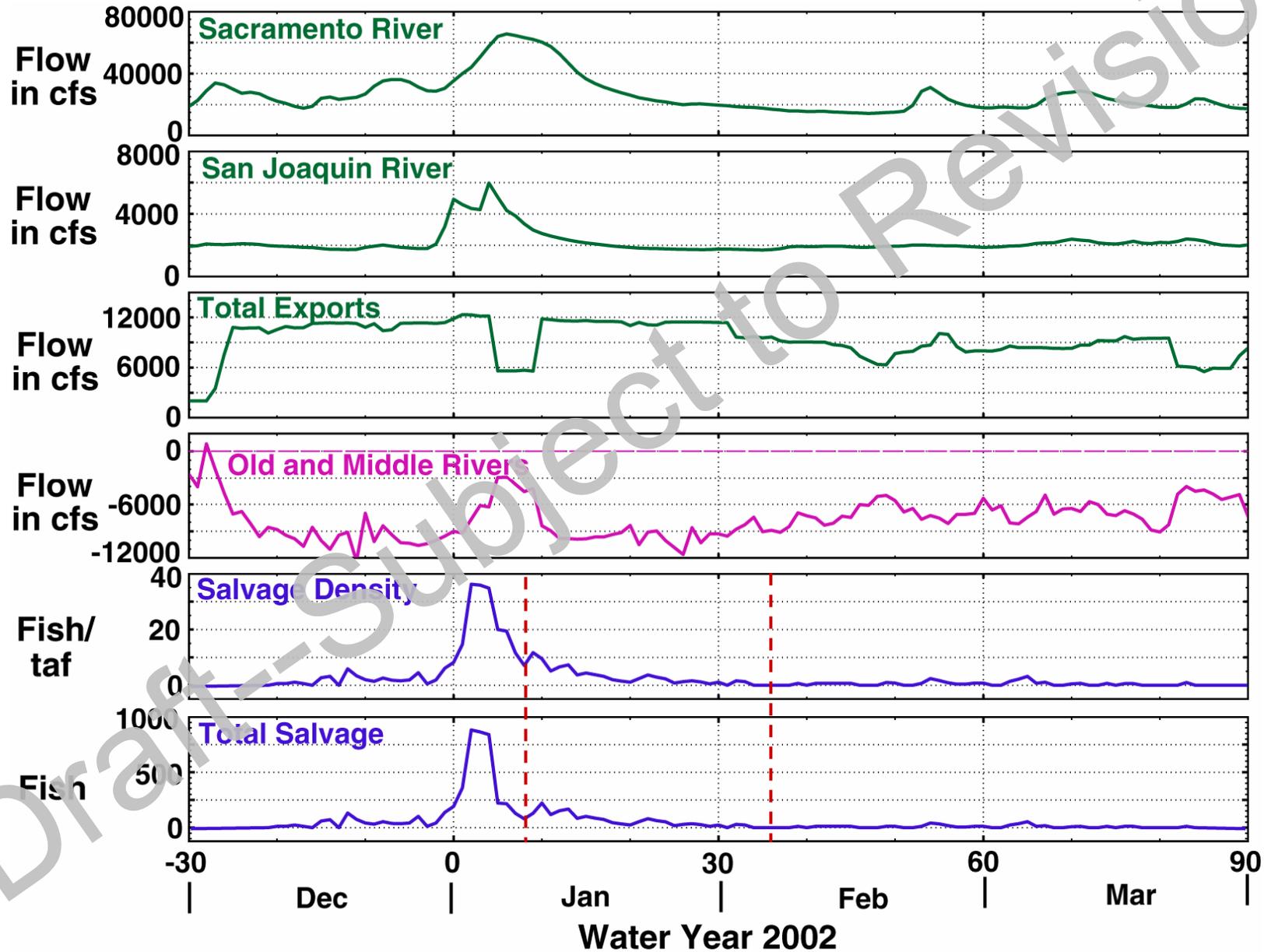
**Jan 8, 2002**



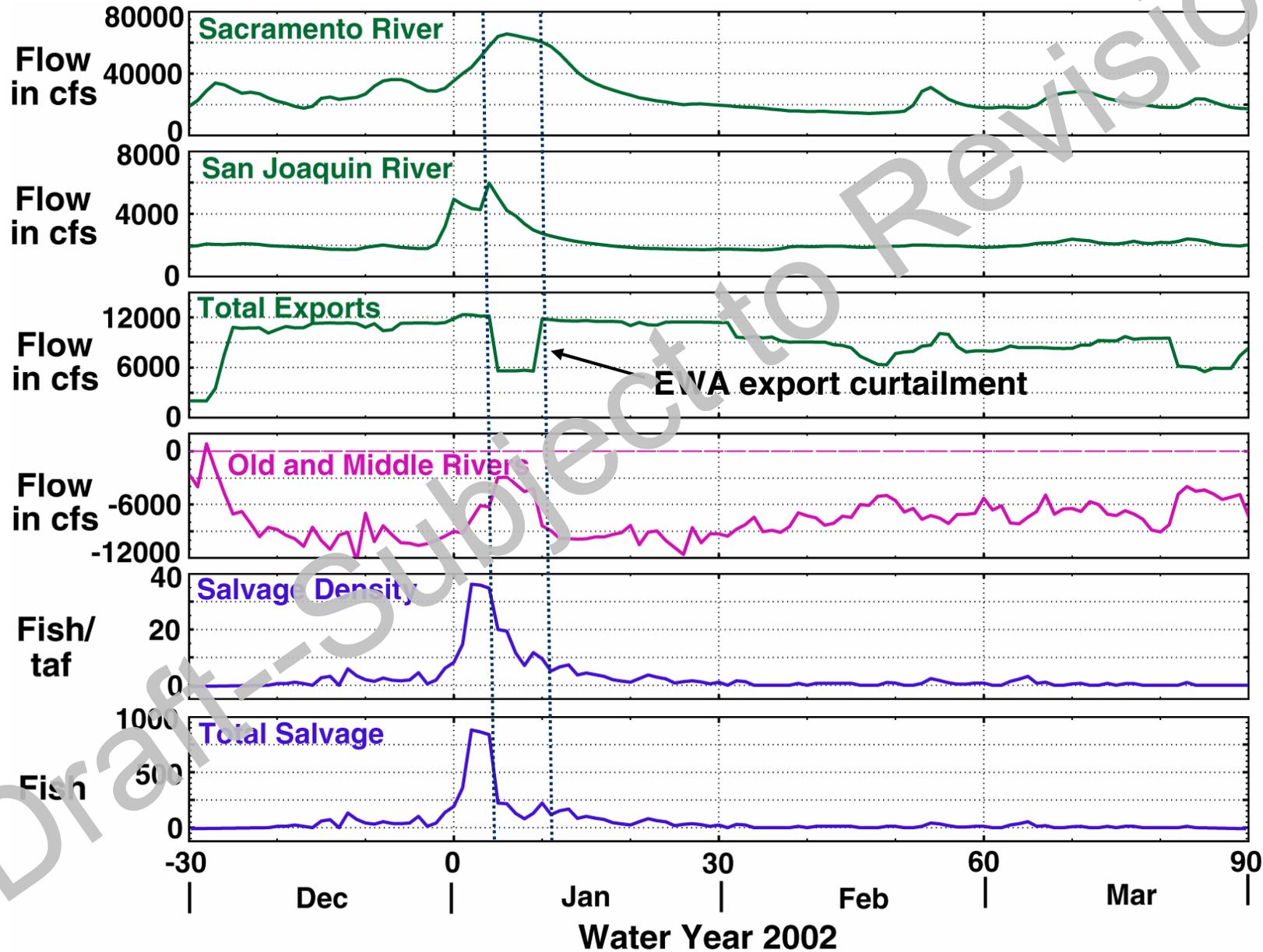
**Feb 6, 2002**



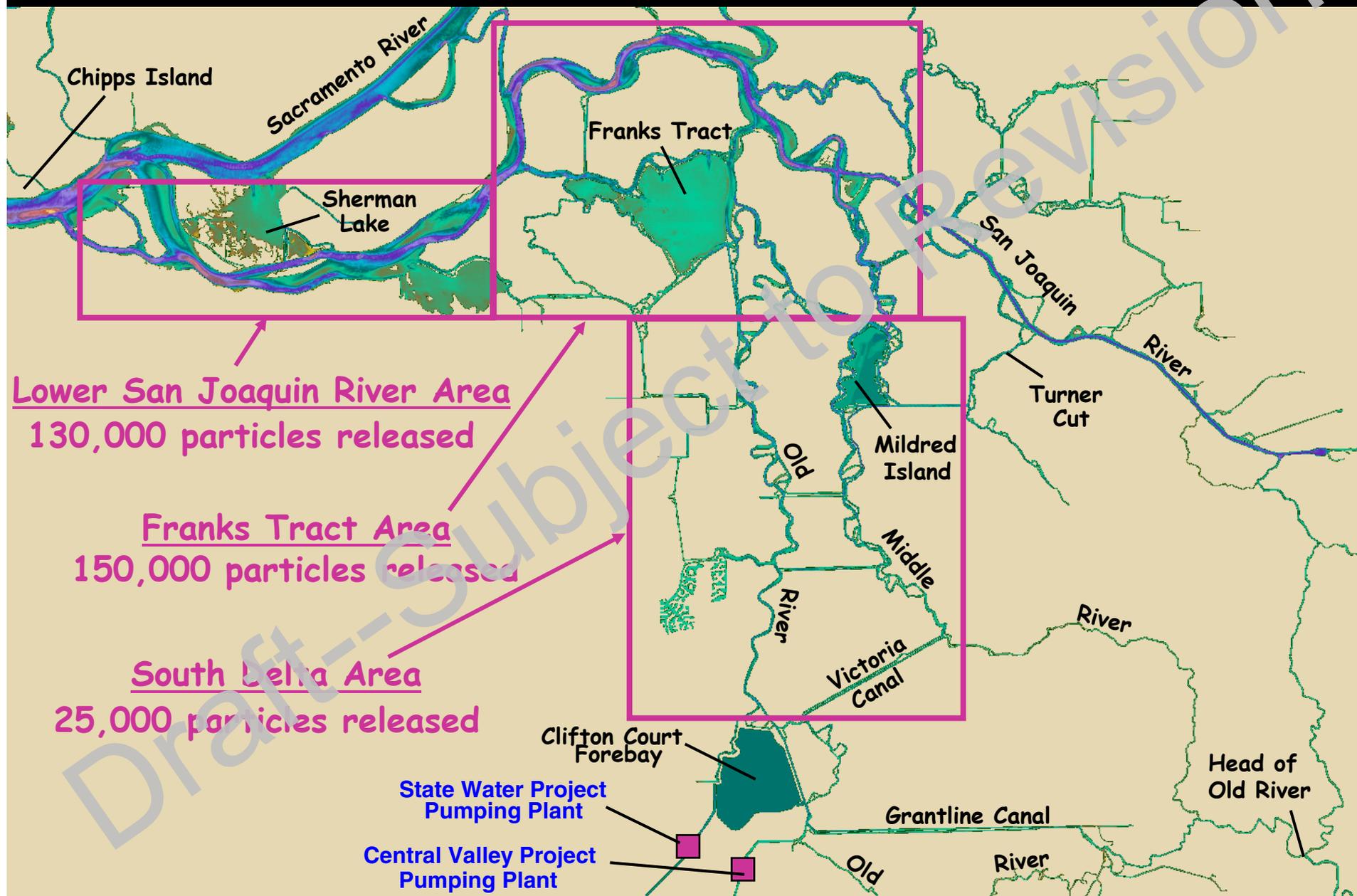
# Winter 2002 Delta Flows and Salvage



# Winter 2002 Delta Flows and Salvage



