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

Pete Smith
U.S. Geological Survey
Sacramento, CA

Collaborators:

Salvage/ Flows

Jay Simi, USGS
Cathy Ruhl, USGS
IEP Biologists

Modeling

John Donovan, USGS
Henry Wong, USBR

2006 EWA Workshop
November 28, 2006

Outline

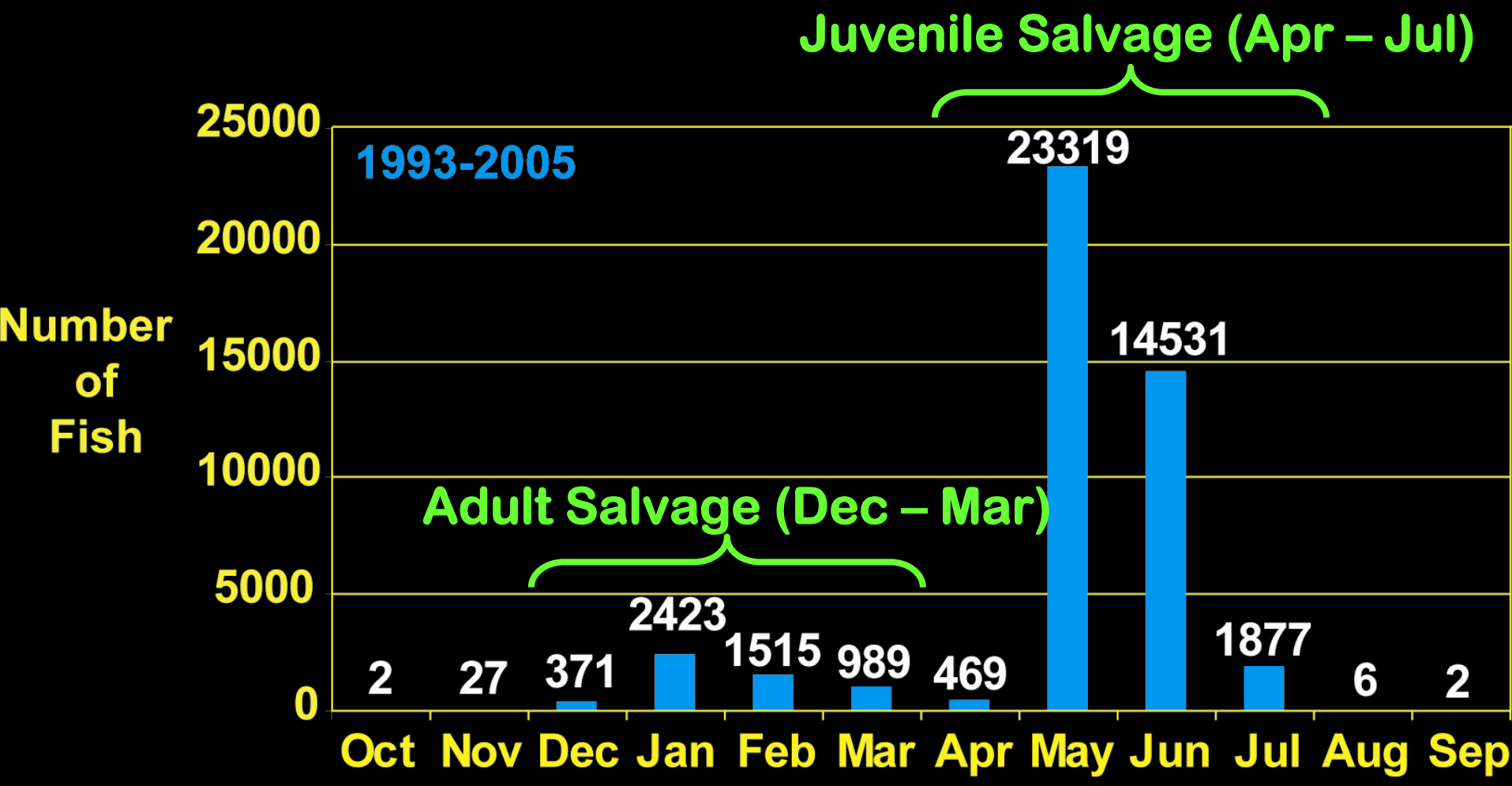
- Delta smelt salvage data
- Old and Middle River flow as as a predictor of salvage
- Adult entrainment estimates from salvage data
- Adult entrainment estimates from 3D particle-tracking model
- Checking estimates of entrainment against the SKT data

South Delta Fish Facilities

Skinner Fish Facility (DWR)

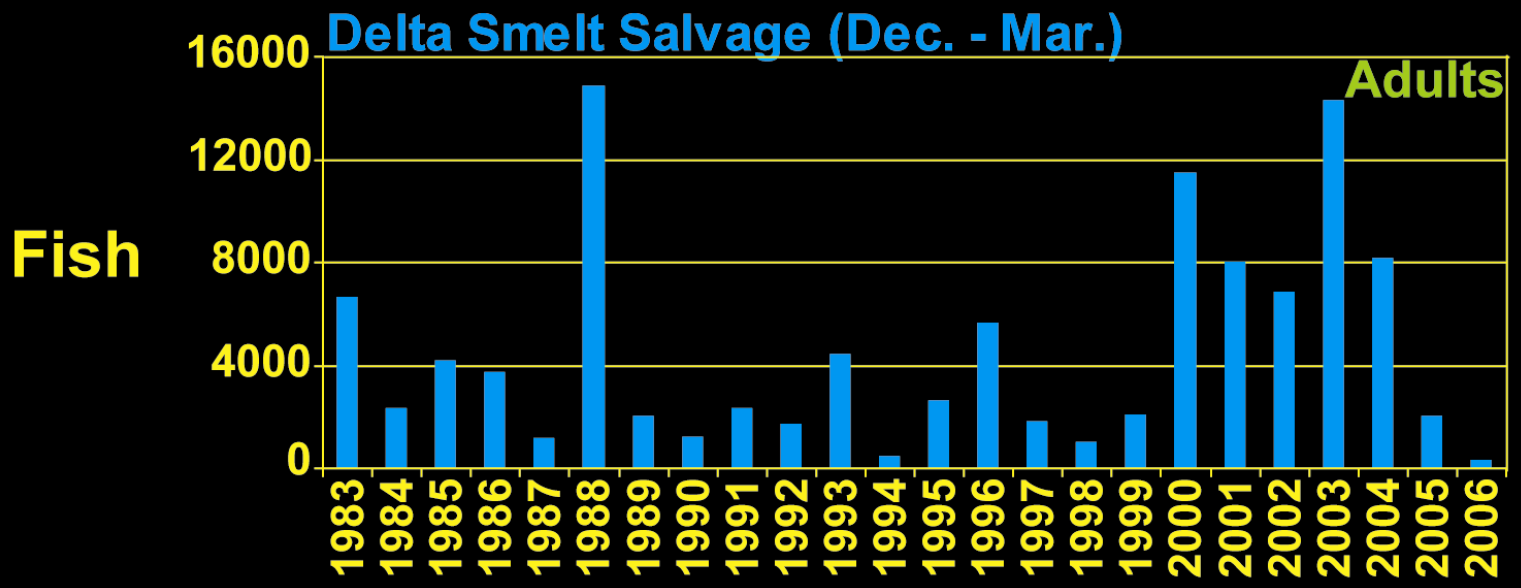
Tracy Fish Facility (USBR)

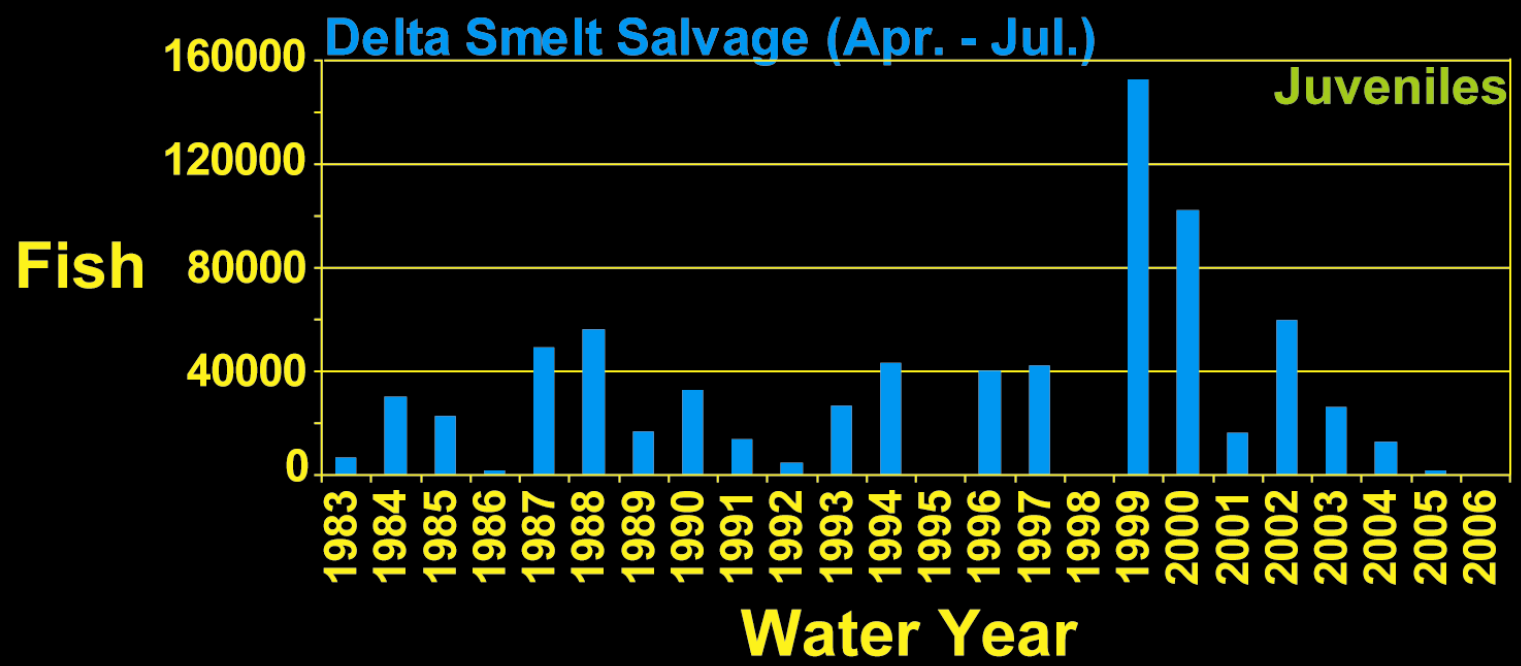
Average Delta Smelt Salvage by Month



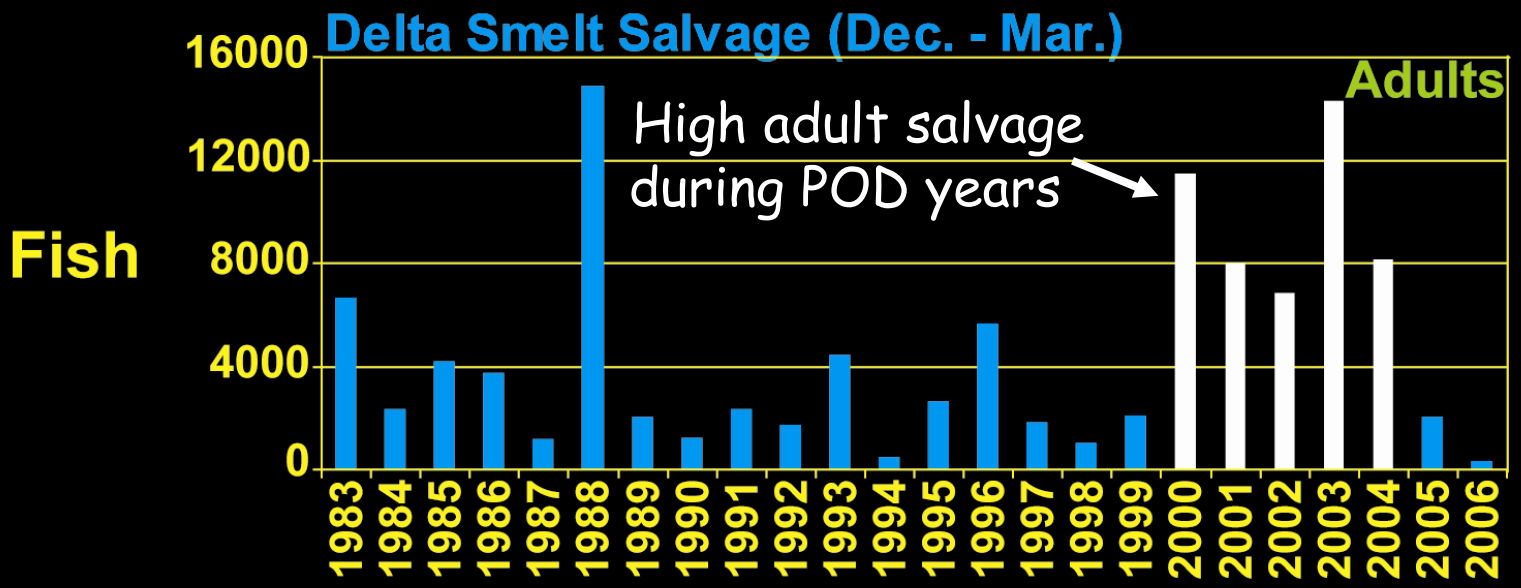
Note: Only fish 20 millimeters or larger are counted in salvage