# Three Areas Used for Particle-Tracking Experiment to Estimate Adult Delta Smelt Entrainment in WY 2002



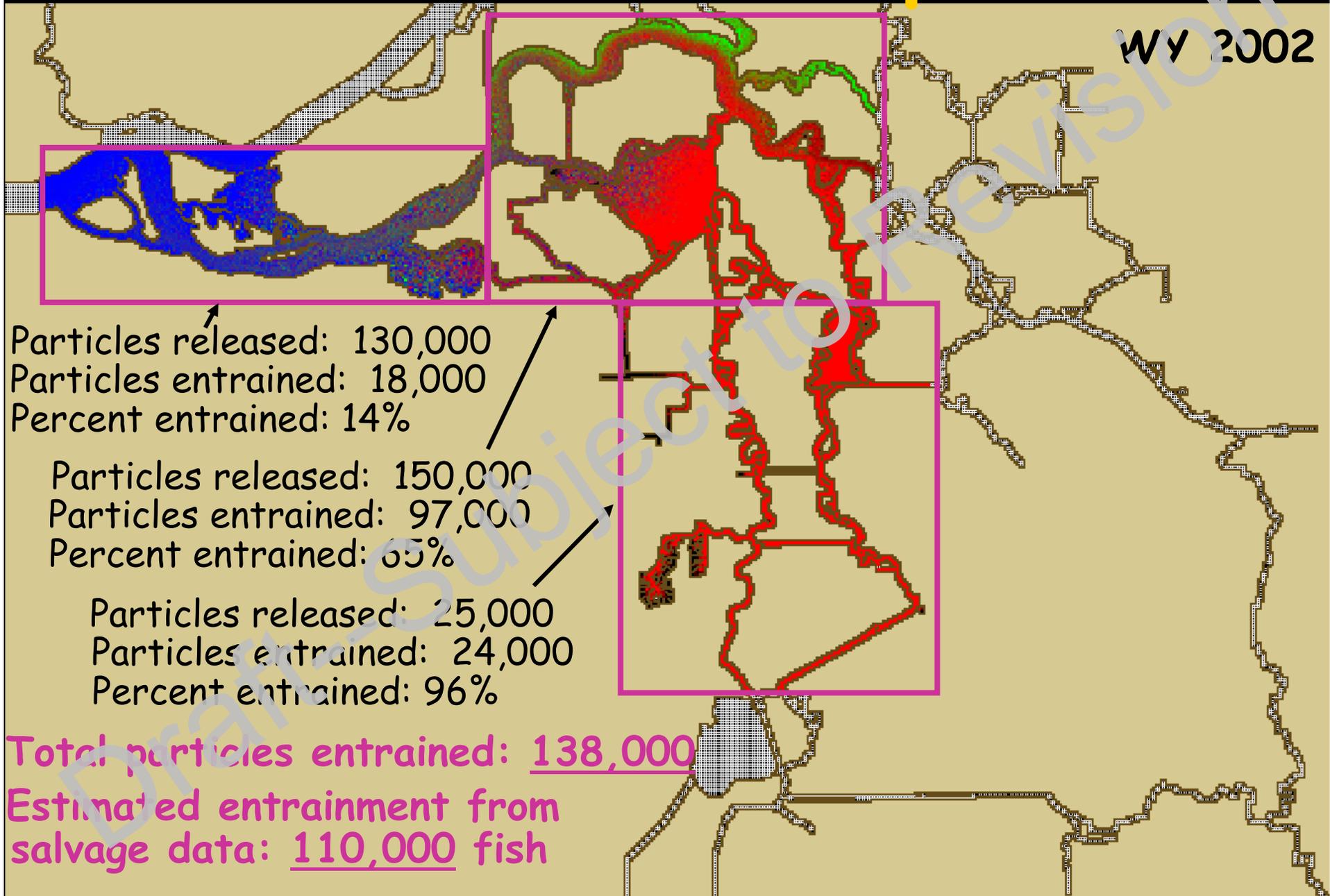
# Details of PTM Experiment

- Particles, each simulating an adult delta smelt, were released randomly in each of the three areas beginning on Dec 10, 2001 and continuing for two weeks.
- Particles were only released in the upper 12 feet of the water column
- Particles were tracked for 45 days and counted if they were entrained at the pumps.