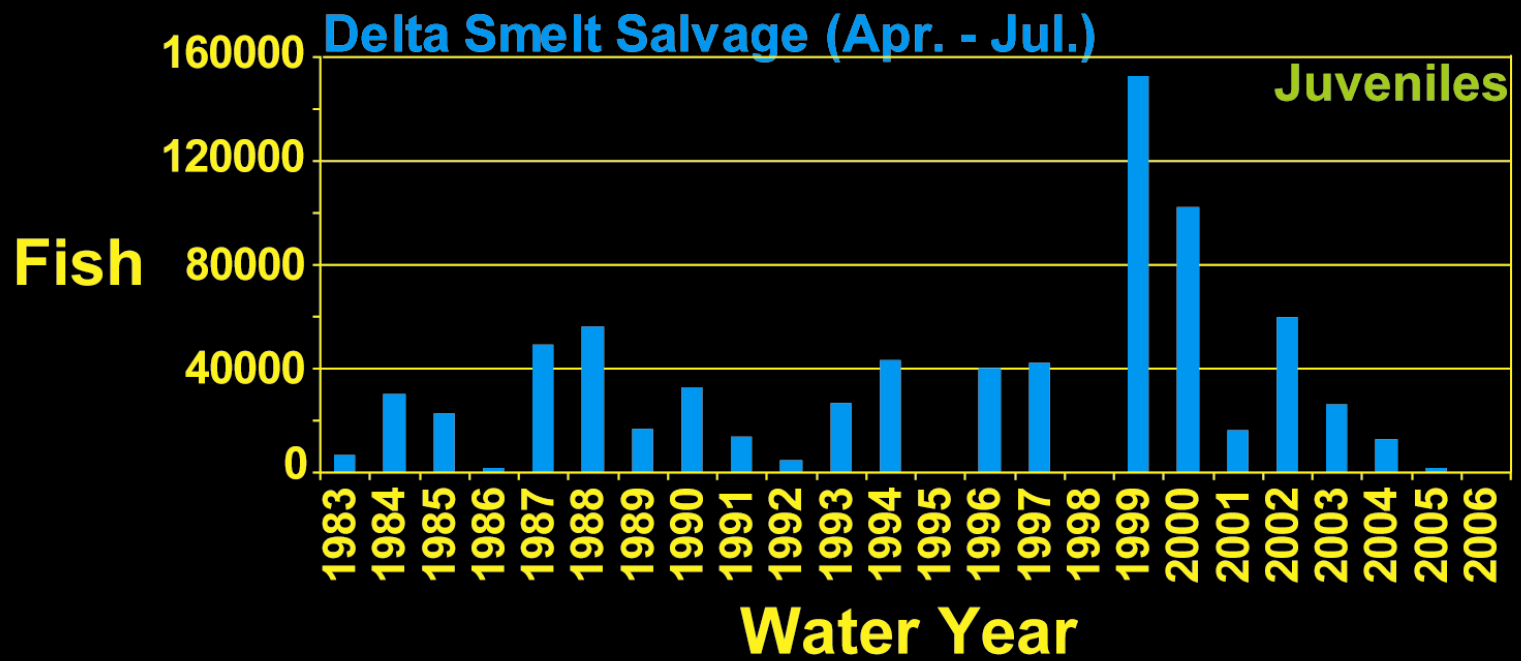
24-Year Trends in Delta Smelt Salvage



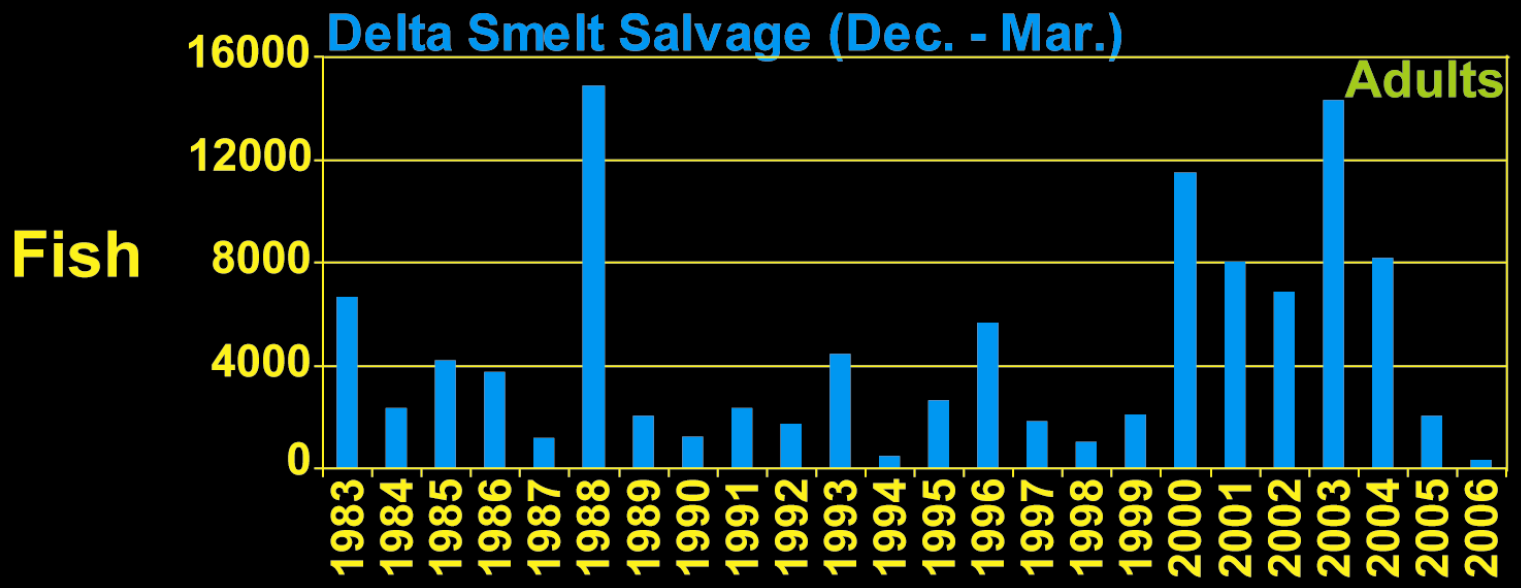


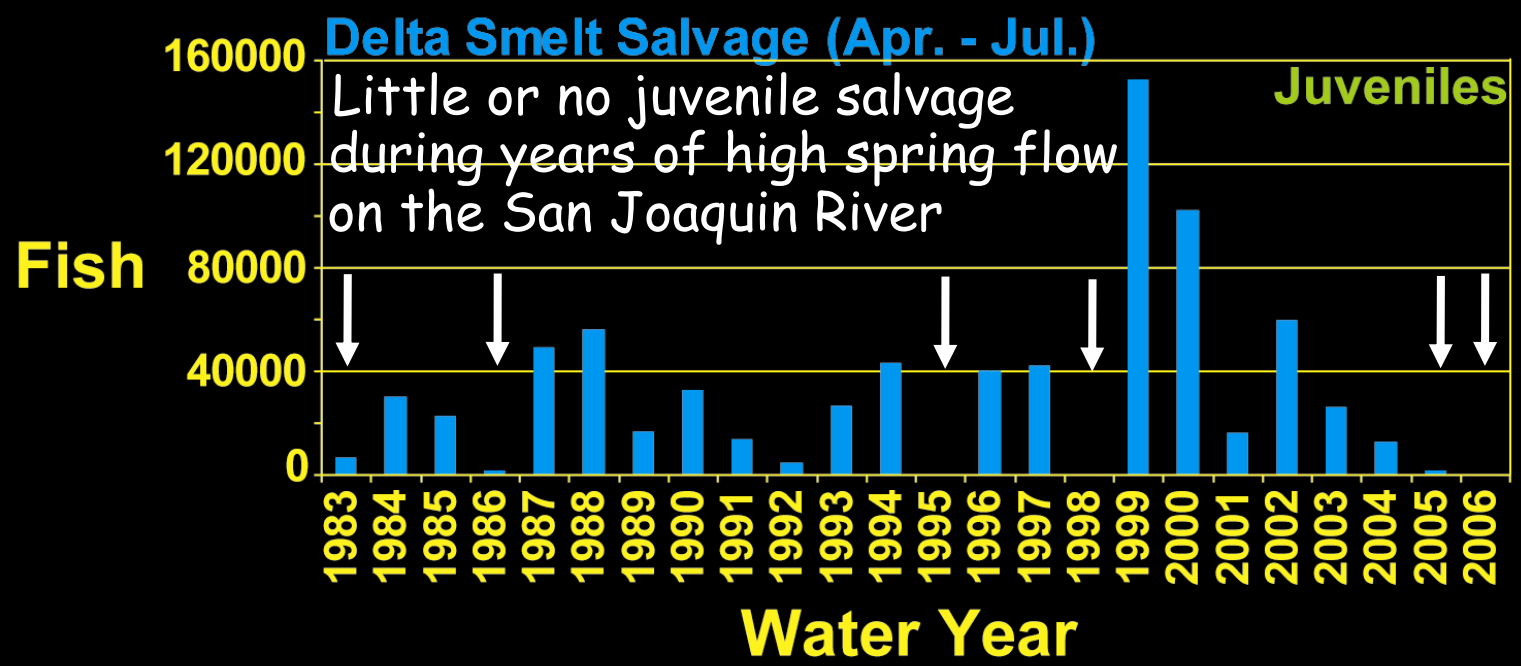
24-Year Trends in Delta Smelt Salvage

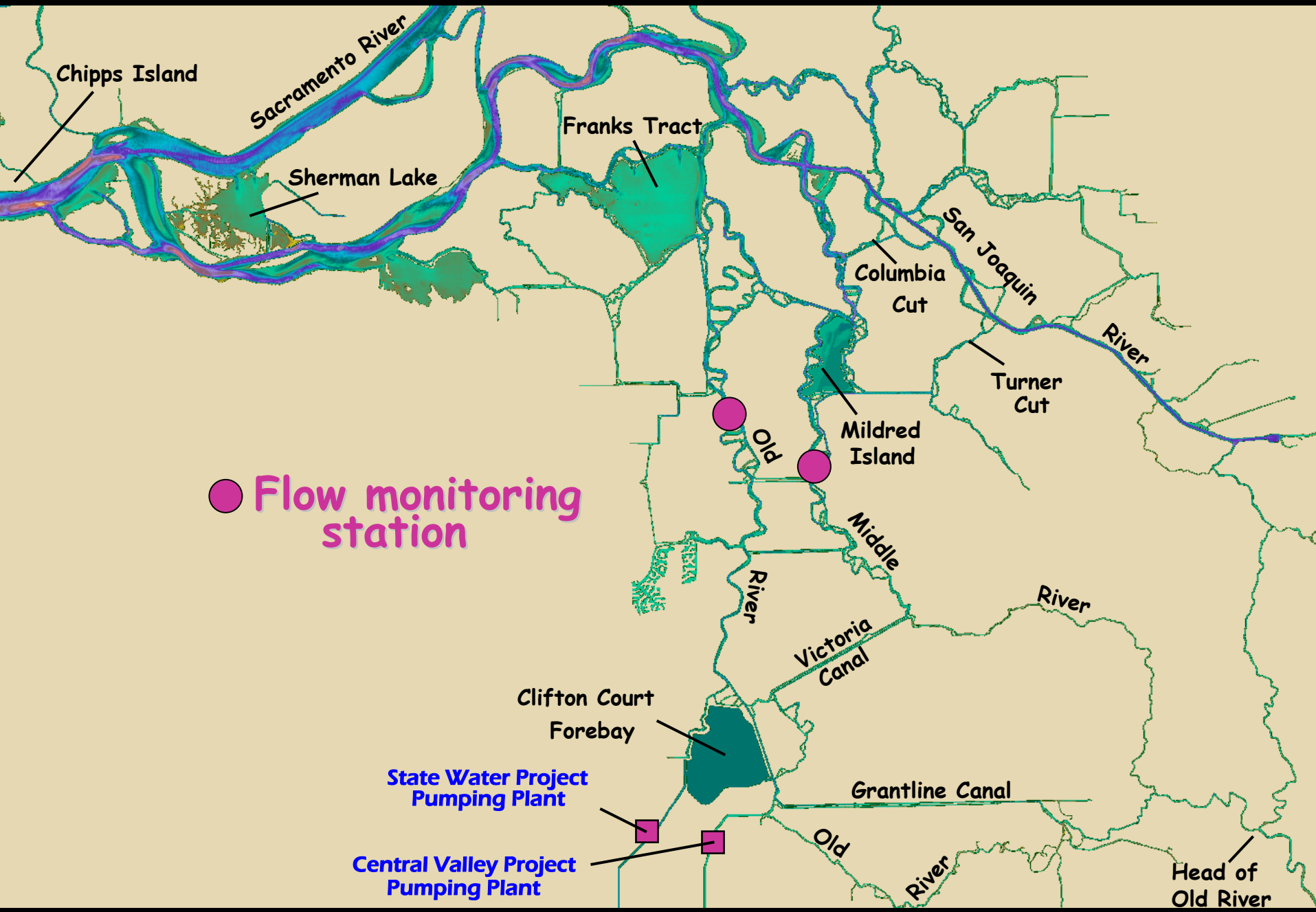




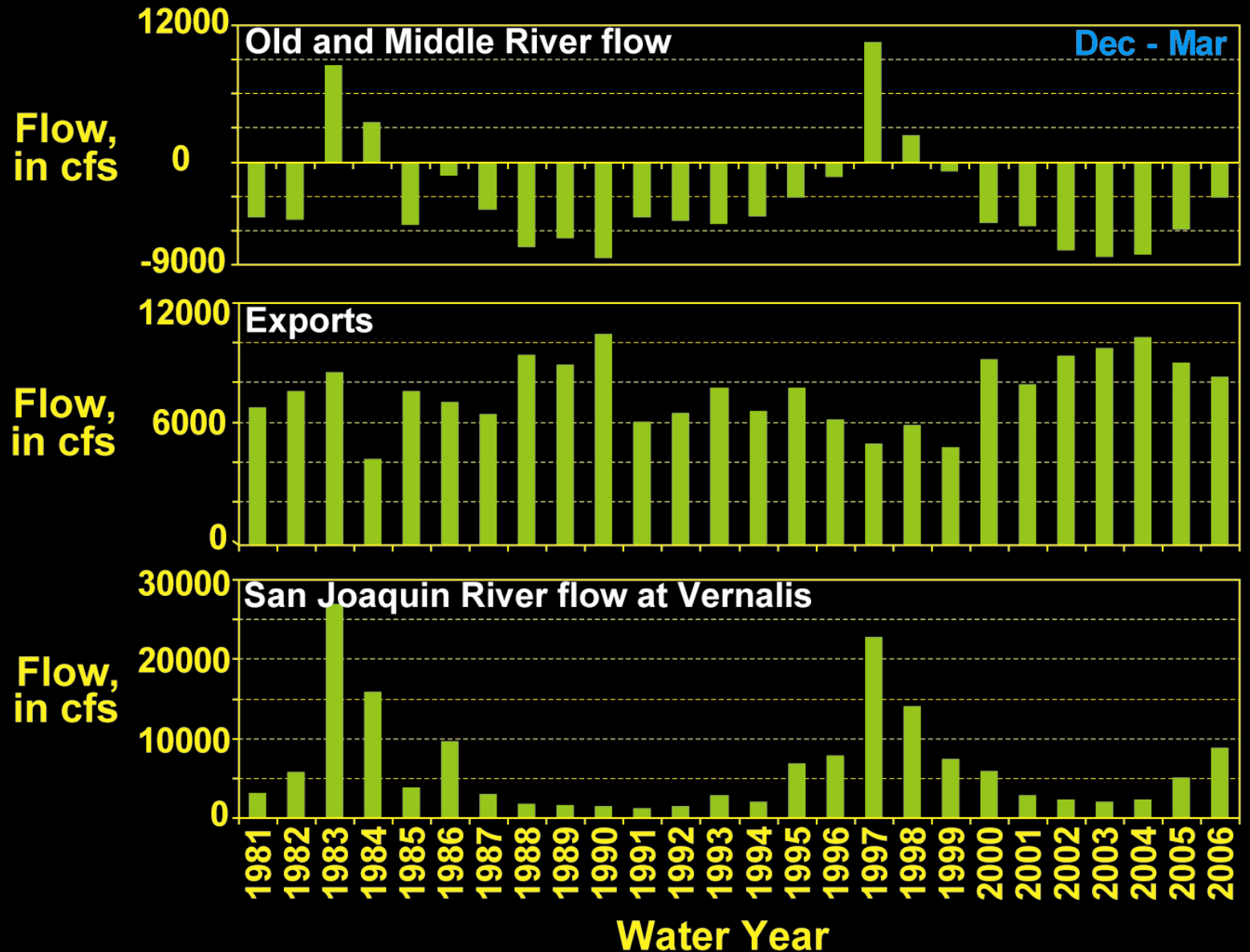
24-Year Trends in Delta Smelt Salvage



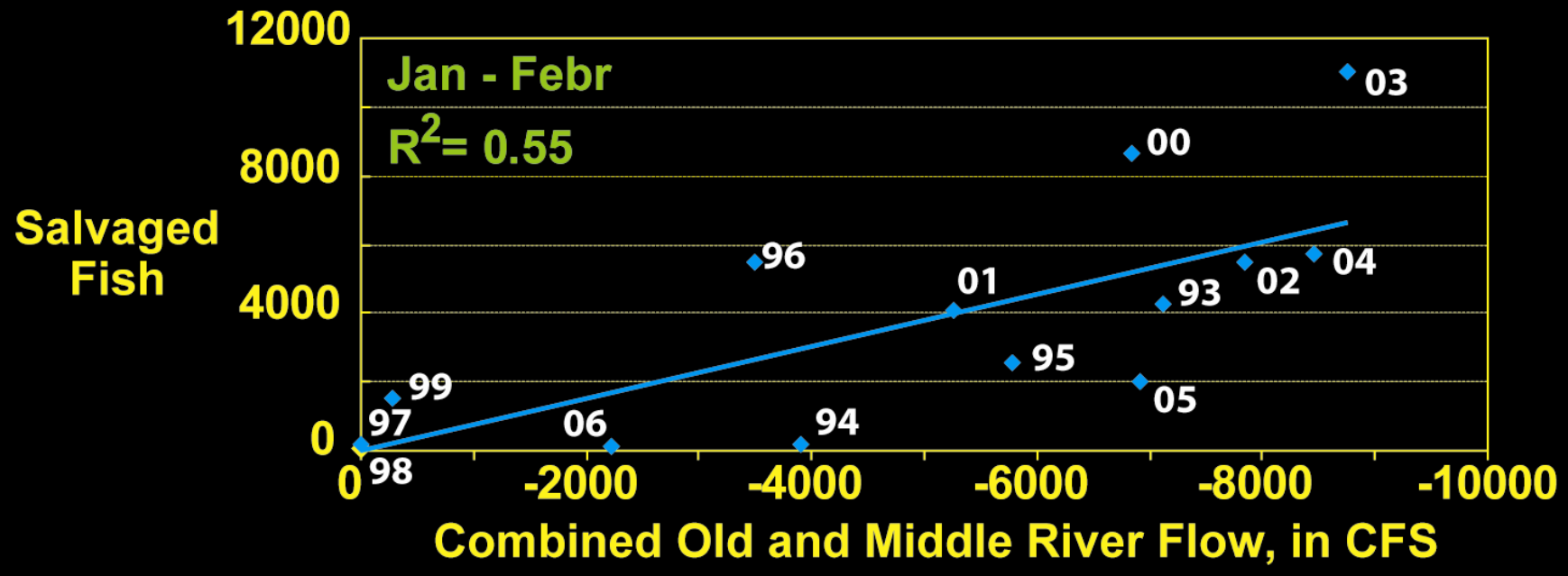


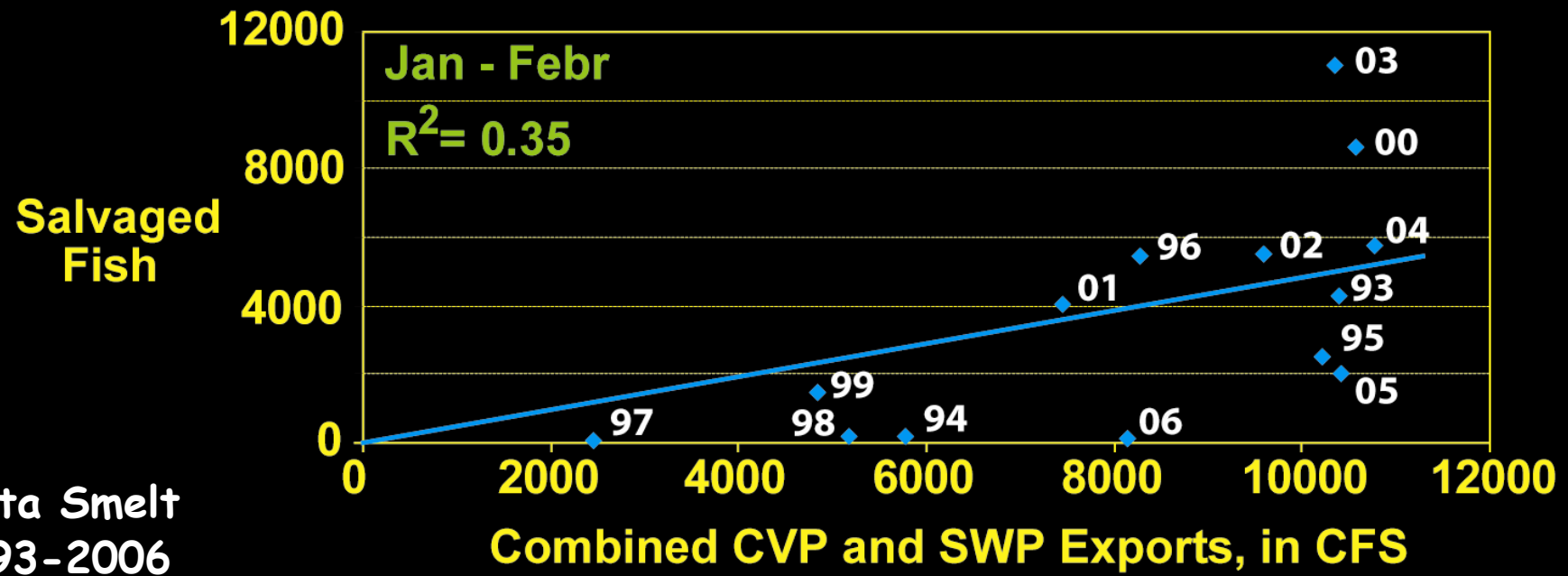

Chipps Island
Sacramento River
Sherman Lake
Franks Tract
San Joaquin
River
Columbia
Cut
Turner
Cut
Mildred
Island
Old
Middle
River
Flow monitoring
station
River
Victoria
Canal
Clifton Court
Forebay
State Water Project
Pumping Plant
Central Valley Project
Pumping Plant
Grantline Canal
Old
River
Head of
Old River