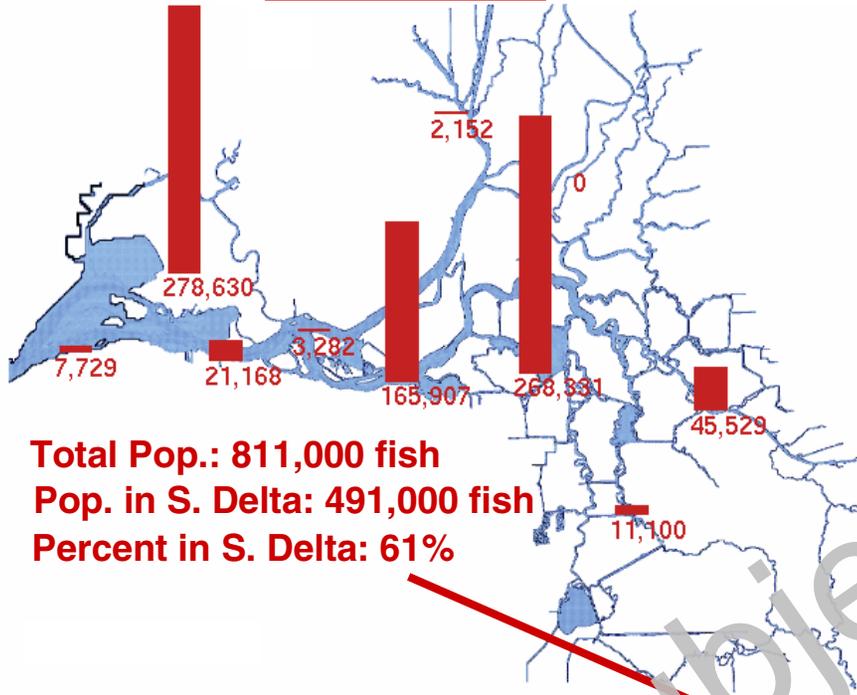
# Results of PTM Experiment

WY 2002

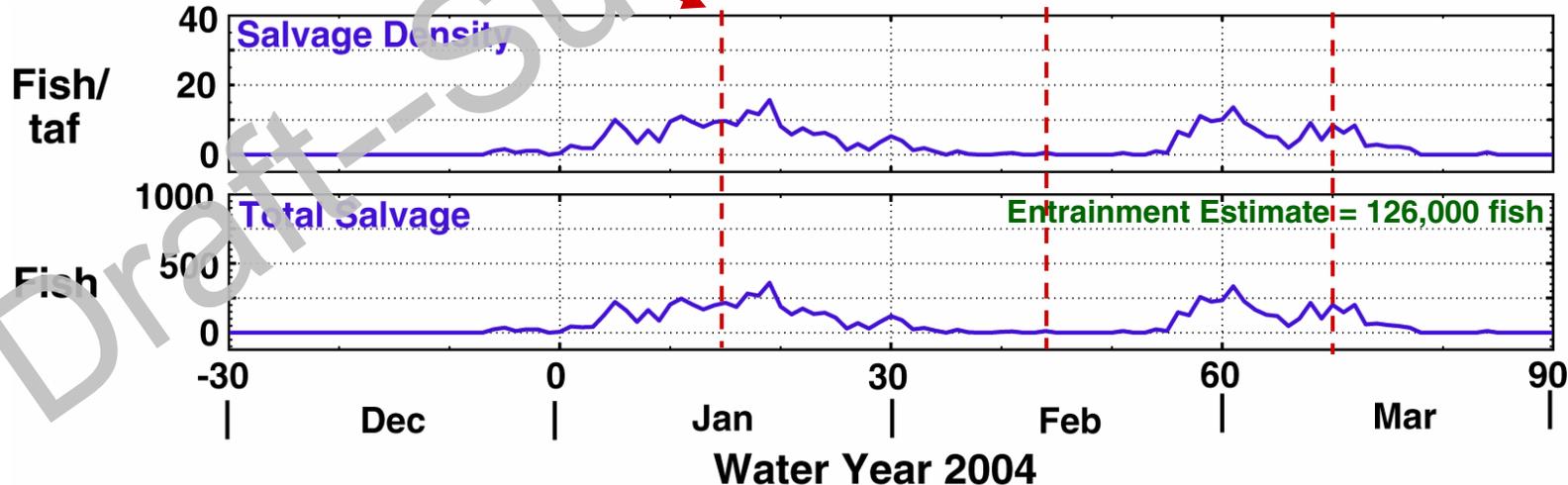
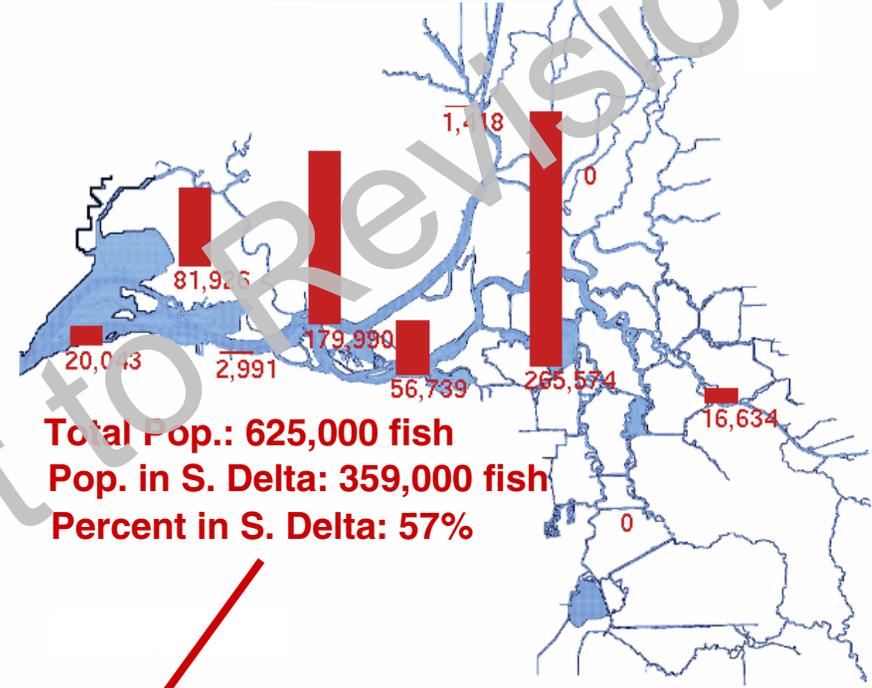


# 2004 Spring Kodiak Trawl Surveys and Salvage

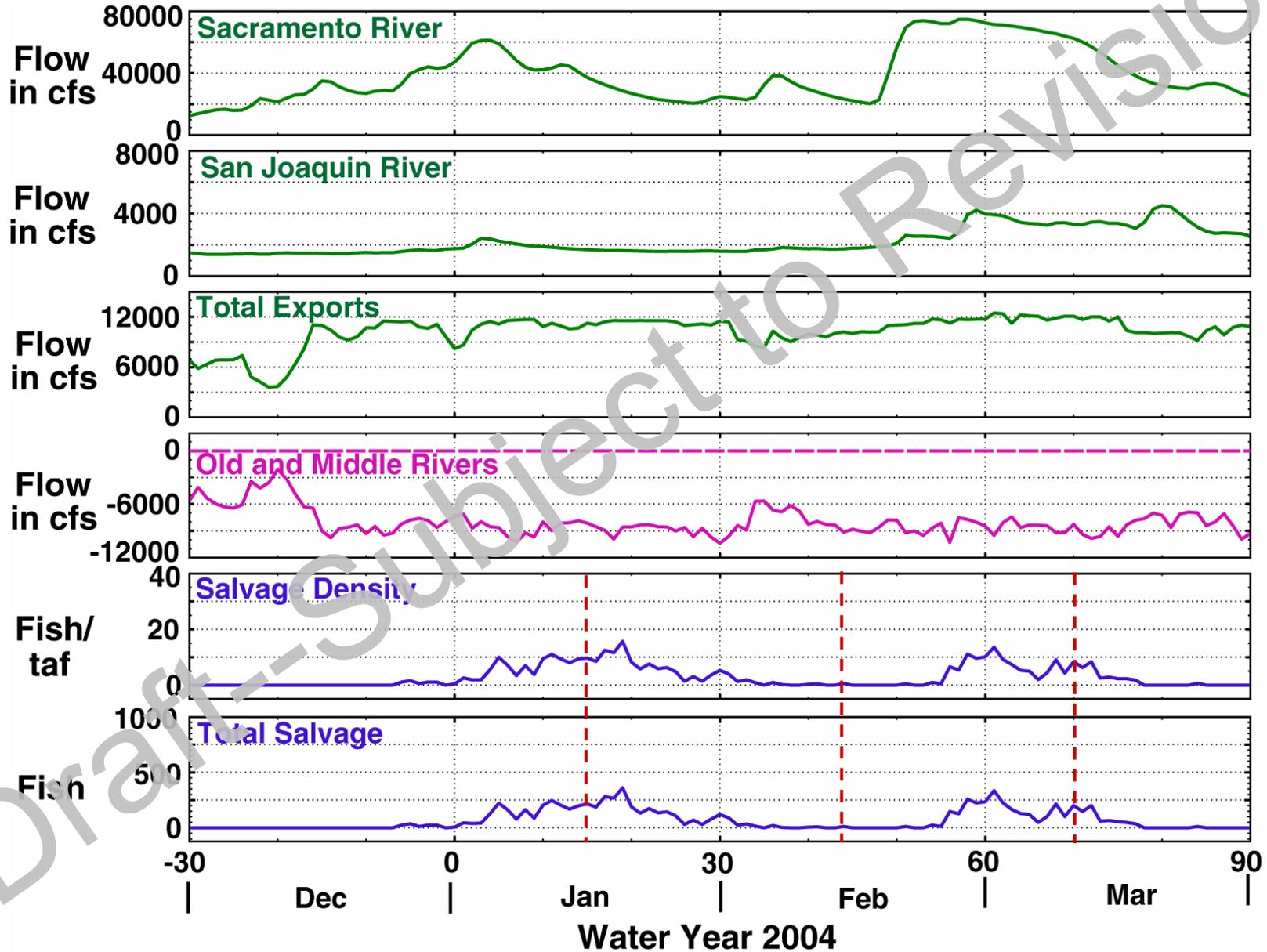
**Jan 14, 2004**



**Feb 13, 2004**



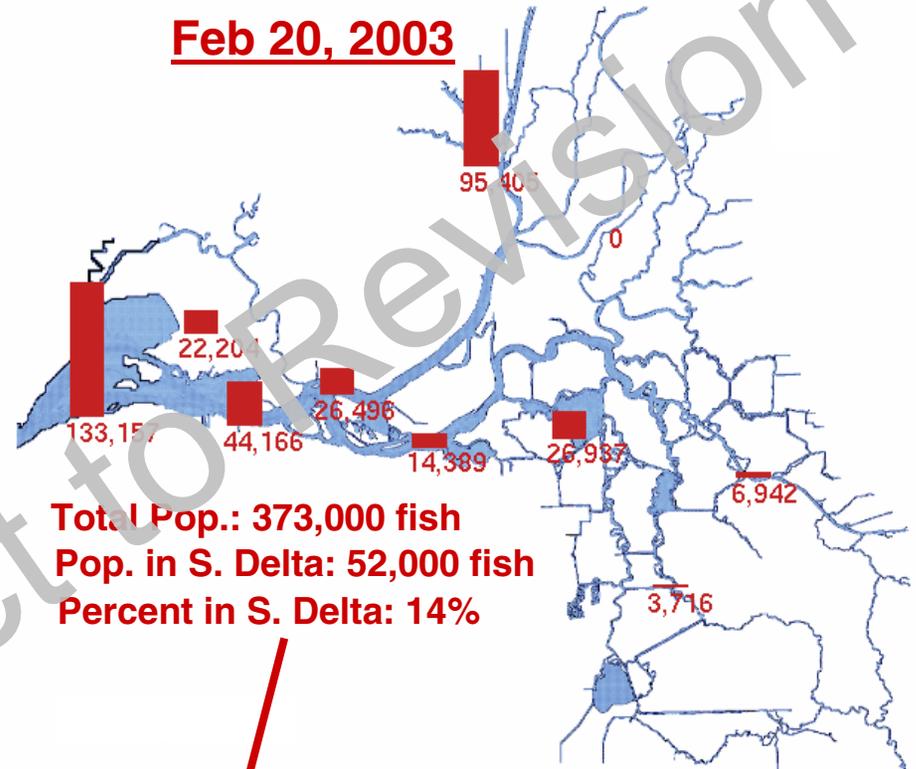