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



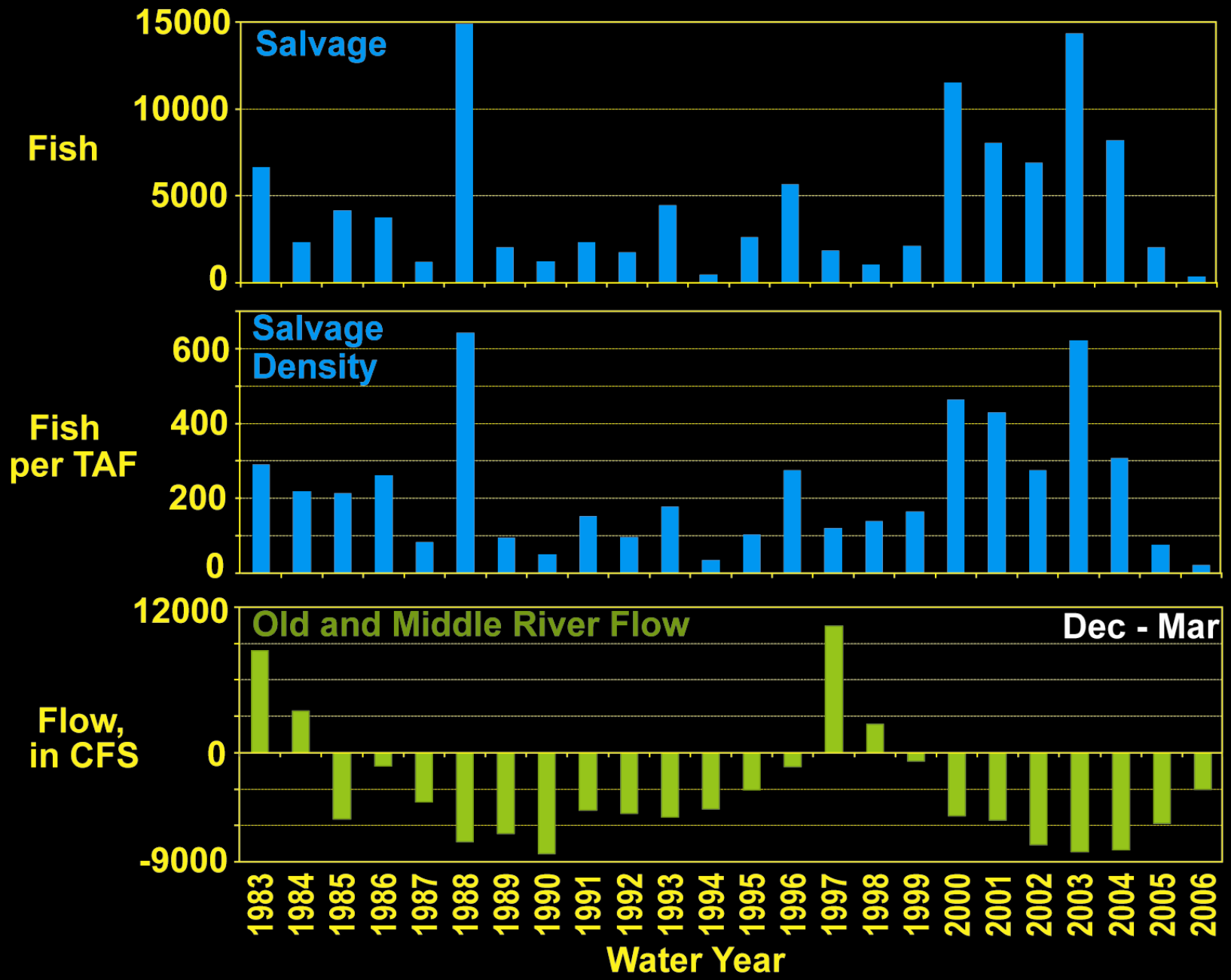
Winter Salvage versus Flow Regressions



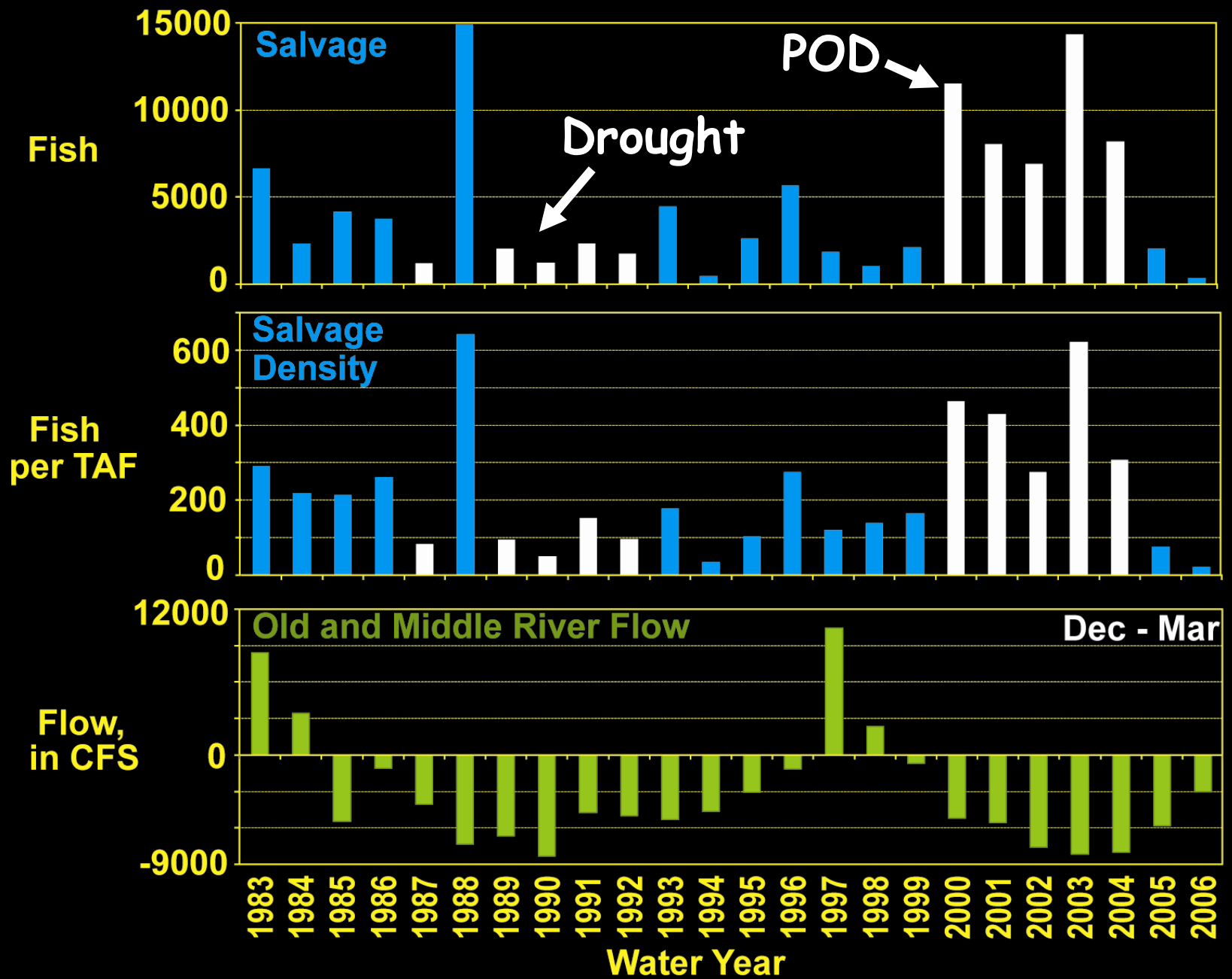


Delta Smelt
1993-2006

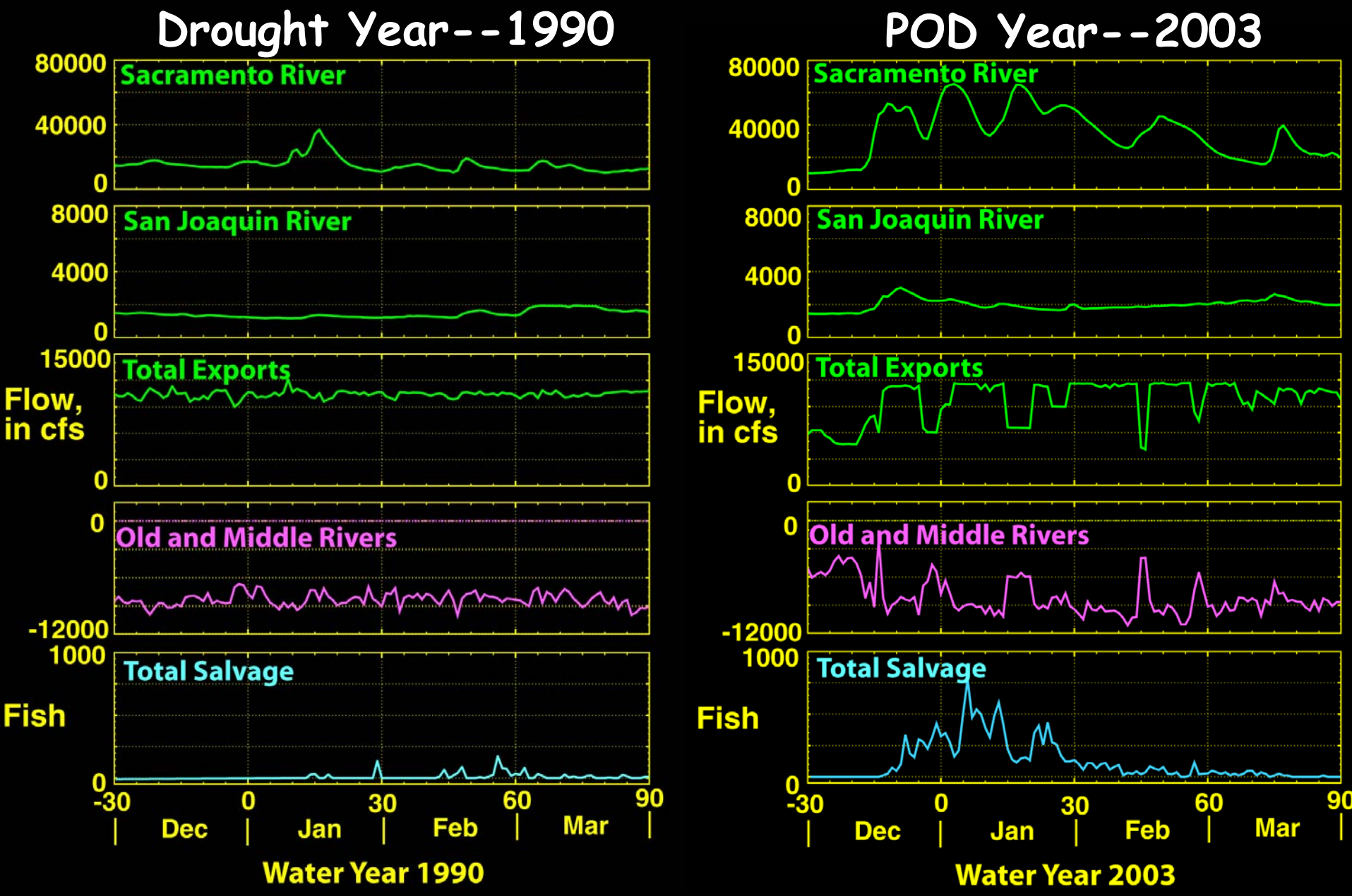
Winter Delta Smelt Salvage and Flows



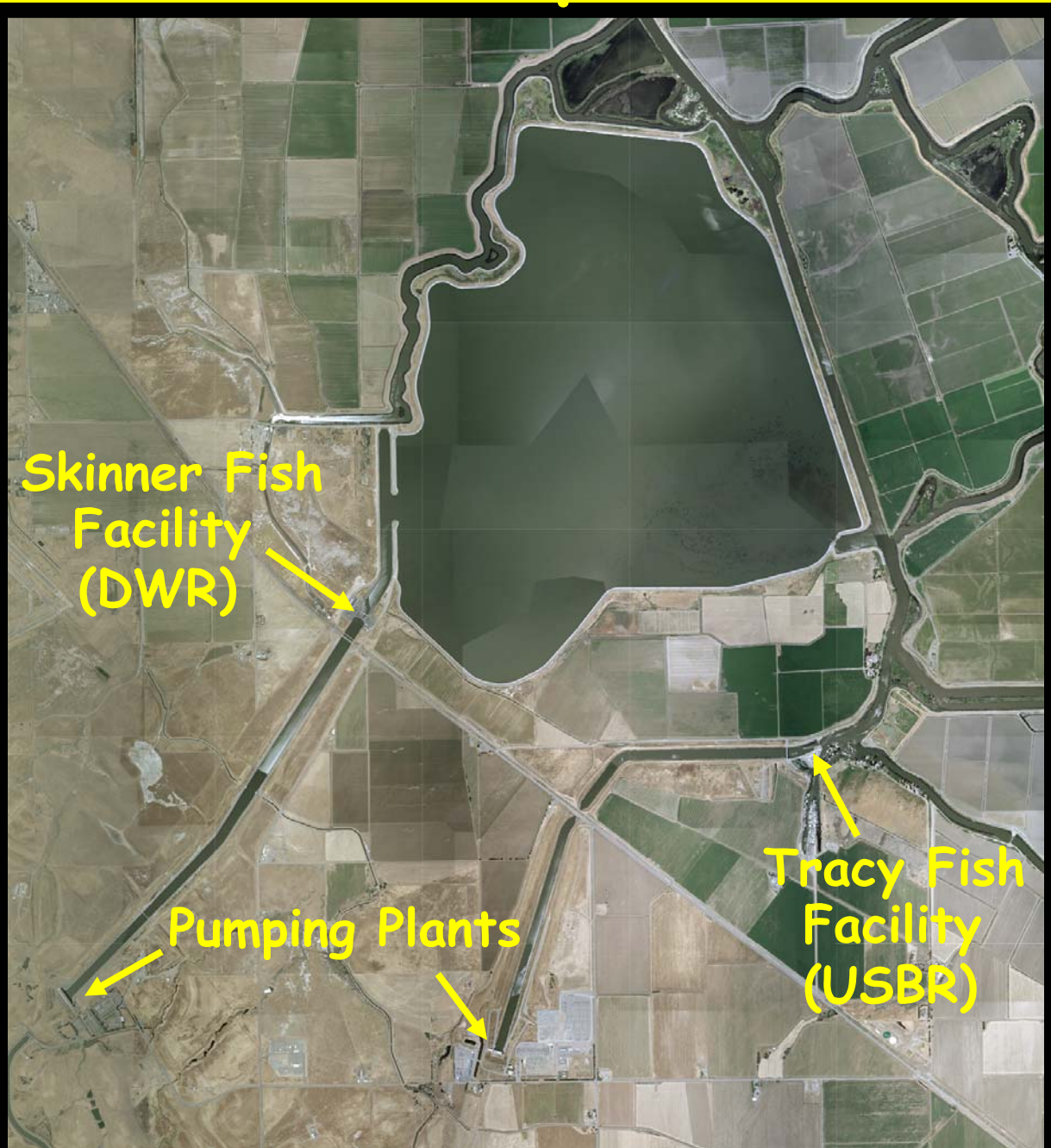
Winter Delta Smelt Salvage and Flows

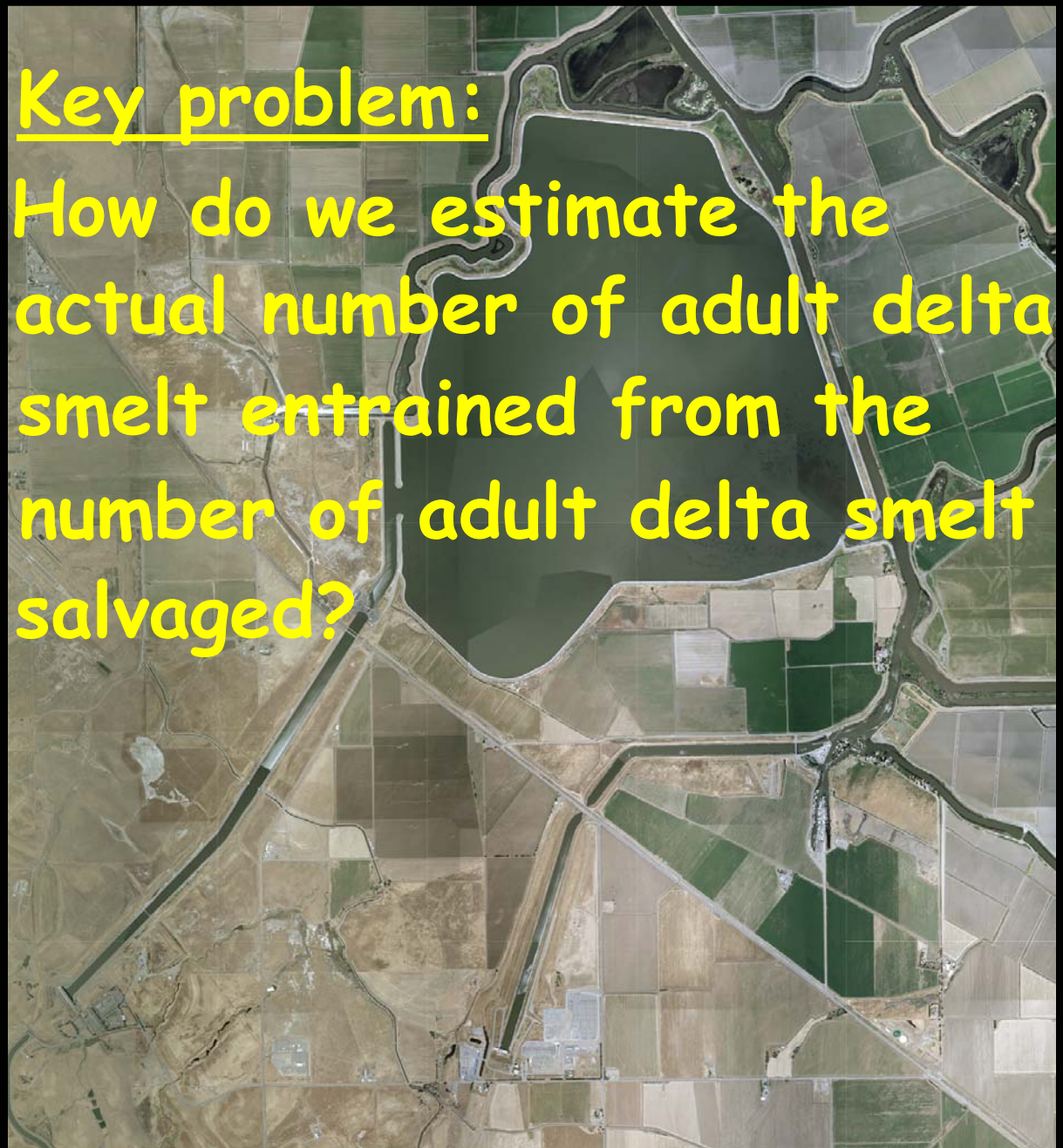


Comparison of 1990 and 2003



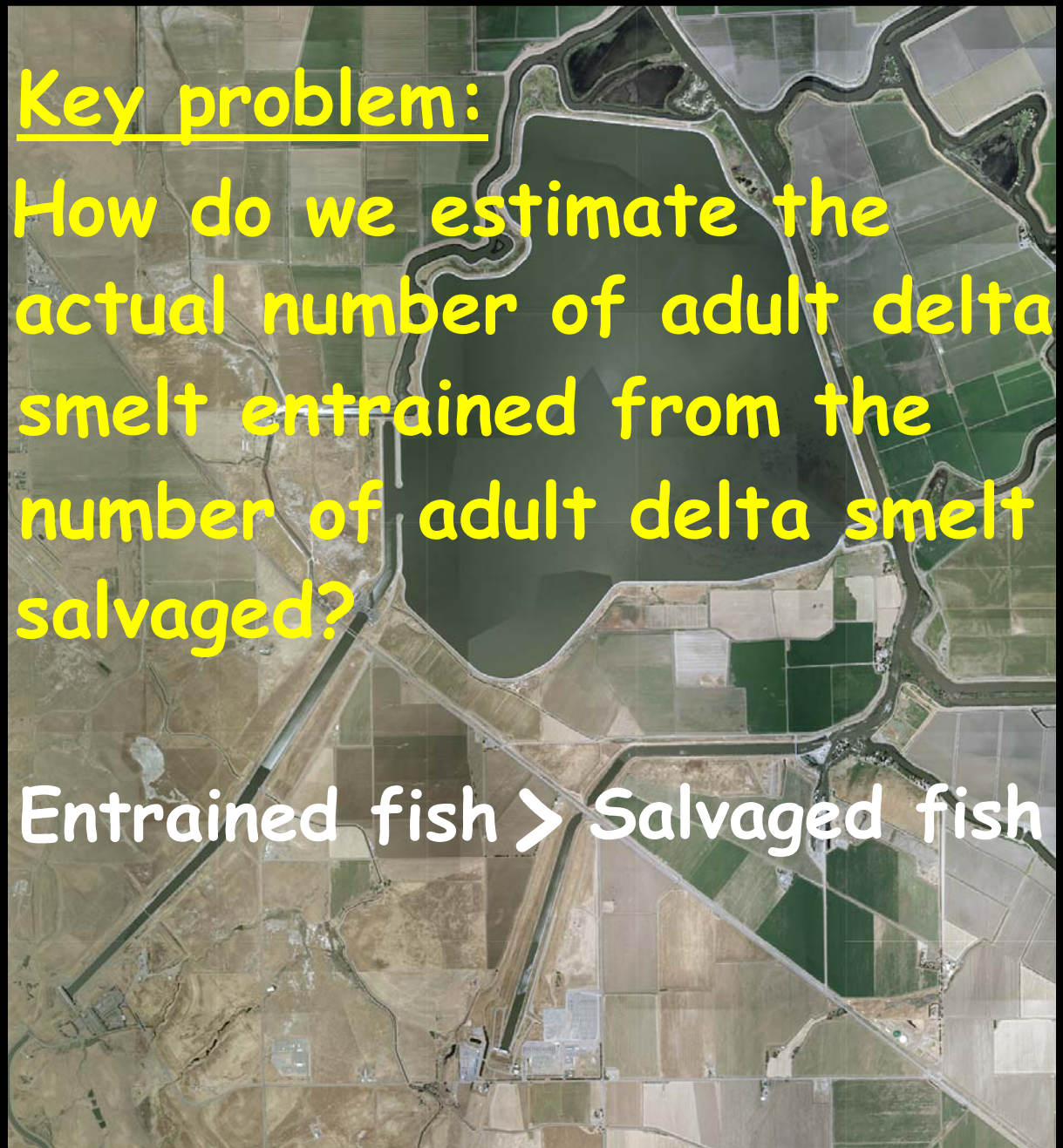
South Delta Export Facilities





Key problem:

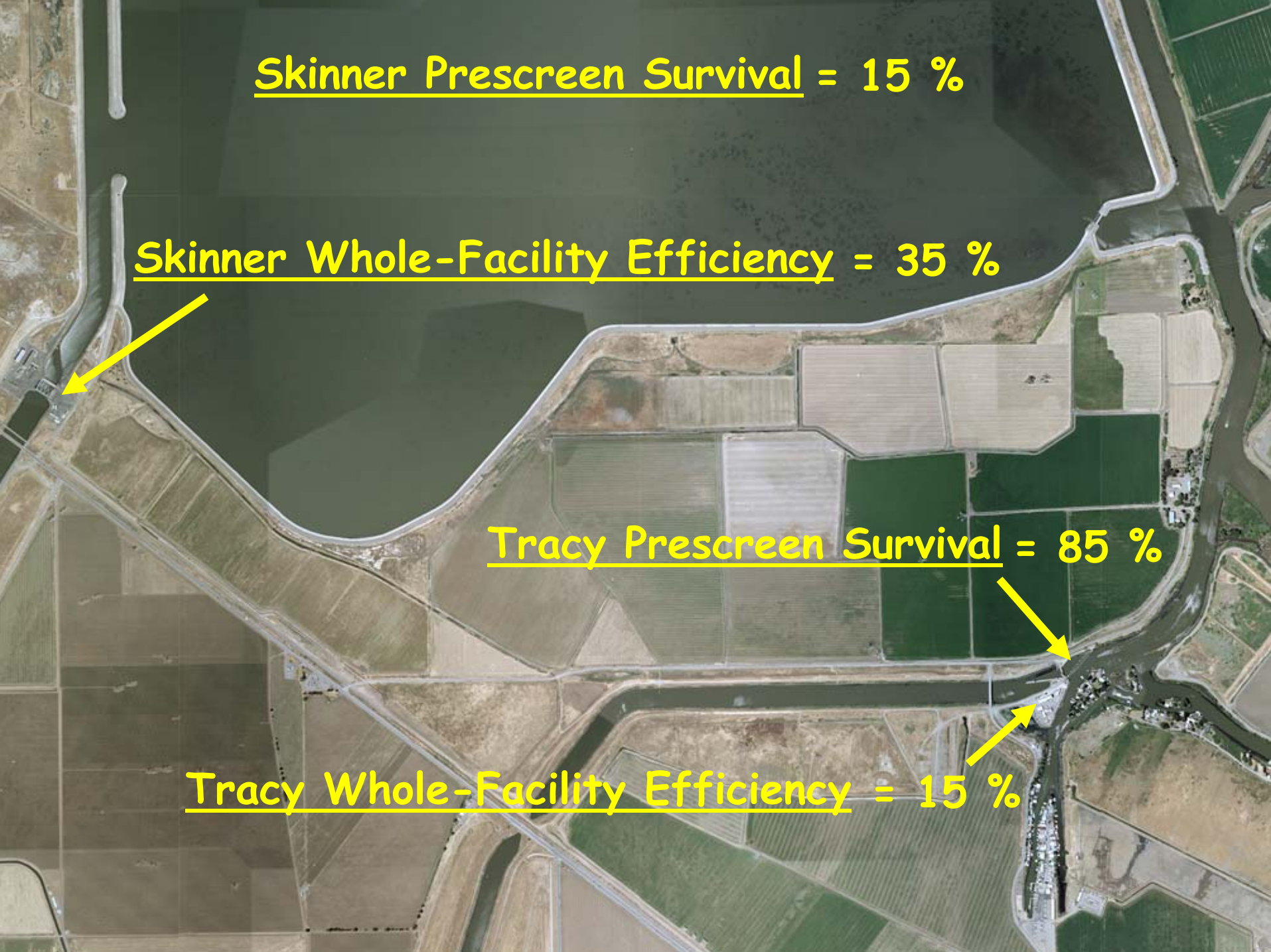
How do we estimate the actual number of adult delta smelt entrained from the number of adult delta smelt salvaged?



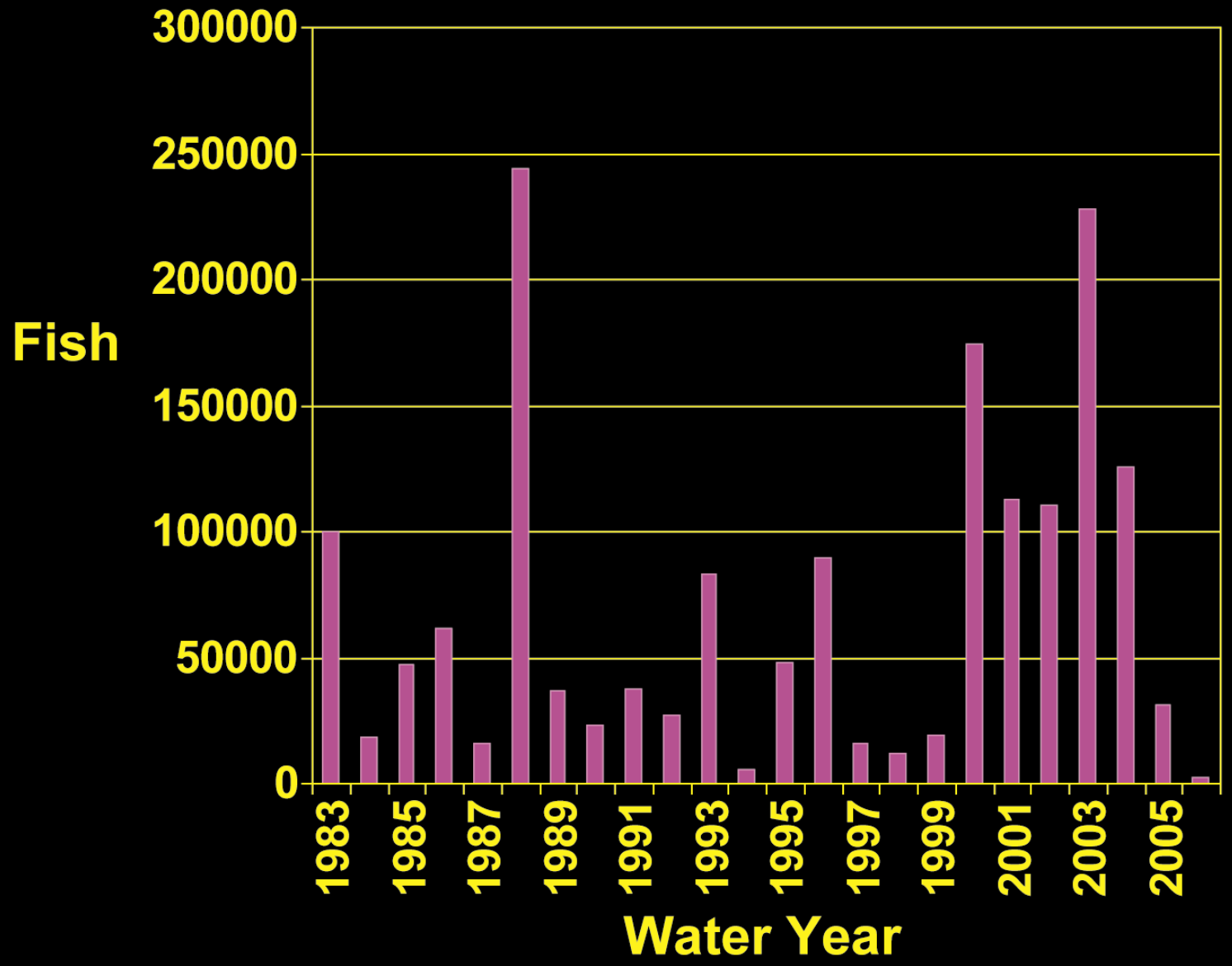
Key problem:

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

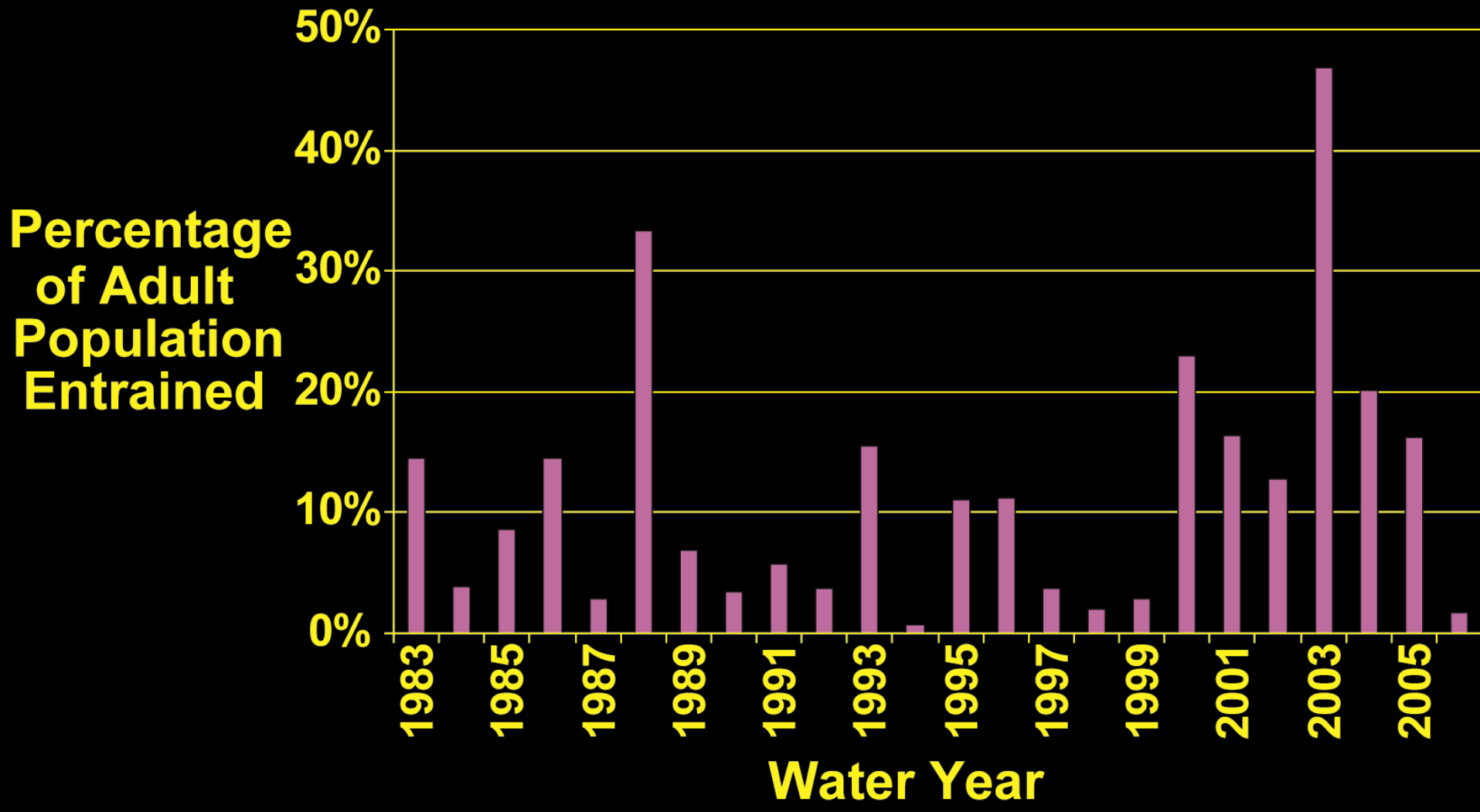
Entrained fish > Salvaged fish


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



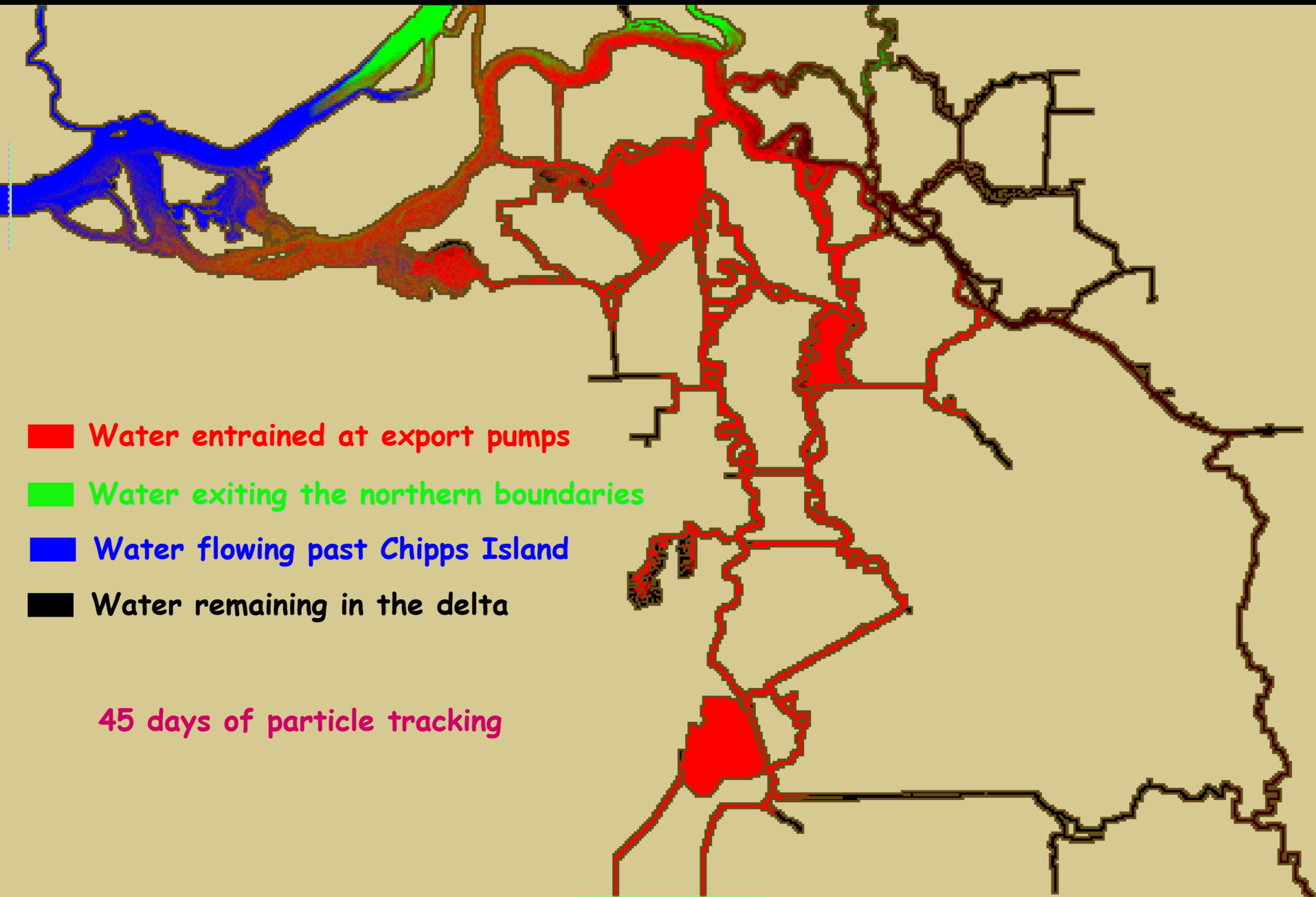
Adult Delta Smelt Entrainment Estimates in Percentage of Population



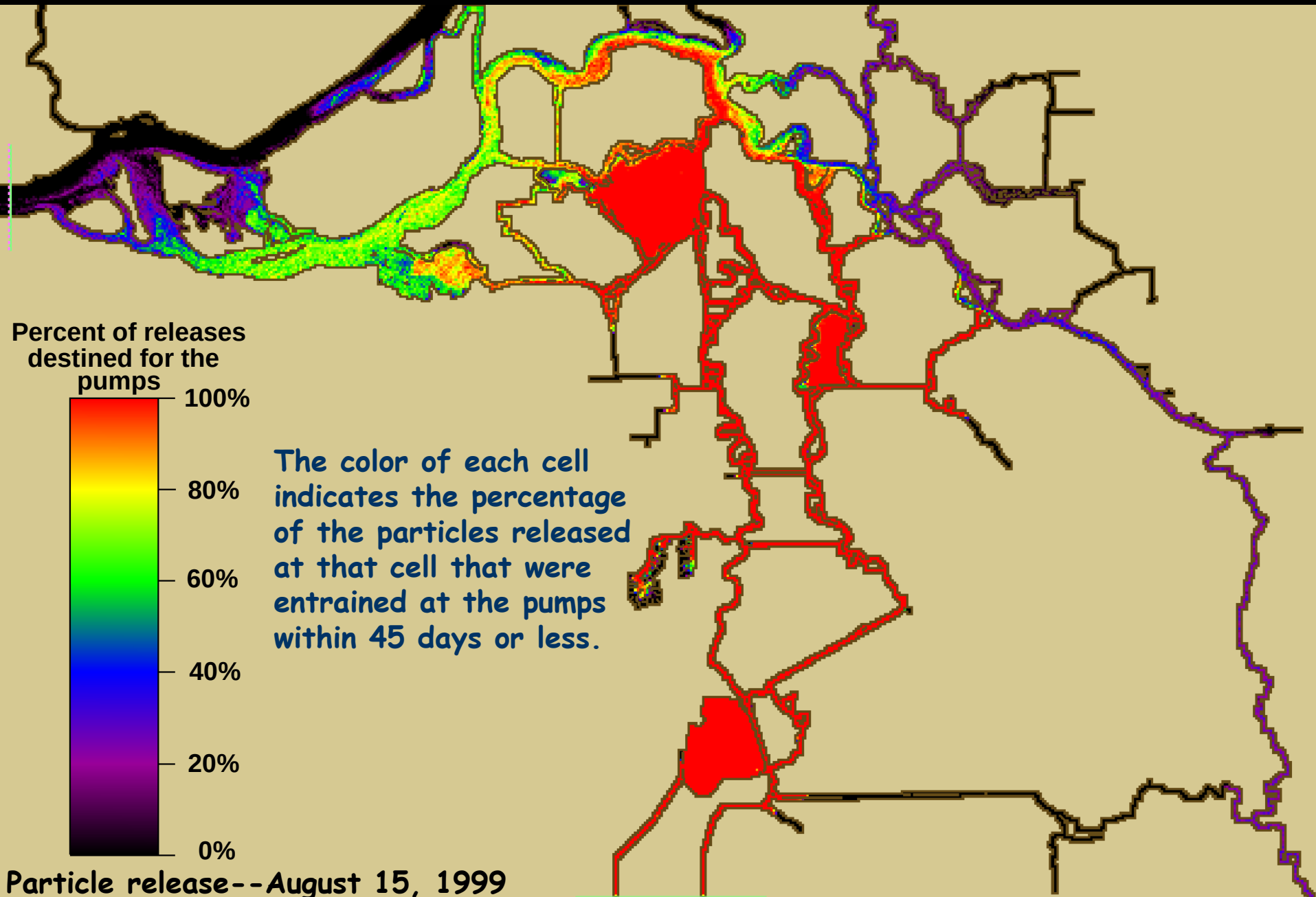
Note: Population estimates taken from Miller(2005)

Are these entrainment estimates reasonable?

Zone of Entrainment – Aug 15, 1999

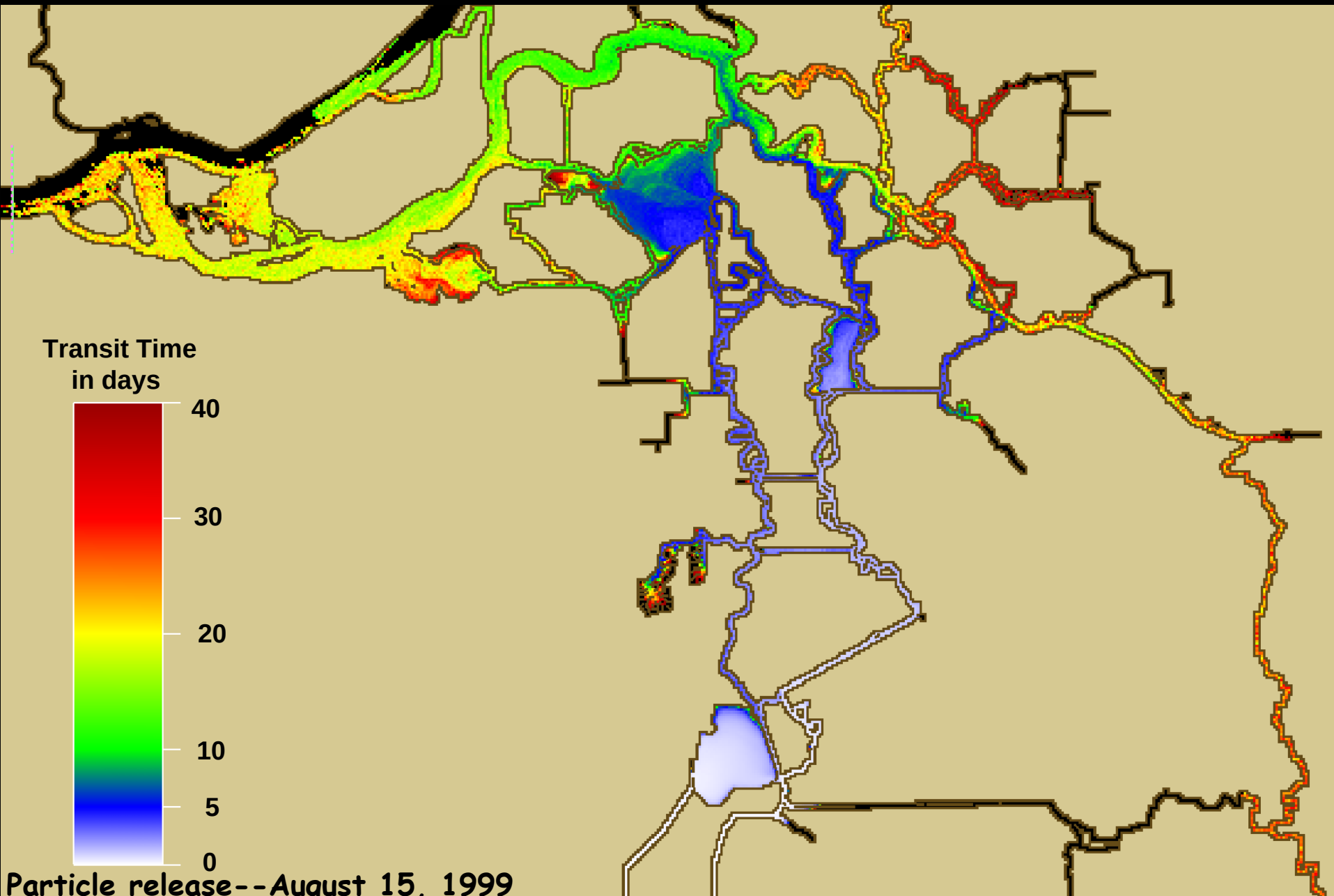


Percent of Particles Entrained at Pumps within 45 days



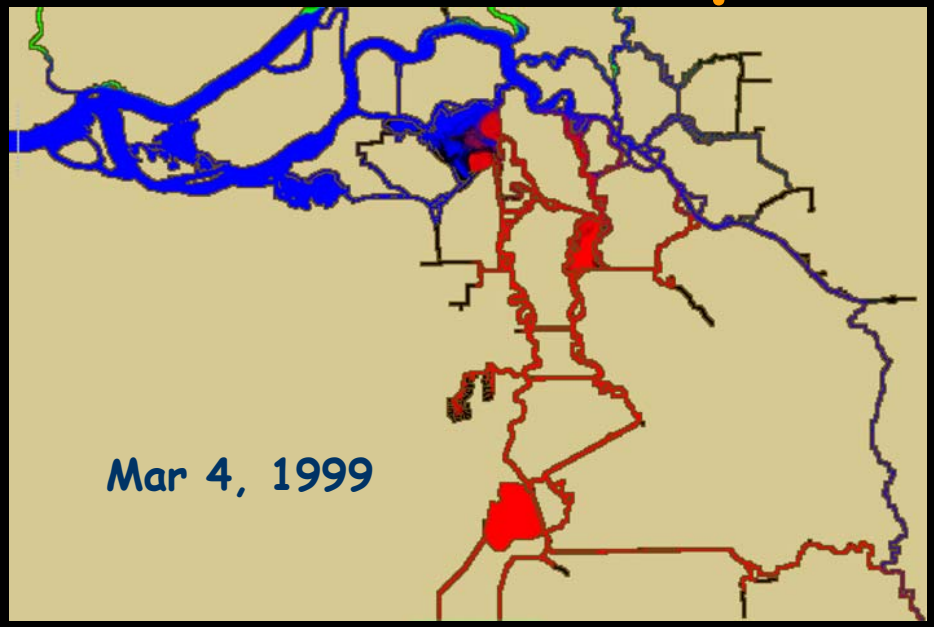
Particle release--August 15, 1999

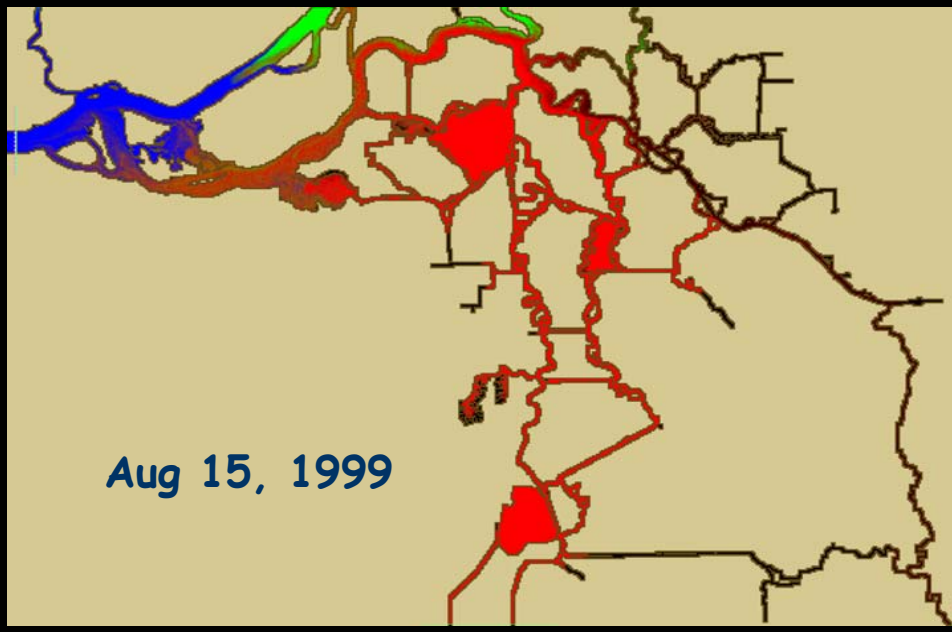
Transit Time of Particles Entrained at Pumps

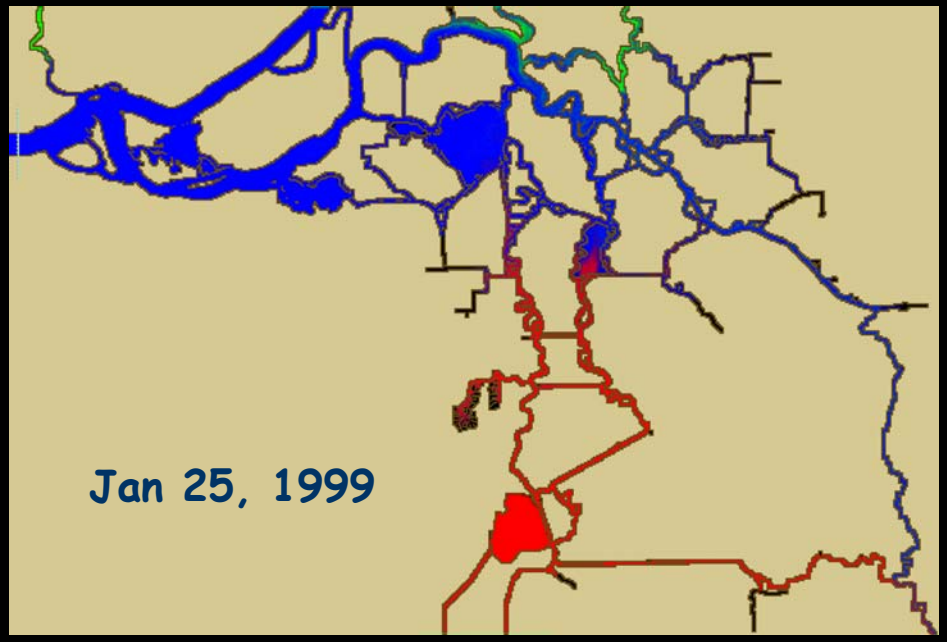


Particle release--August 15, 1999

Compare ZOEs







Water entrained at export pumps

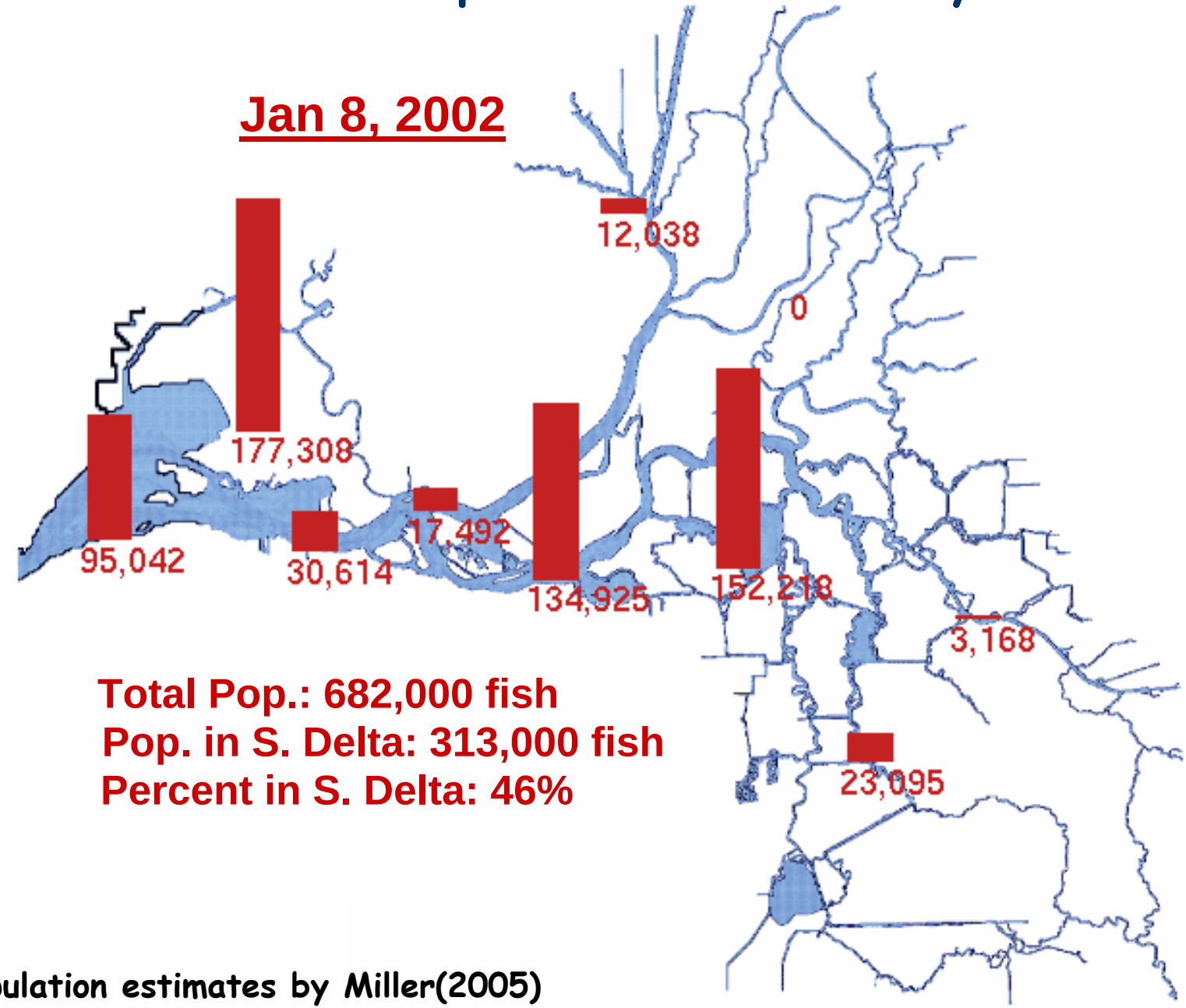
Water exiting the northern boundaries

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

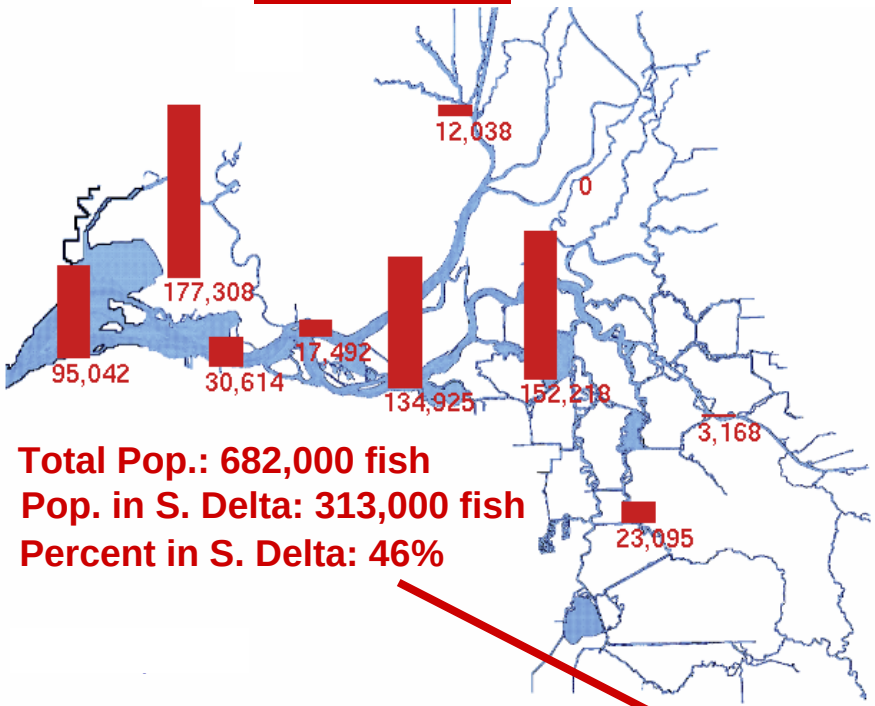


Total Pop.: 682,000 fish
Pop. in S. Delta: 313,000 fish
Percent in S. Delta: 46%

Note: Population estimates by Miller(2005)