# Winter 2004 Delta Flows and Salvage



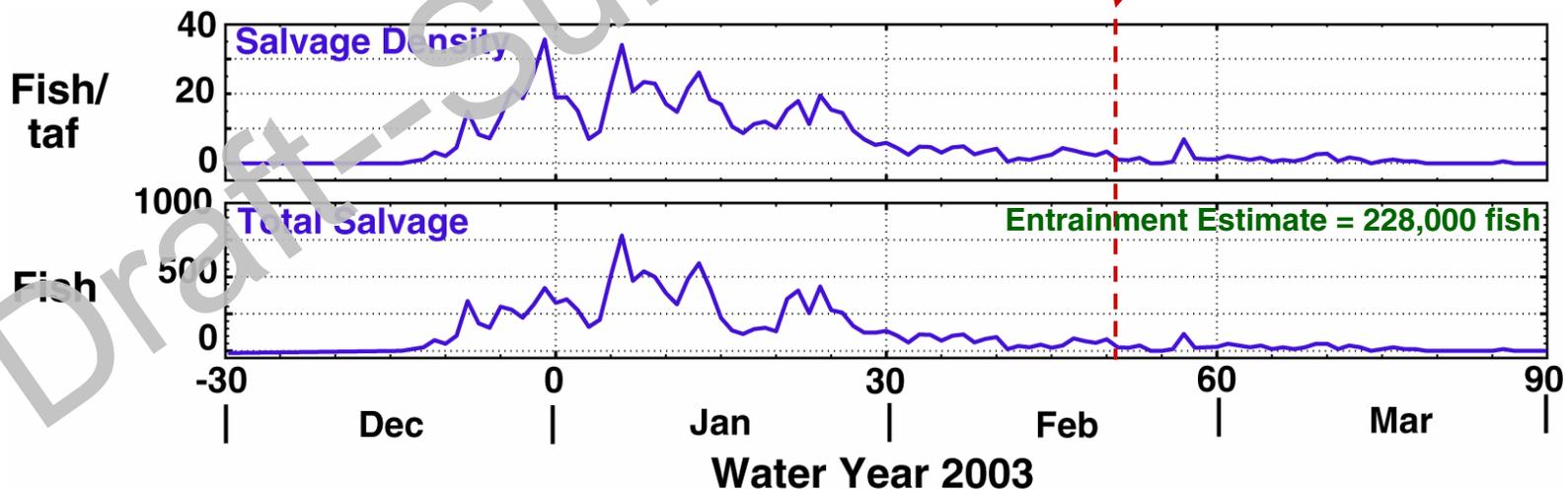
# 2003 Spring Kodiak Trawl Survey and Salvage

No January Survey