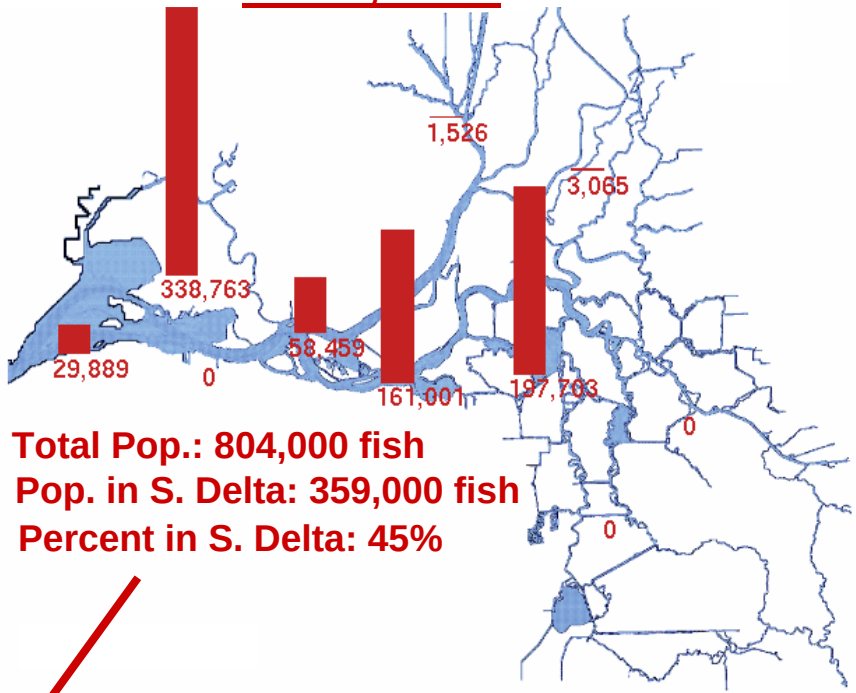
2002 Spring Kodiak Trawl Surveys and Salvage

Jan 8, 2002

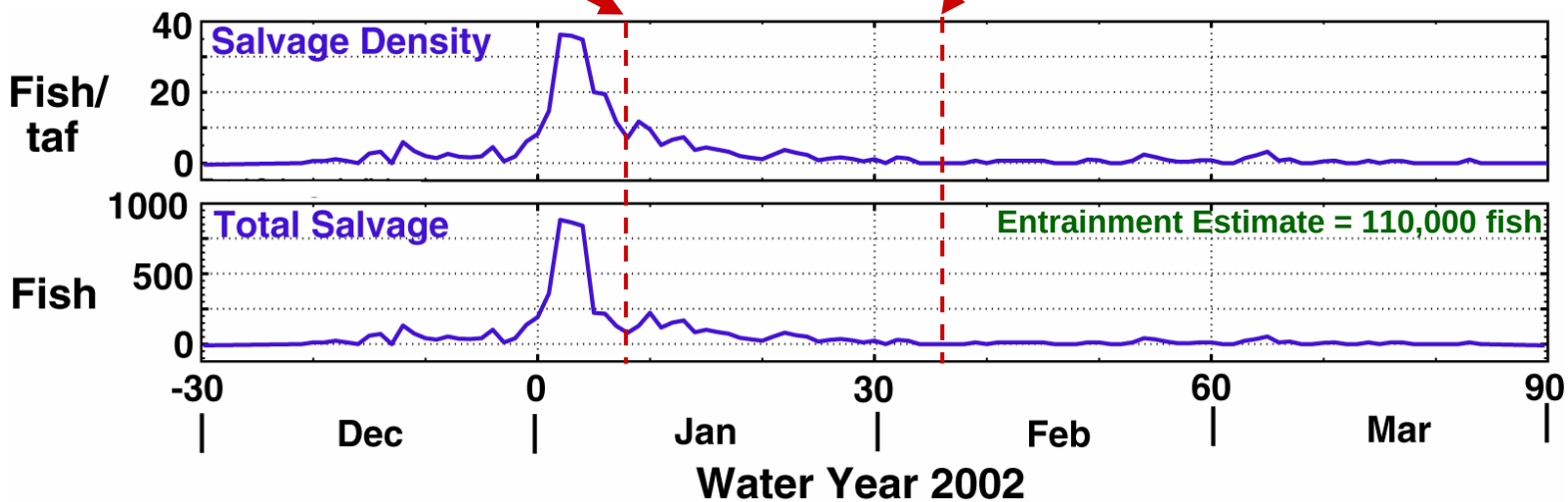


Total Pop.: 682,000 fish
Pop. in S. Delta: 313,000 fish
Percent in S. Delta: 46%

Feb 6, 2002

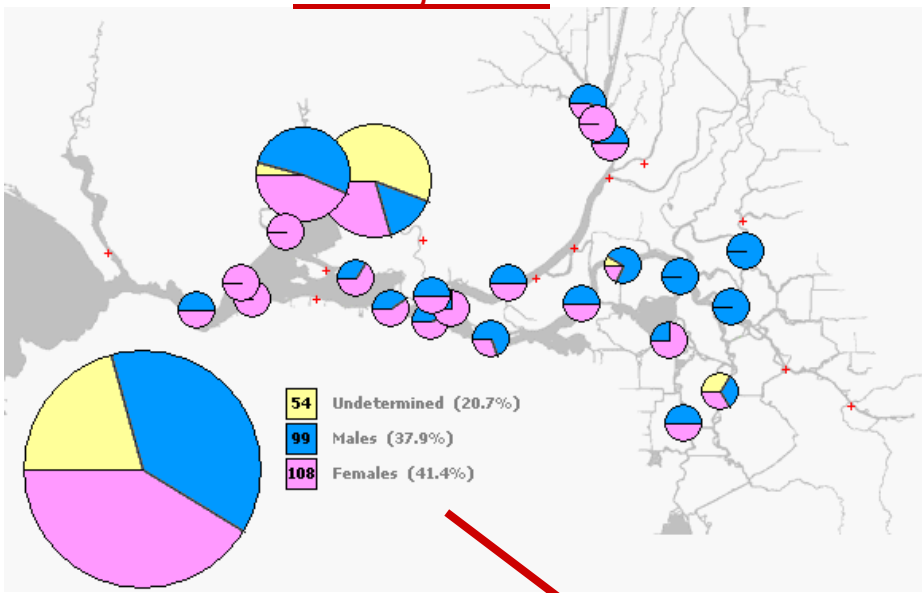


Total Pop.: 804,000 fish
Pop. in S. Delta: 359,000 fish
Percent in S. Delta: 45%

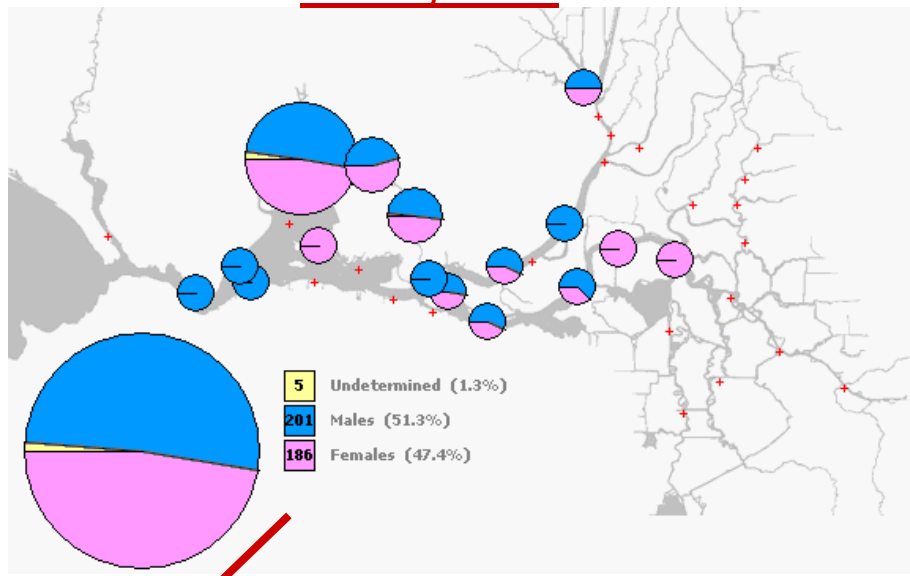


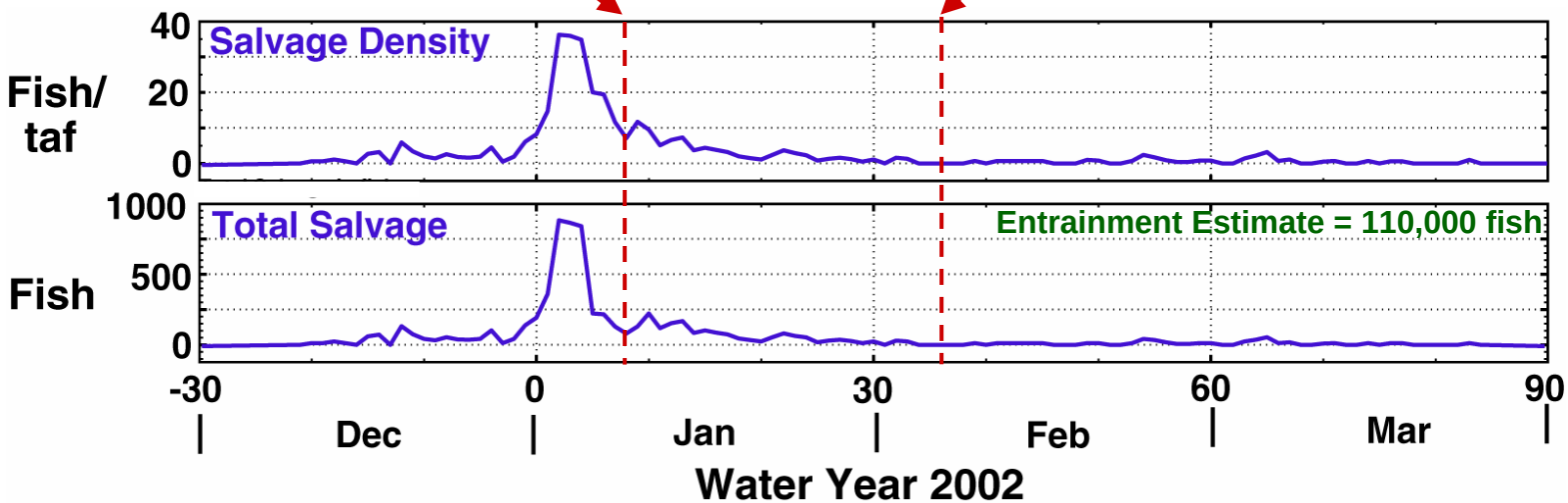
2002 Spring Kodiak Trawl Surveys and Salvage

Jan 8, 2002

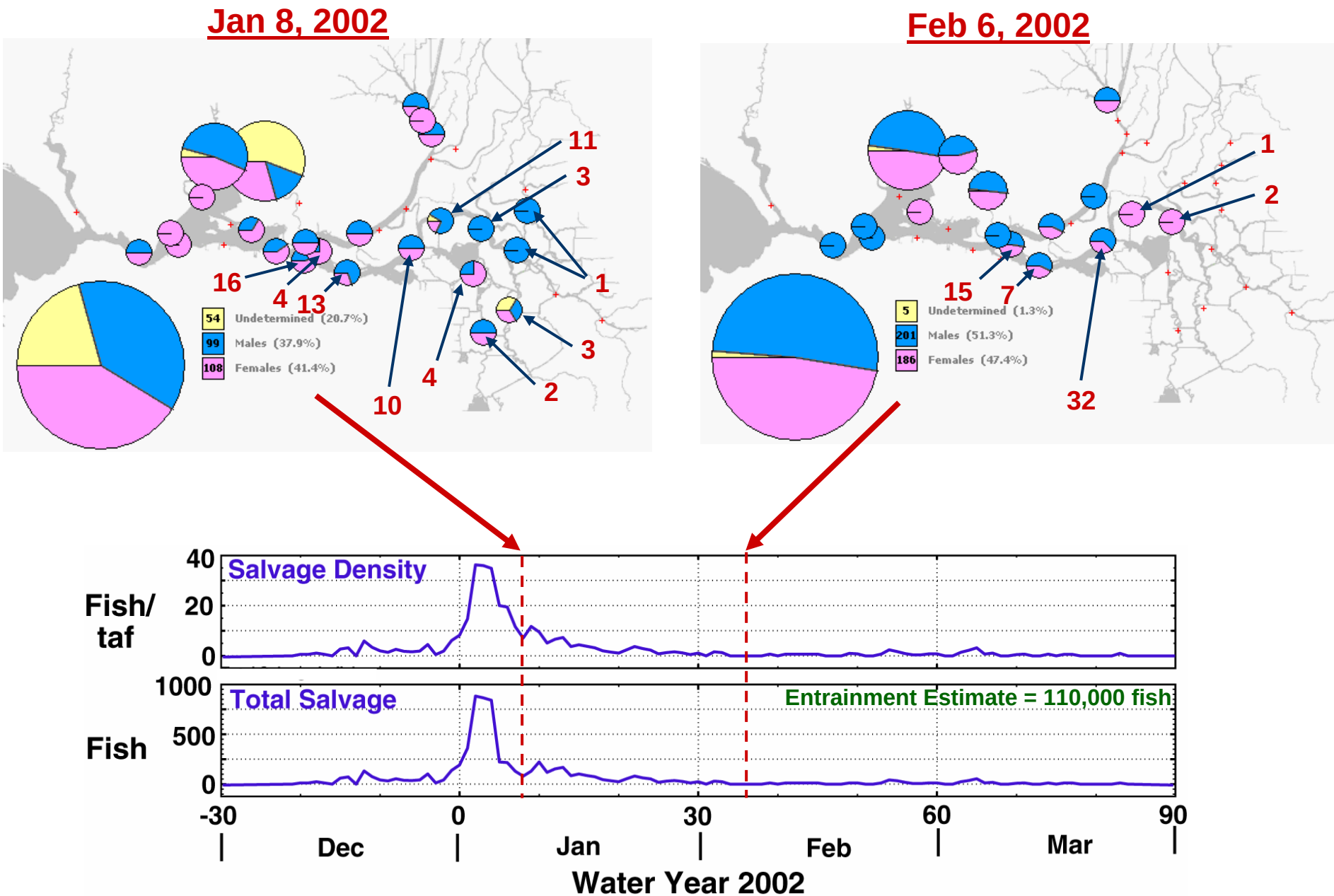


Feb 6, 2002

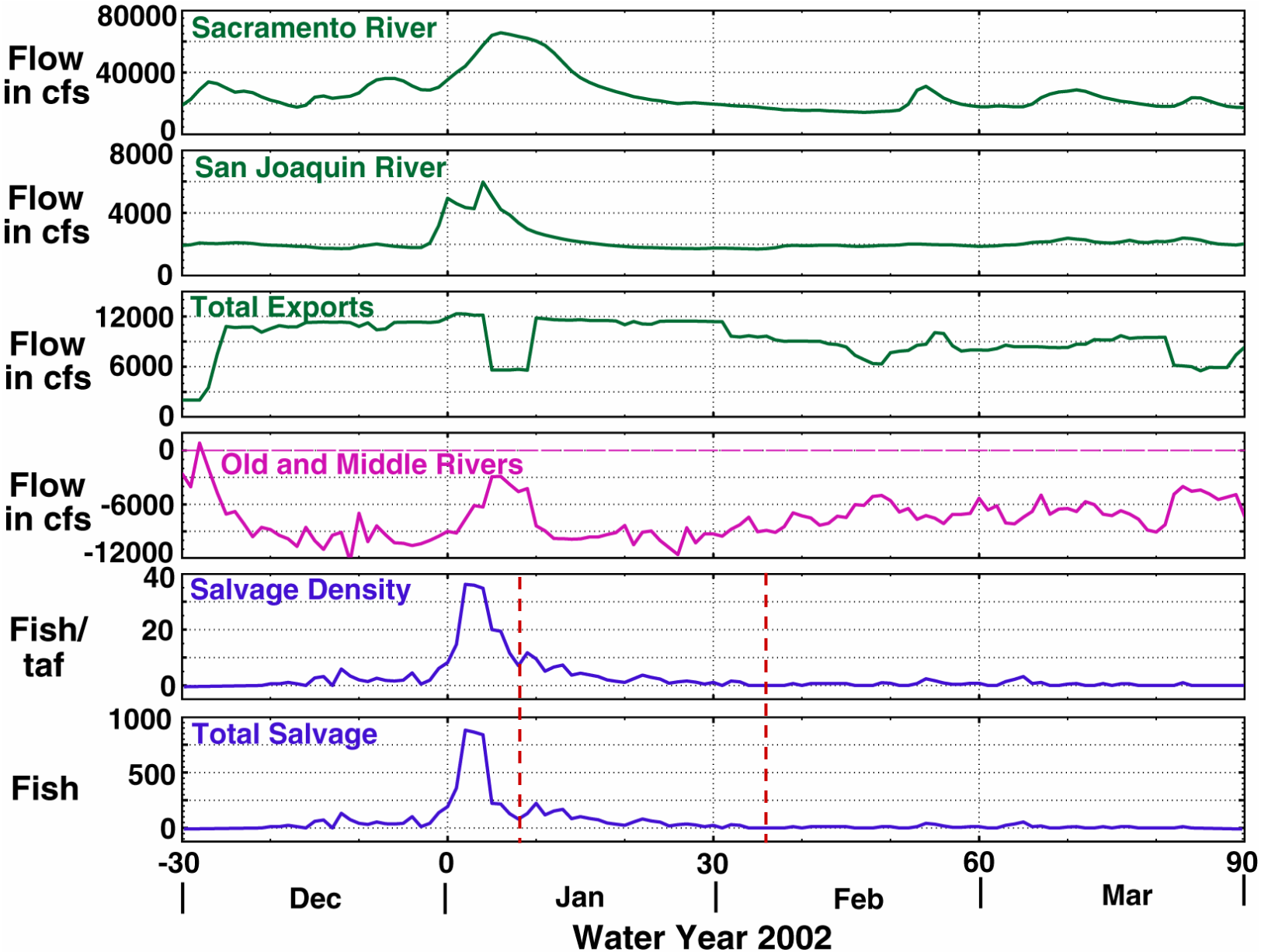




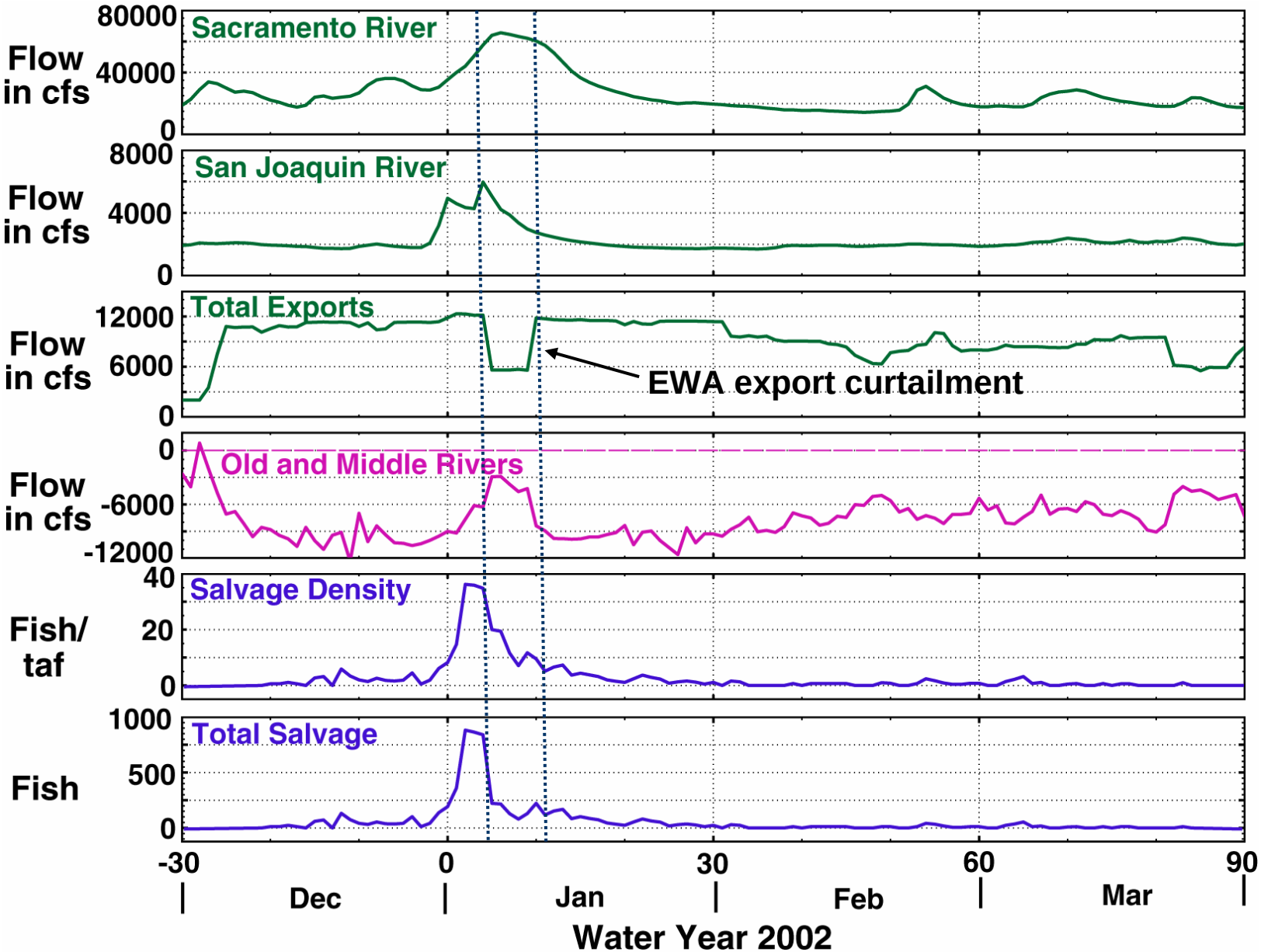
2002 Spring Kodiak Trawl Surveys and Salvage