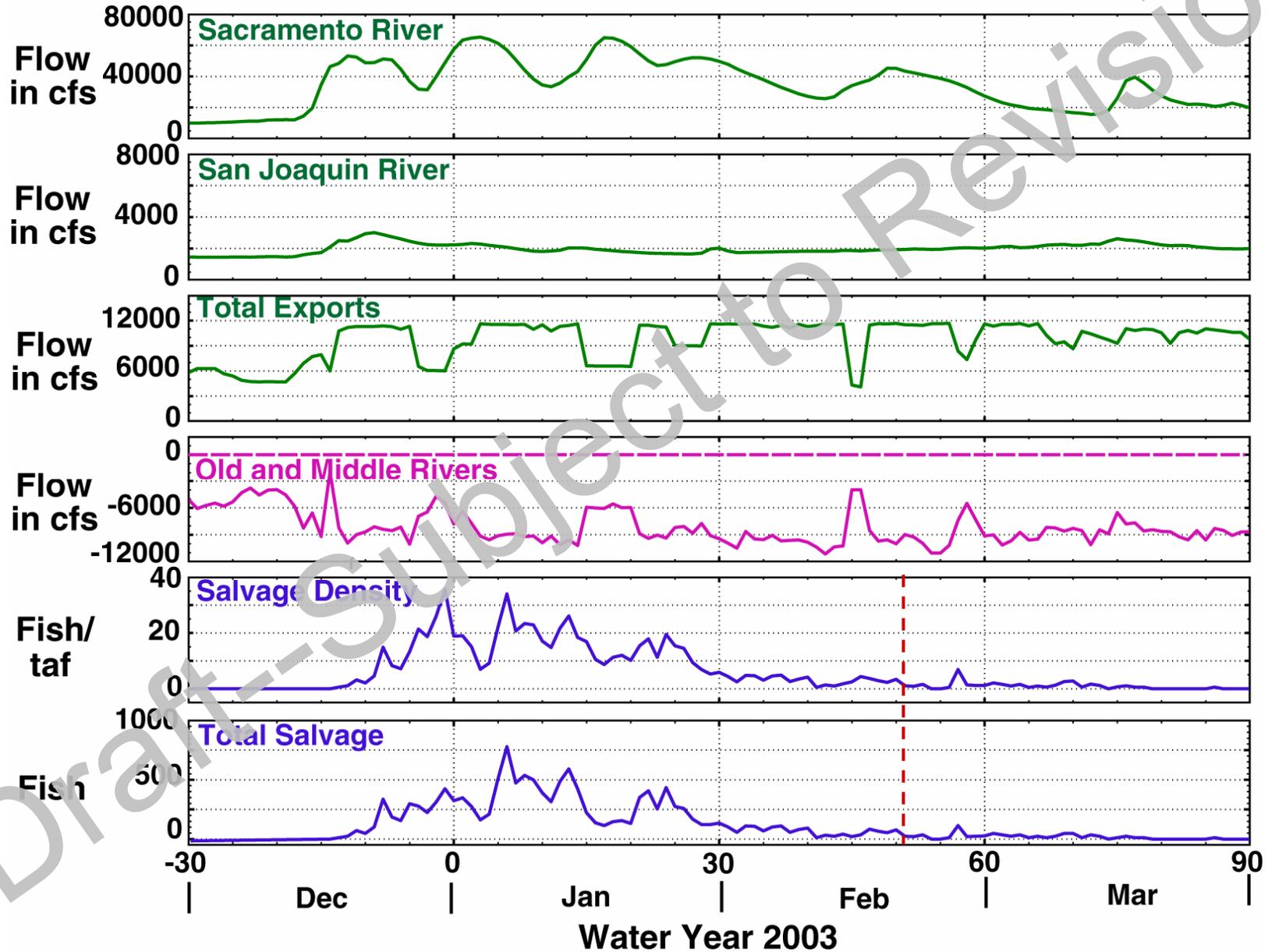
Feb 20, 2003



Total Pop.: 373,000 fish  
Pop. in S. Delta: 52,000 fish  
Percent in S. Delta: 14%