Winter 2002 Delta Flows and Salvage

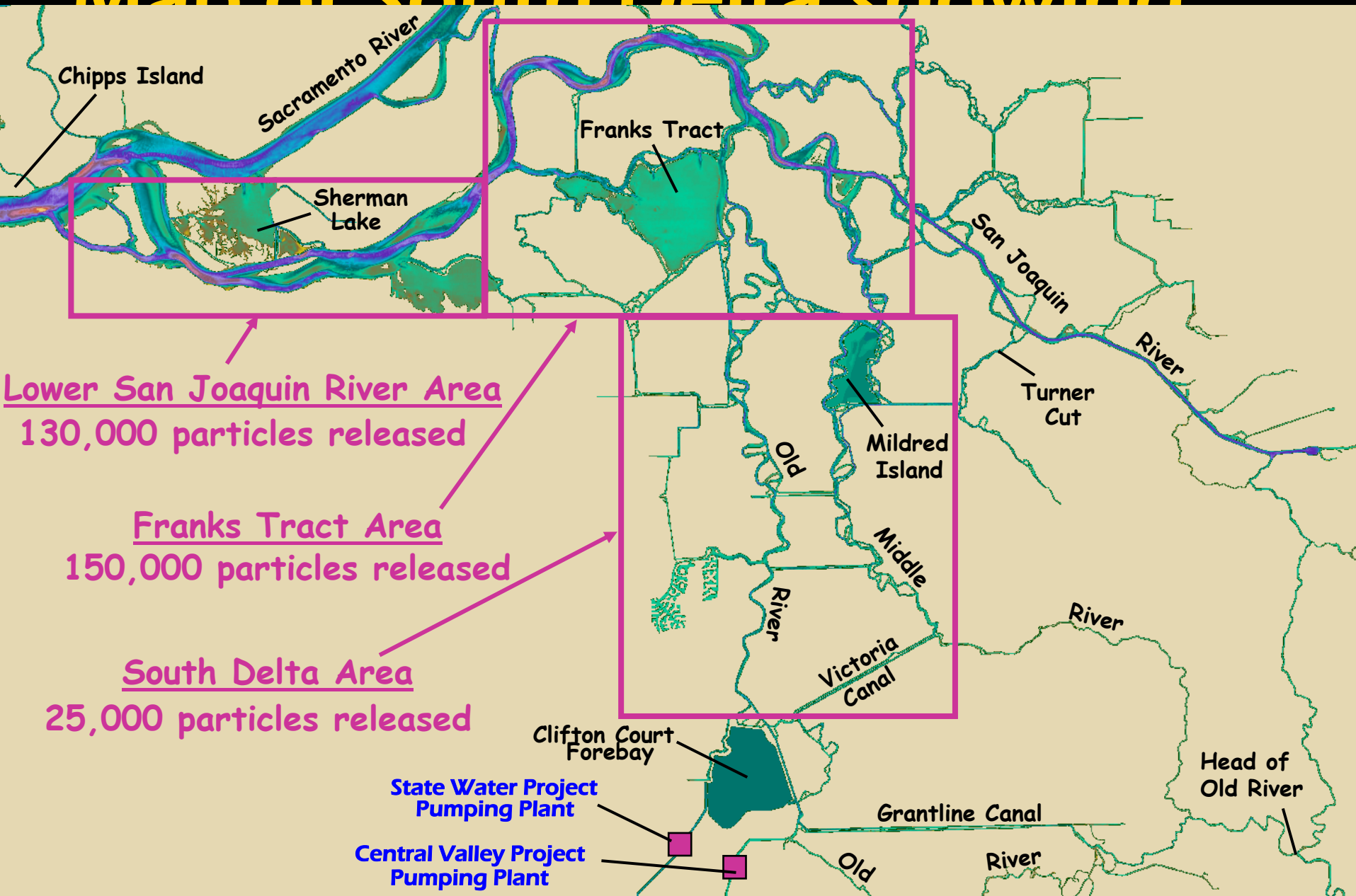


Winter 2002 Delta Flows and Salvage



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

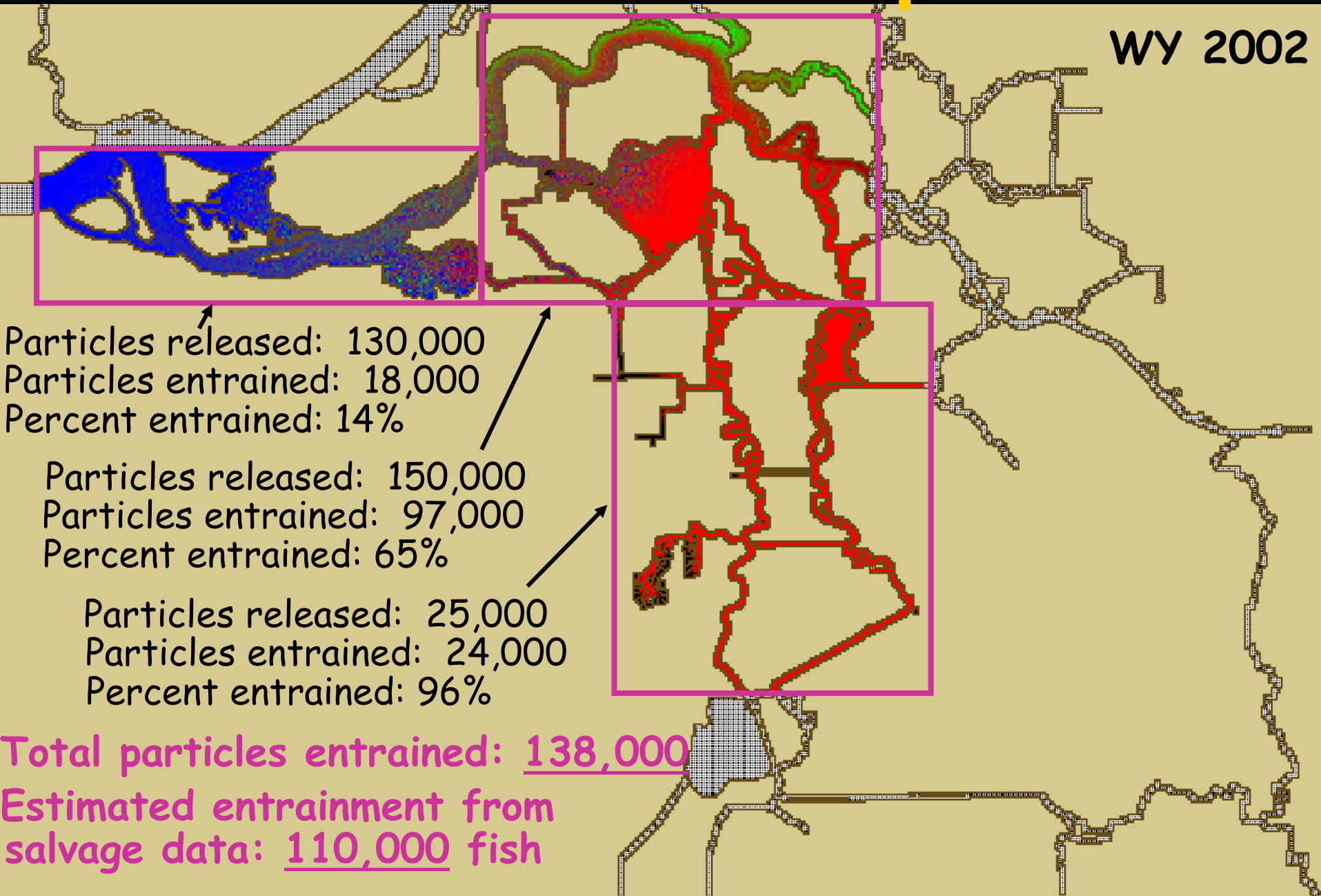
Map of South Delta showing



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



Particles released: 130,000
Particles entrained: 18,000
Percent entrained: 14%

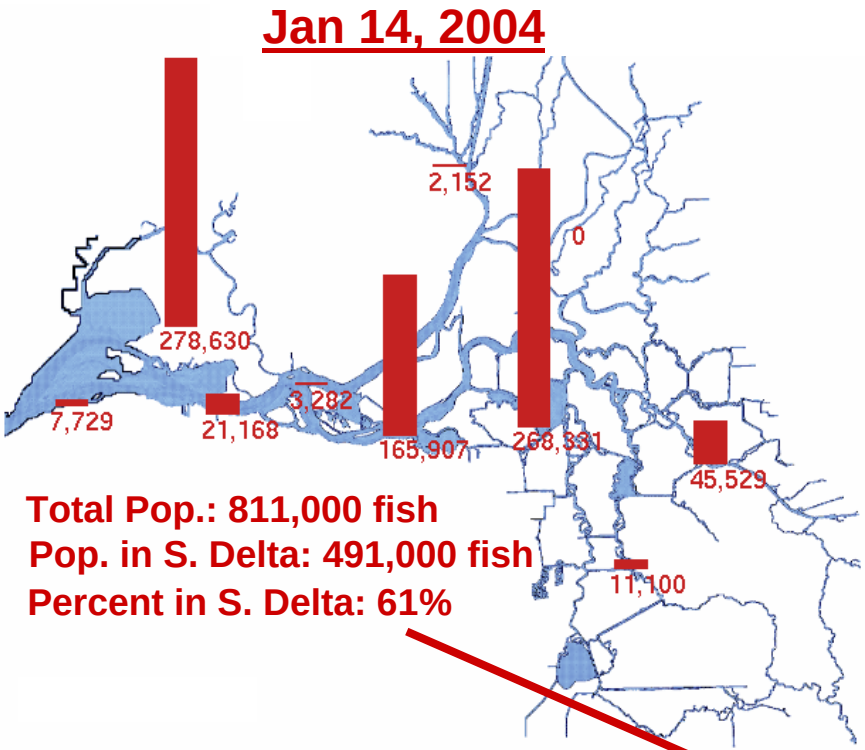
Particles released: 150,000
Particles entrained: 97,000
Percent entrained: 65%

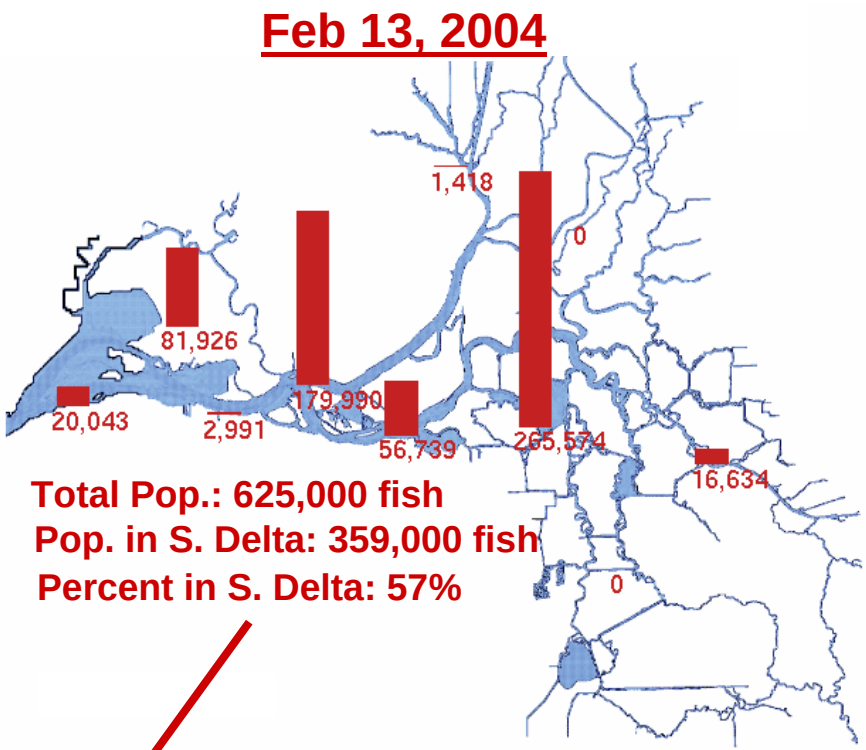
Particles released: 25,000
Particles entrained: 24,000
Percent entrained: 96%

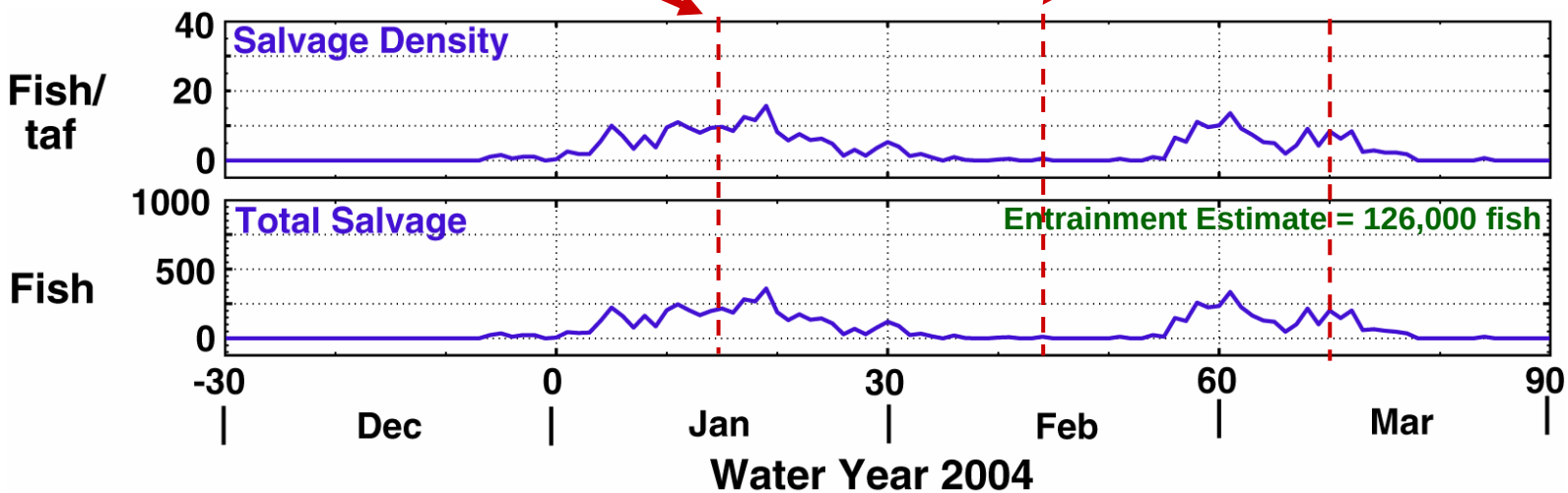
Total particles entrained: 138,000

Estimated entrainment from salvage data: 110,000 fish

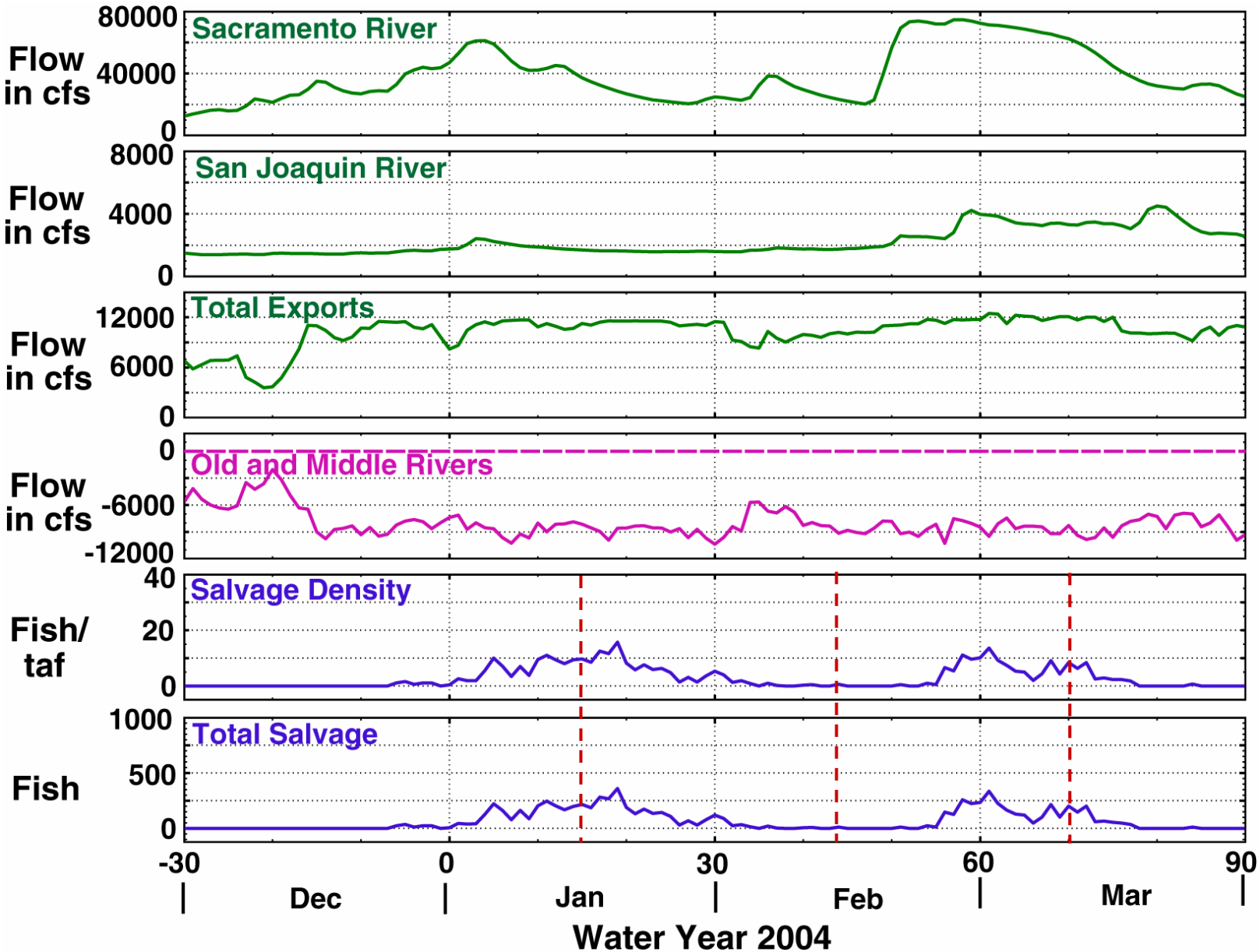
2004 Spring Kodiak Trawl Surveys and Salvage