# Winter 2003 Delta Flows and Salvage

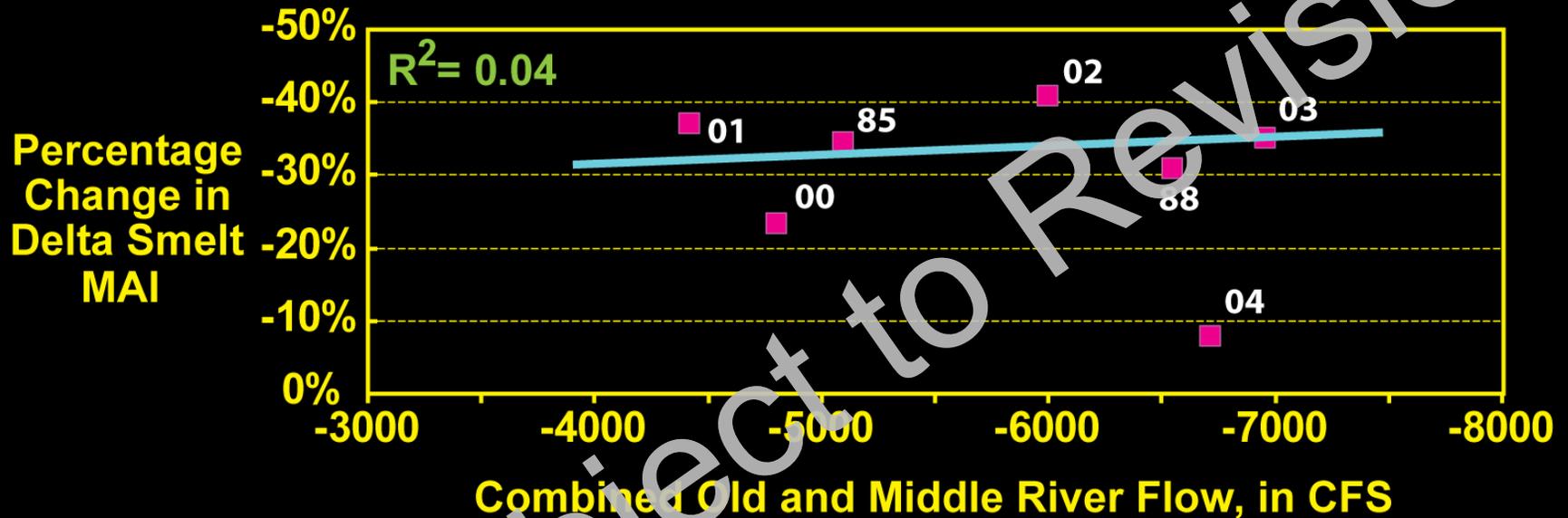


# Regression Analysis

Draft--Subject to Revision



# Population Effect?



Screen for identifying years with entrainment effects:

- % of adult population entrained greater than mean
- > Dec-Jun average of combined O&M River flow > 4,000 cfs

$$\text{MAI} = \text{Mean Abundance Index} = \frac{1}{2} \left( \frac{\text{STN Index}}{\text{Mean}} + \frac{\text{FMWT Index}}{\text{Mean}} \right)$$

Period for defining mean = 1983 to 2005

# Summary and Conclusions

1. When delta smelt are in the South Delta, the combined flow in Old and Middle River is a reasonably good predictor of salvage for both adult and juvenile delta smelt.



# Summary and Conclusions (cont'd)

2. The cause of the high winter salvage of delta smelt during the POD years was mostly due to pumping larger volumes of water drawn from the north down Old and Middle Rivers.



## Summary and Conclusions (cont'd)

3. The effect of adult delta smelt entrainment at the export facilities on the apparent decline in the population is difficult to determine because of uncertainties in estimating the actual number of delta smelt entrained and the size of the overall population. It is possible, however, that entrainment in certain years has been large.

# Summary and Conclusions (cont'd)

4. Particle tracking experiments using adult delta smelt distribution data from the Spring Kodiak Trawl confirm that the entrainment estimated from the salvage data are reasonable if adult delta smelt are transported anything like neutrally buoyant particles.



## Summary and Conclusions (cont'd)

5. The low numbers of adult delta smelt found in the South Delta in Feb 2003 immediately following the very large salvage event that year suggests that high entrainment of delta smelt may have occurred.



## Summary and Conclusions (cont'd)

6. A data screen identified 7 years (1985, 1988, and 2000-2004) since 1983 in which entrainment effects on the delta smelt population might be important. In all 7 of these years the Mean Abundance Index for delta smelt showed a significant decline from the prior year.