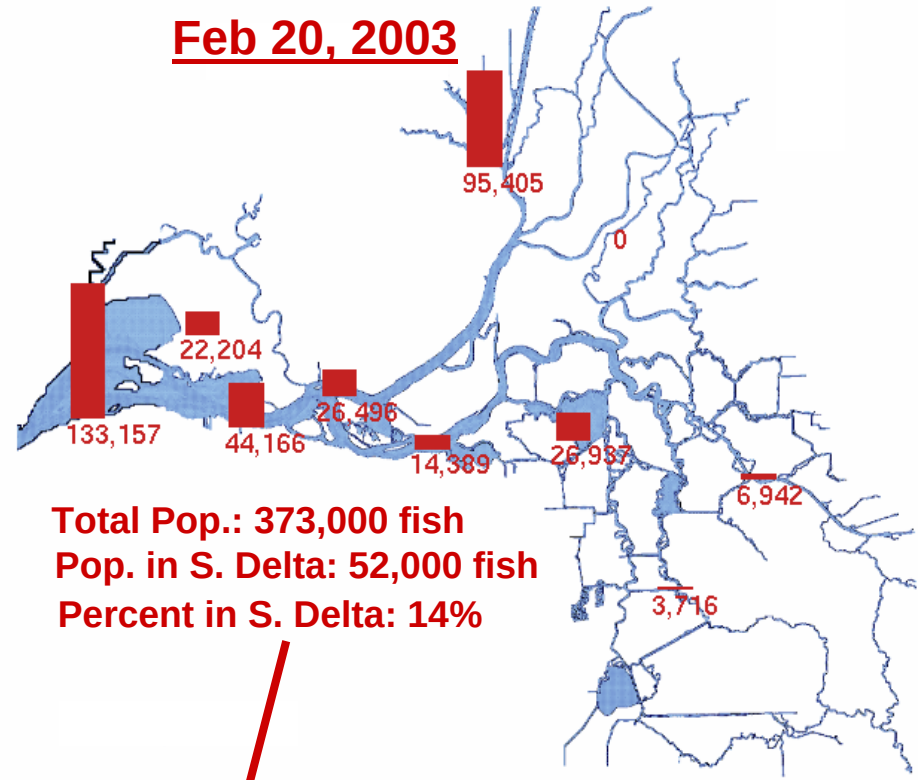


Winter 2004 Delta Flows and Salvage

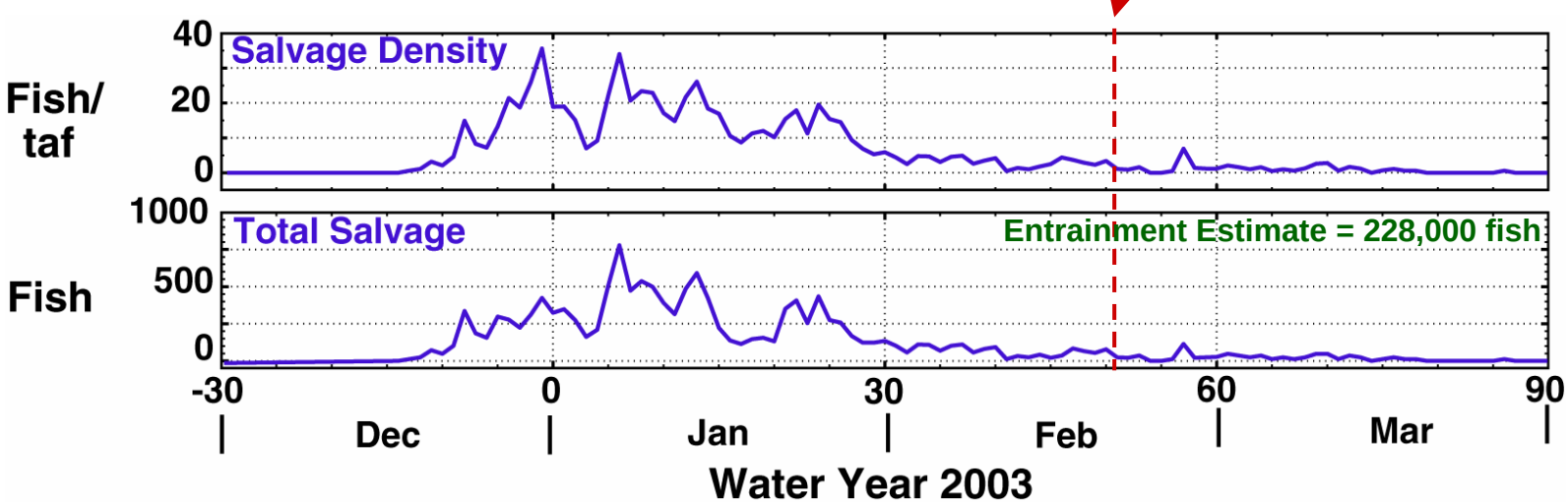


2003 Spring Kodiak Trawl Survey and Salvage

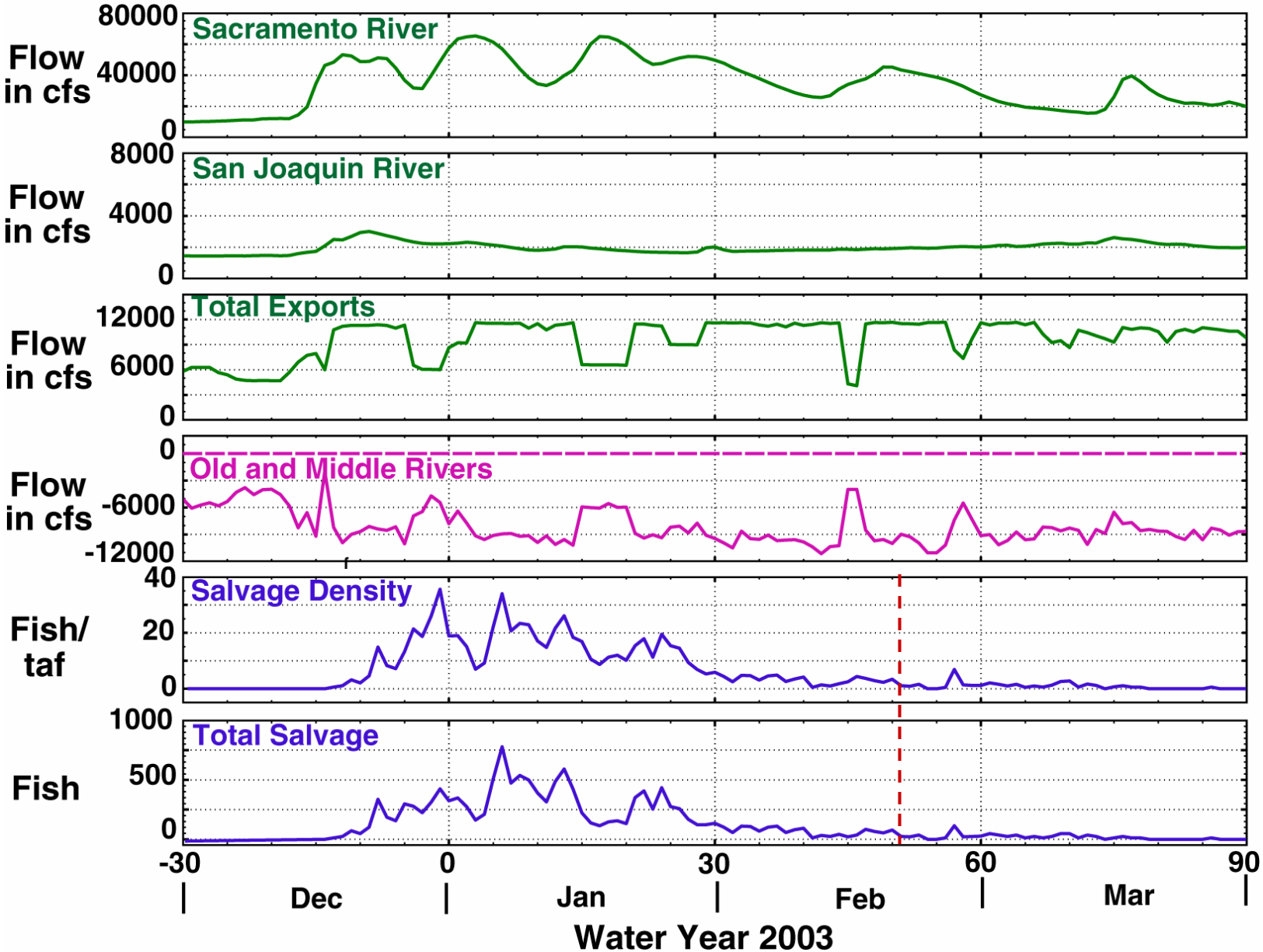
No January Survey



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

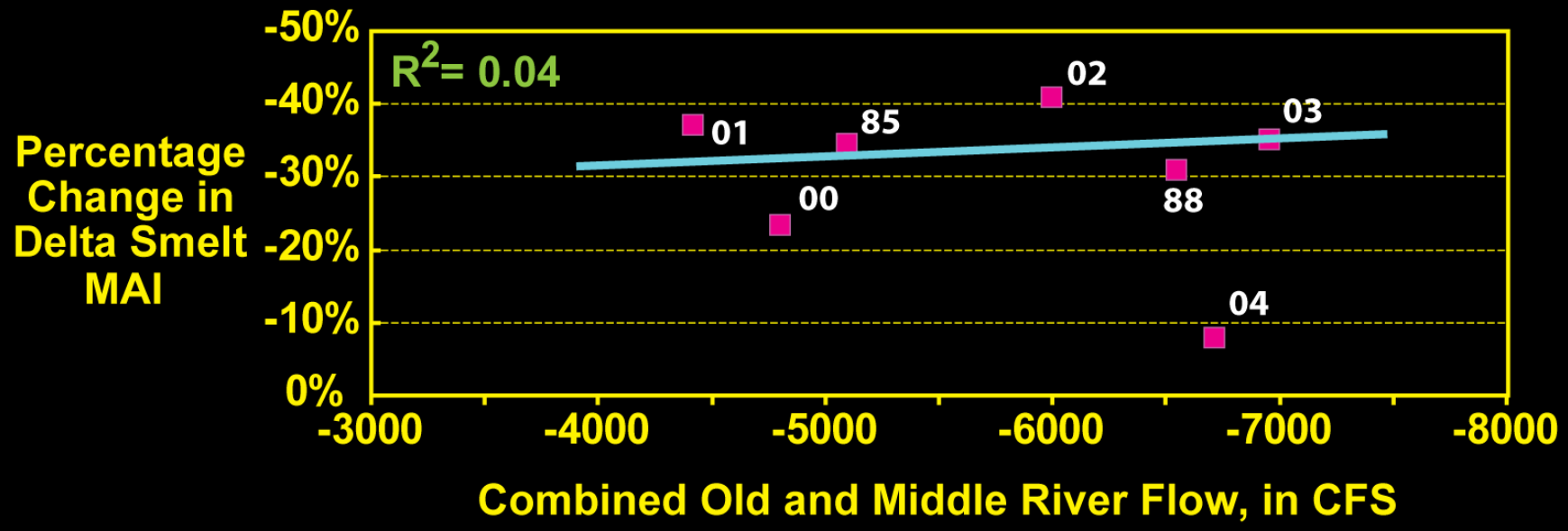


Winter 2003 Delta Flows and Salvage



Regression Analysis

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.

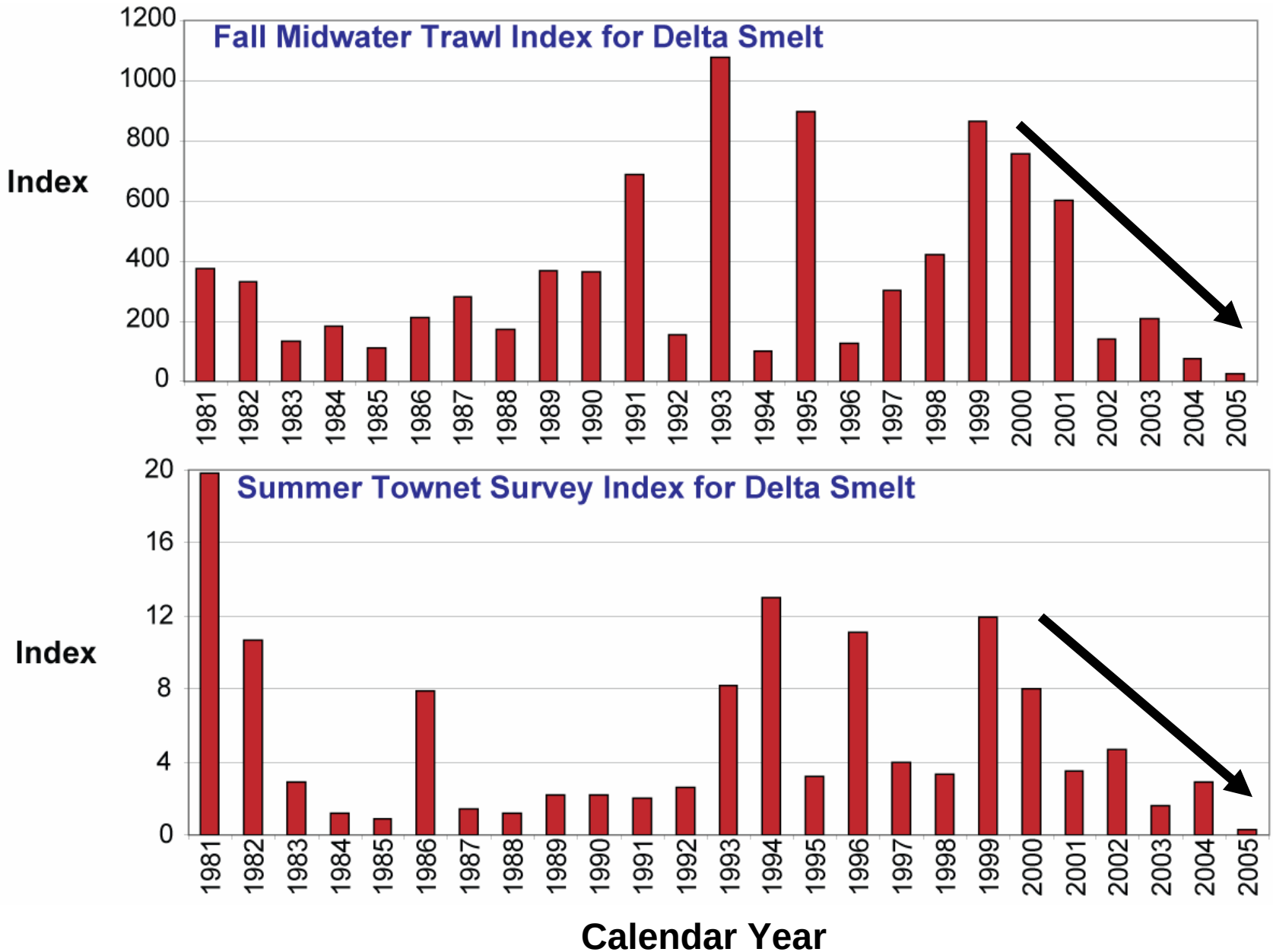
Summary and Conclusions (cont'd)

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.

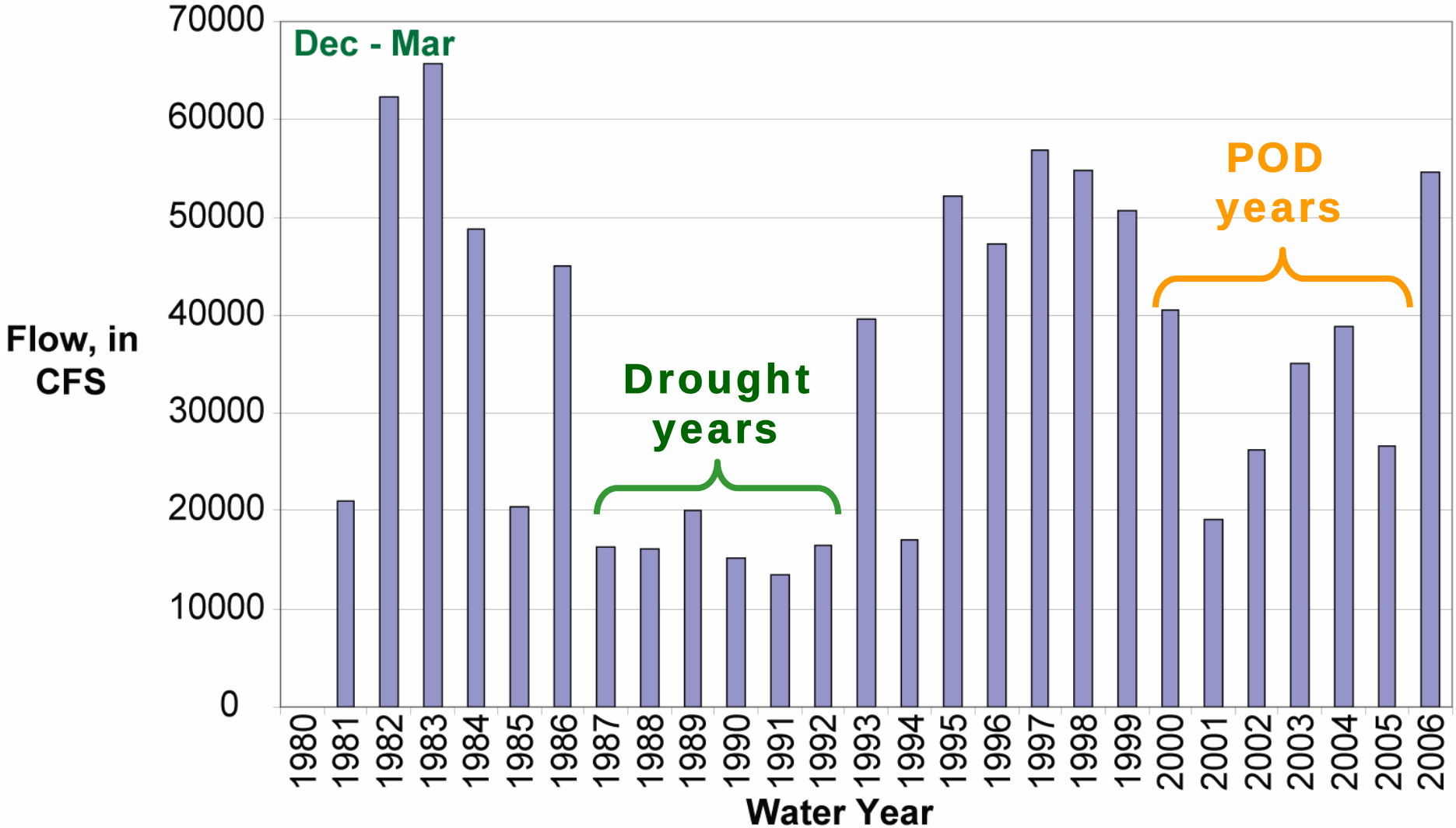
Summary and Conclusions (cont'd)

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.

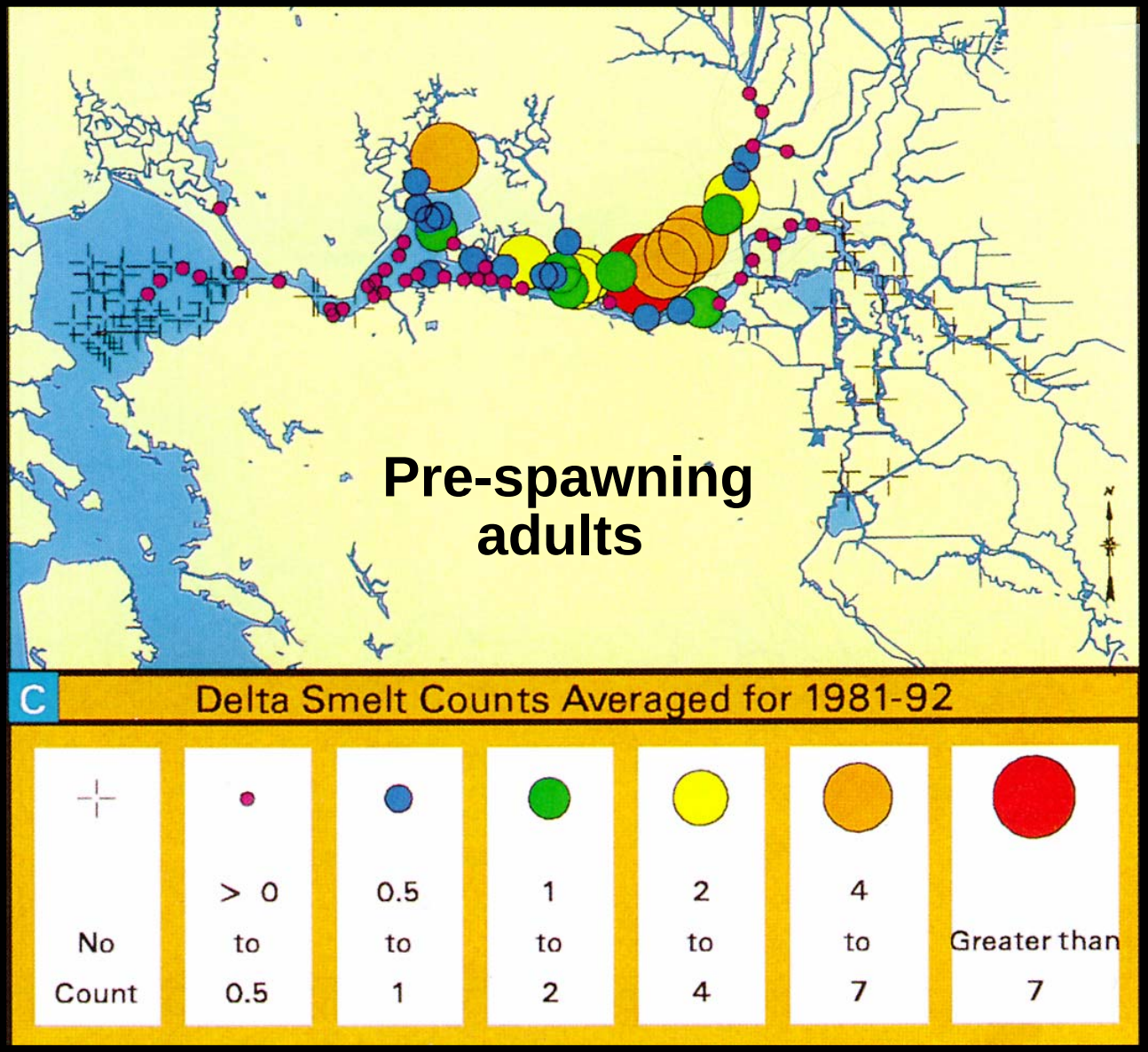
Delta Smelt Abundance Indices



Sacramento River at Freeport

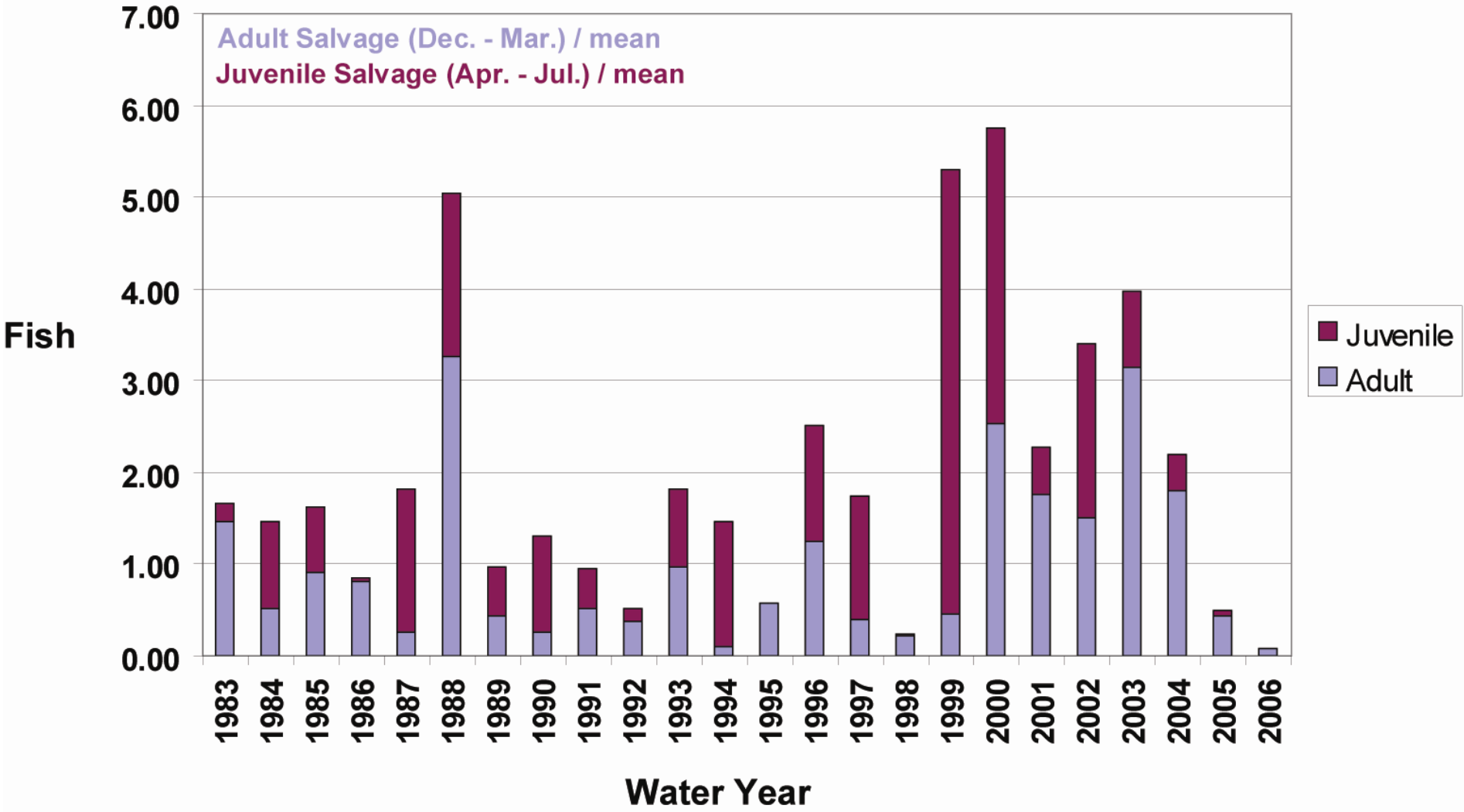


Delta Smelt Distributions in Fall

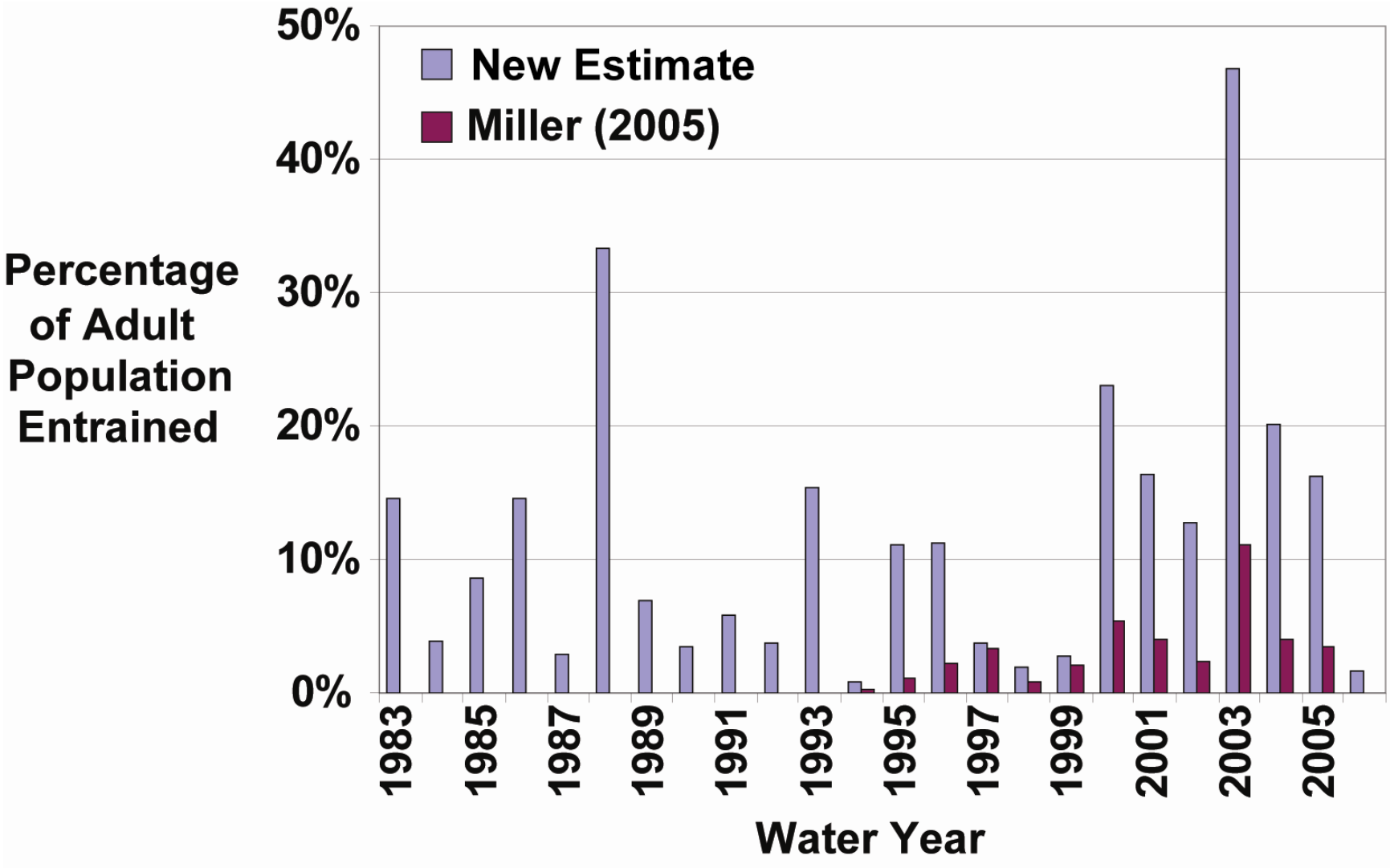


Source: Jim Arthur (USBR), 1996, San Francisco Bay: The Ecosystem

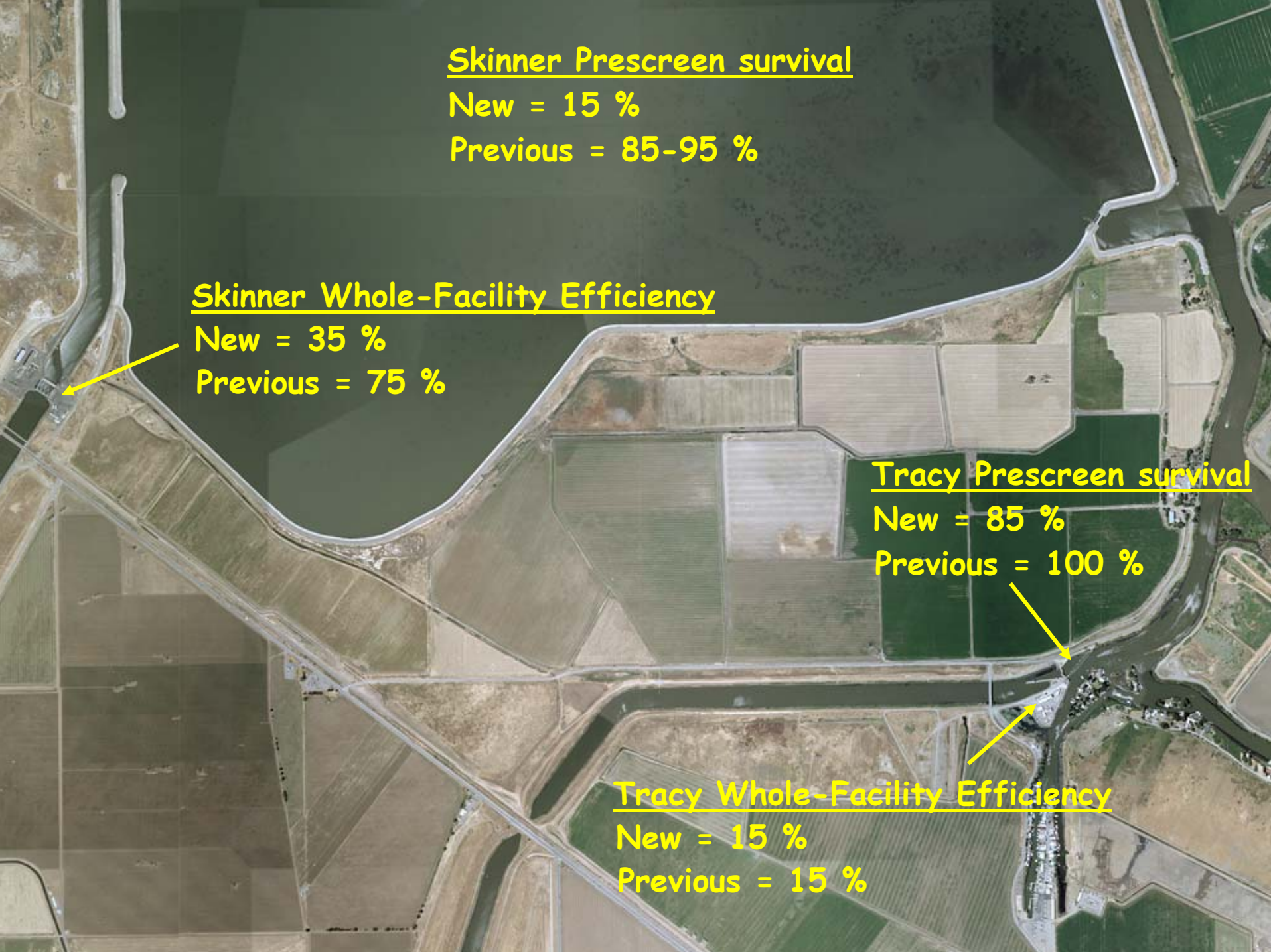
Normalized Yearly Combined (Adult and Juvenile) Delta Smelt Salvage



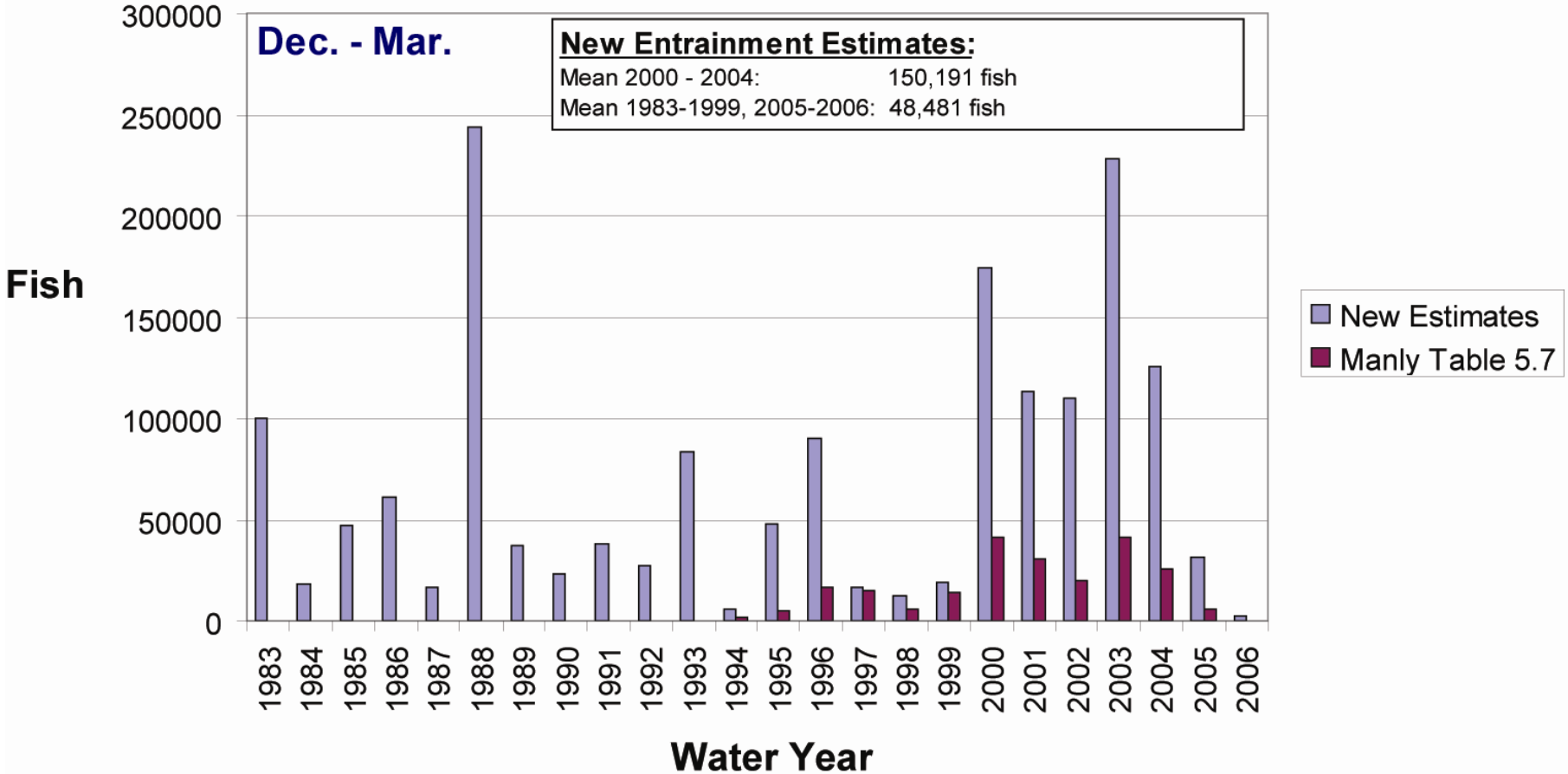
Estimates of Percentage of Adult Delta Smelt Population Entrained



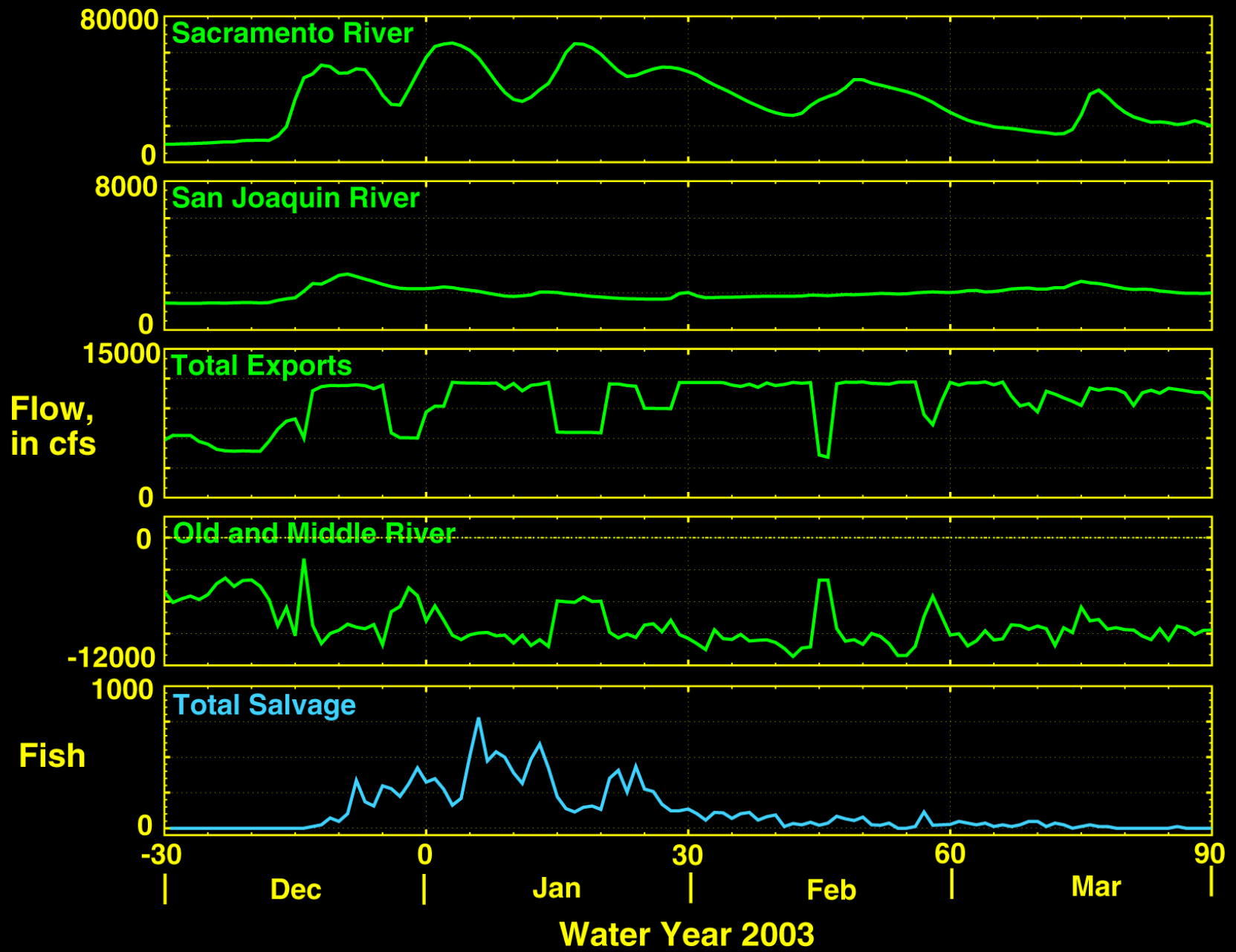
Population estimates are from February Kodiak Trawl by Miller (2005) with slight modifications


Skinner Prescreen survival
New = 15 %
Previous = 85-95 %
Skinner Whole-Facility Efficiency
New = 35 %
Previous = 75 %
Tracy Prescreen survival
New = 85 %
Previous = 100 %
Tracy Whole-Facility Efficiency
New = 15 %
Previous = 15 %

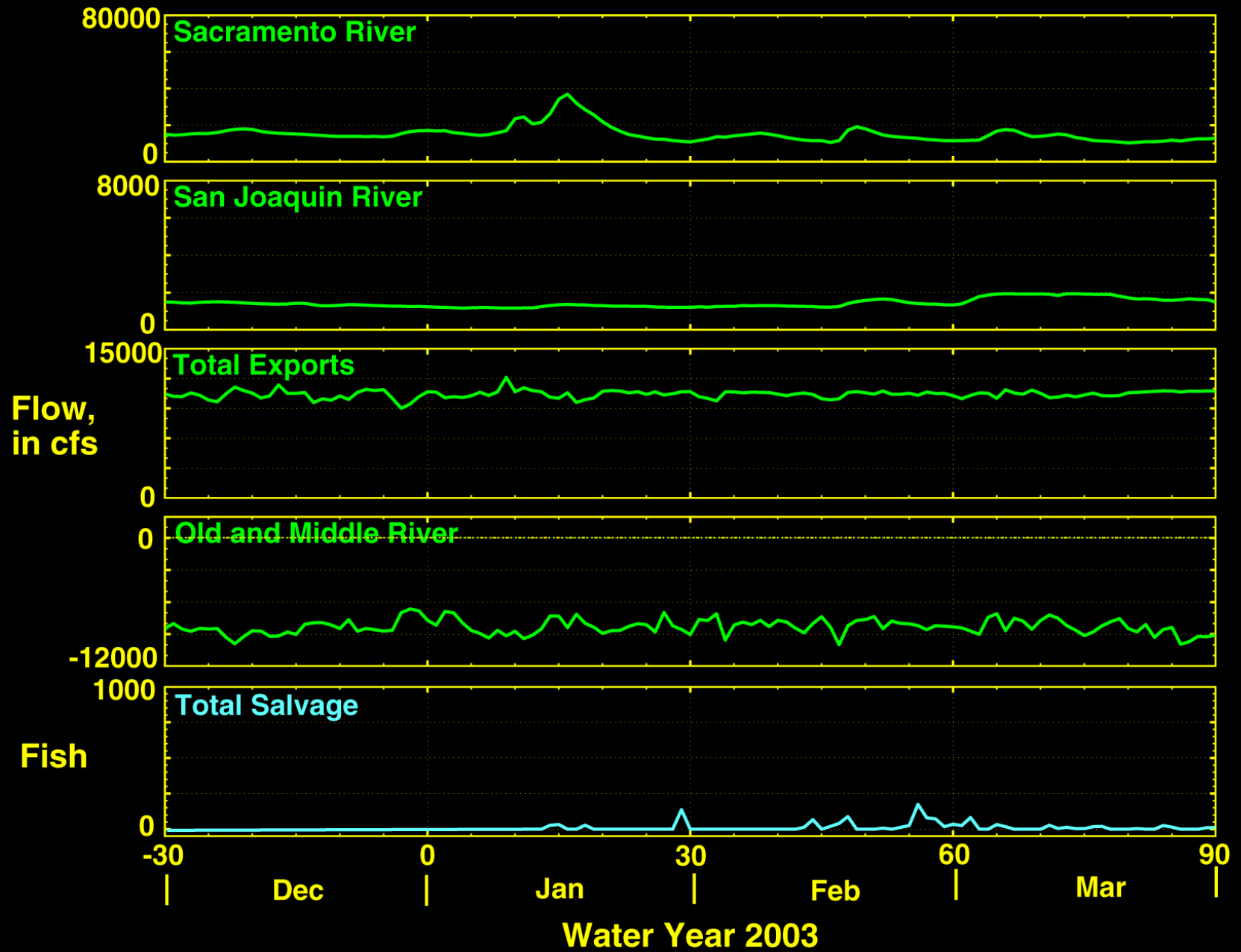
Estimates of Adult Delta Smelt Entrainment from Salvage



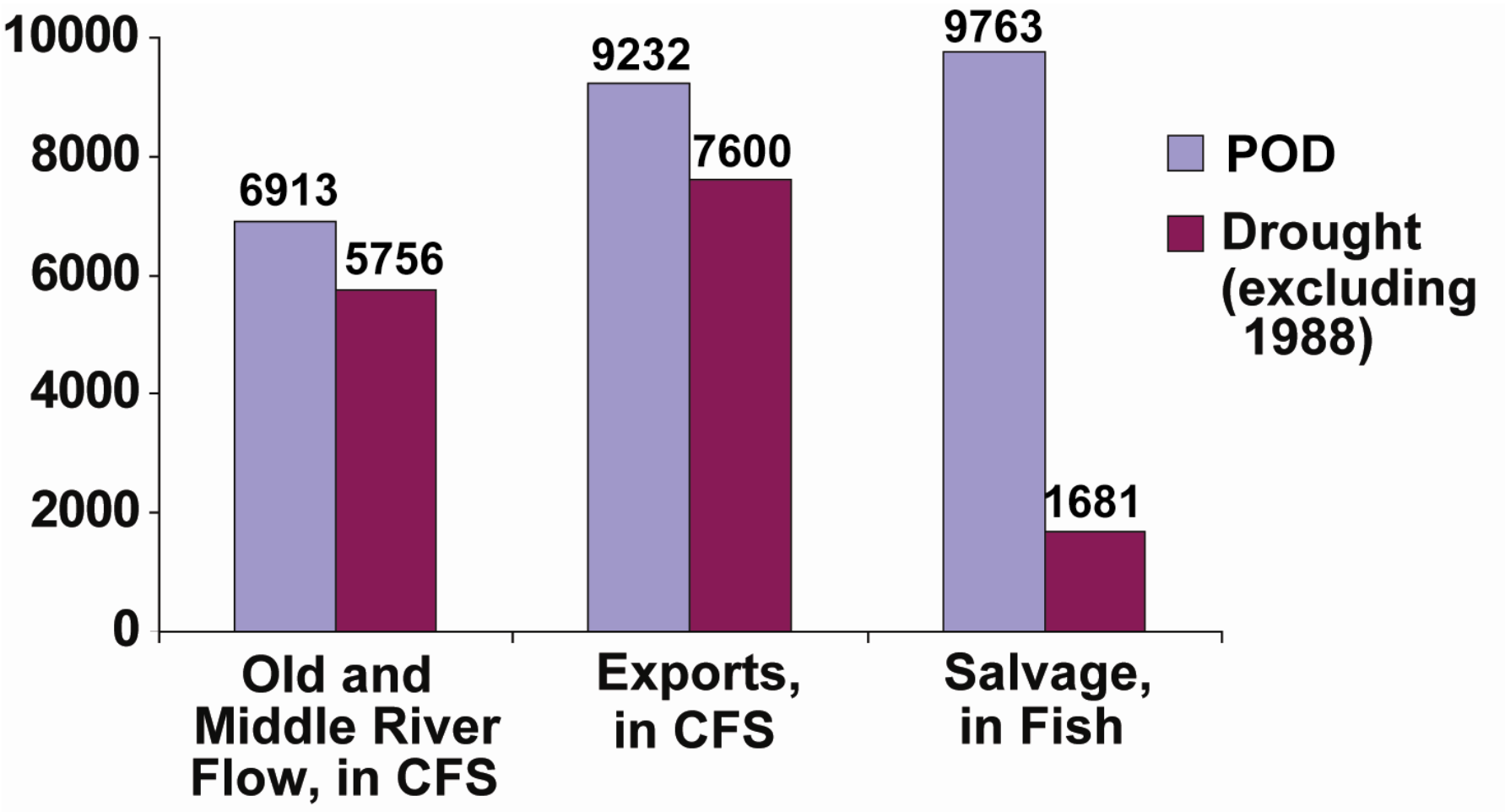
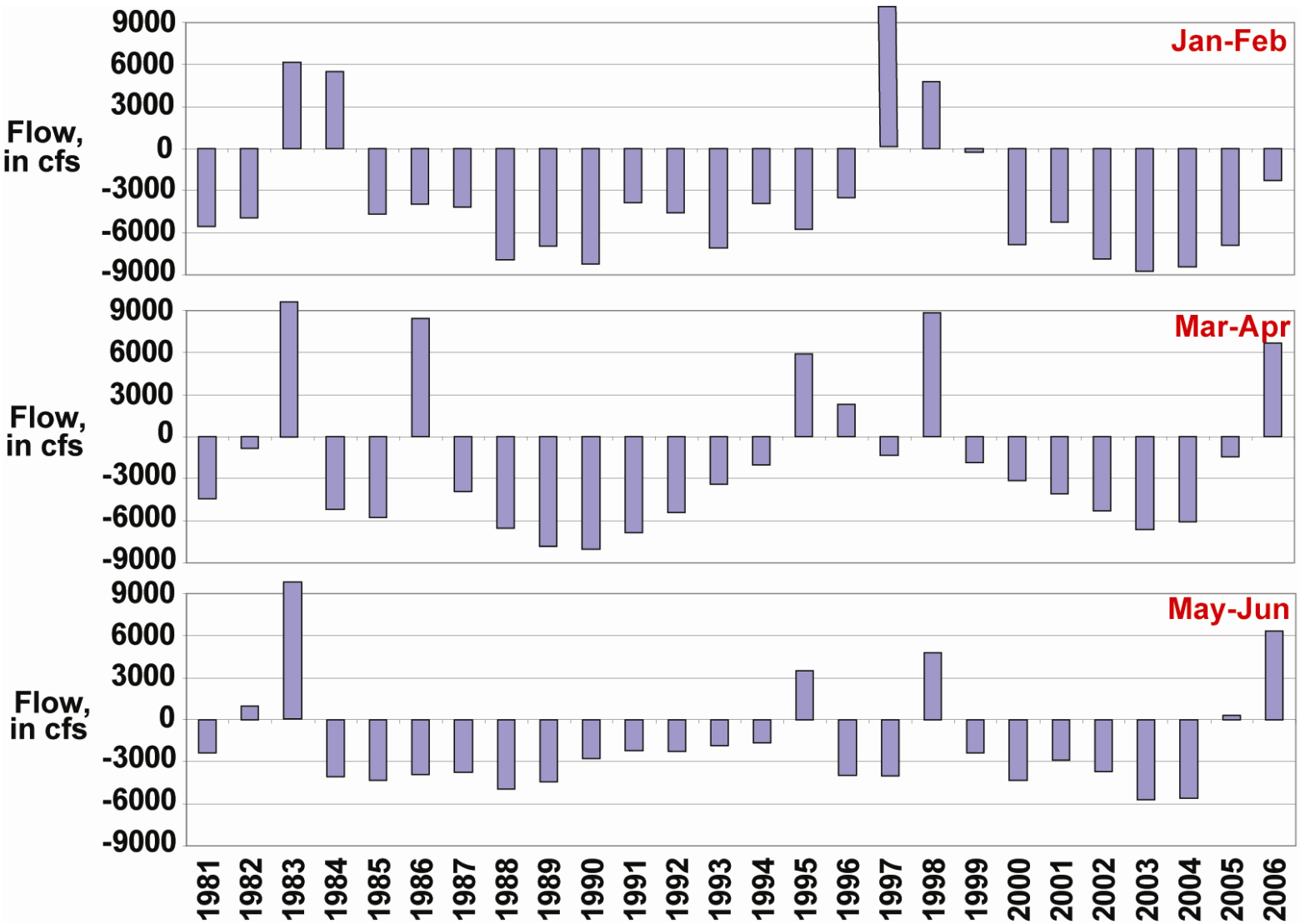
2003 Daily Flows and Delta Smelt Salvage



1990 Daily Flows and Delta Smelt Salvage



Comparison of POD versus Drought years



Combined Old and Middle River Flows