OMR Flows, Turbidity, and Delta Smelt

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Delta Science Program, 980 Ninth St., Sacramento, CA

Has entrainment had a significant population-level effect on Delta Smelt?

- It is very possible, but only in about one-quarter of years since 1980
- It is hard to prove
- High entrainment can mostly be avoided without too high a water cost

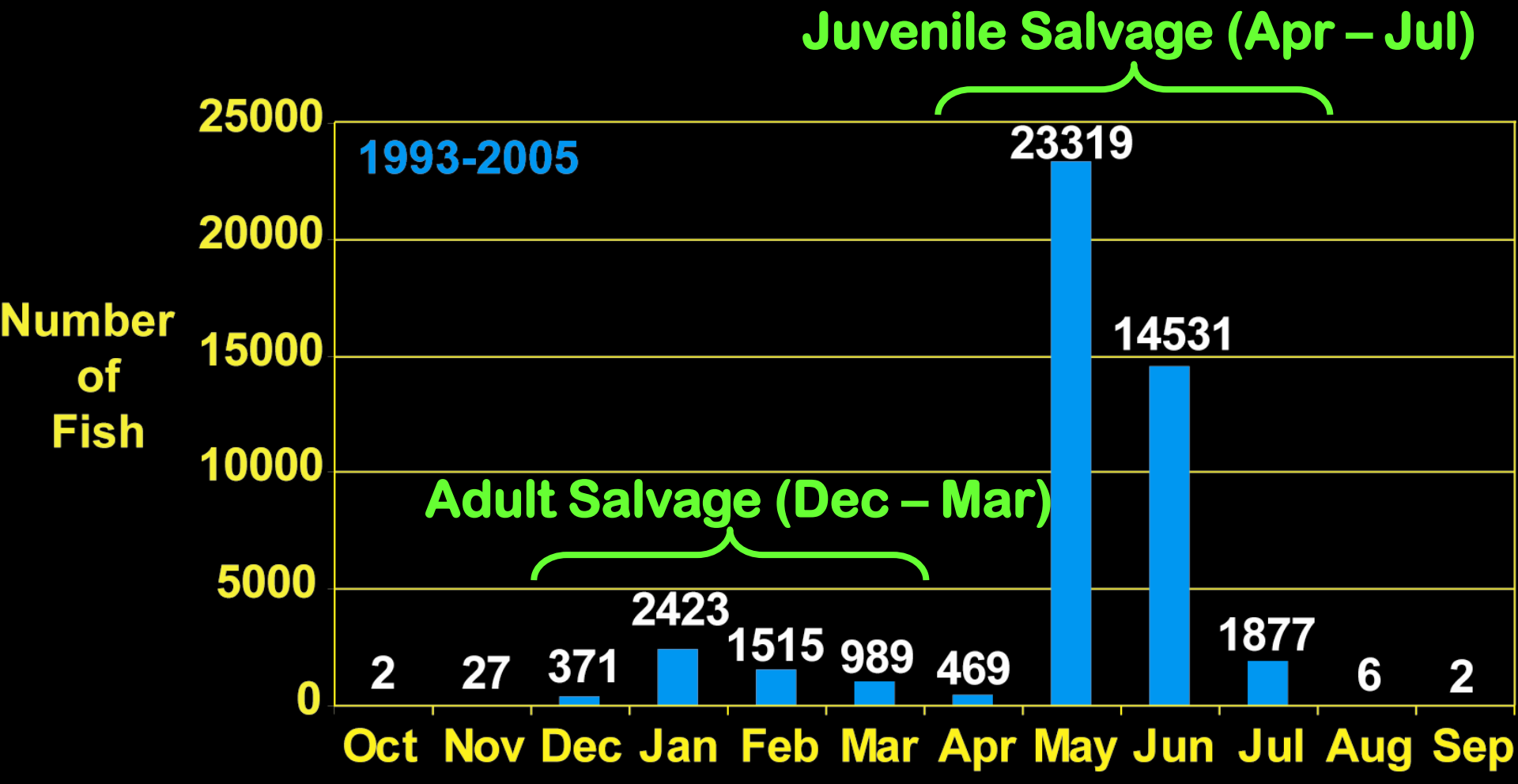
Delta Smelt Salvage Trends

South Delta Fish Facilities

Skinner Fish Facility (DWR)

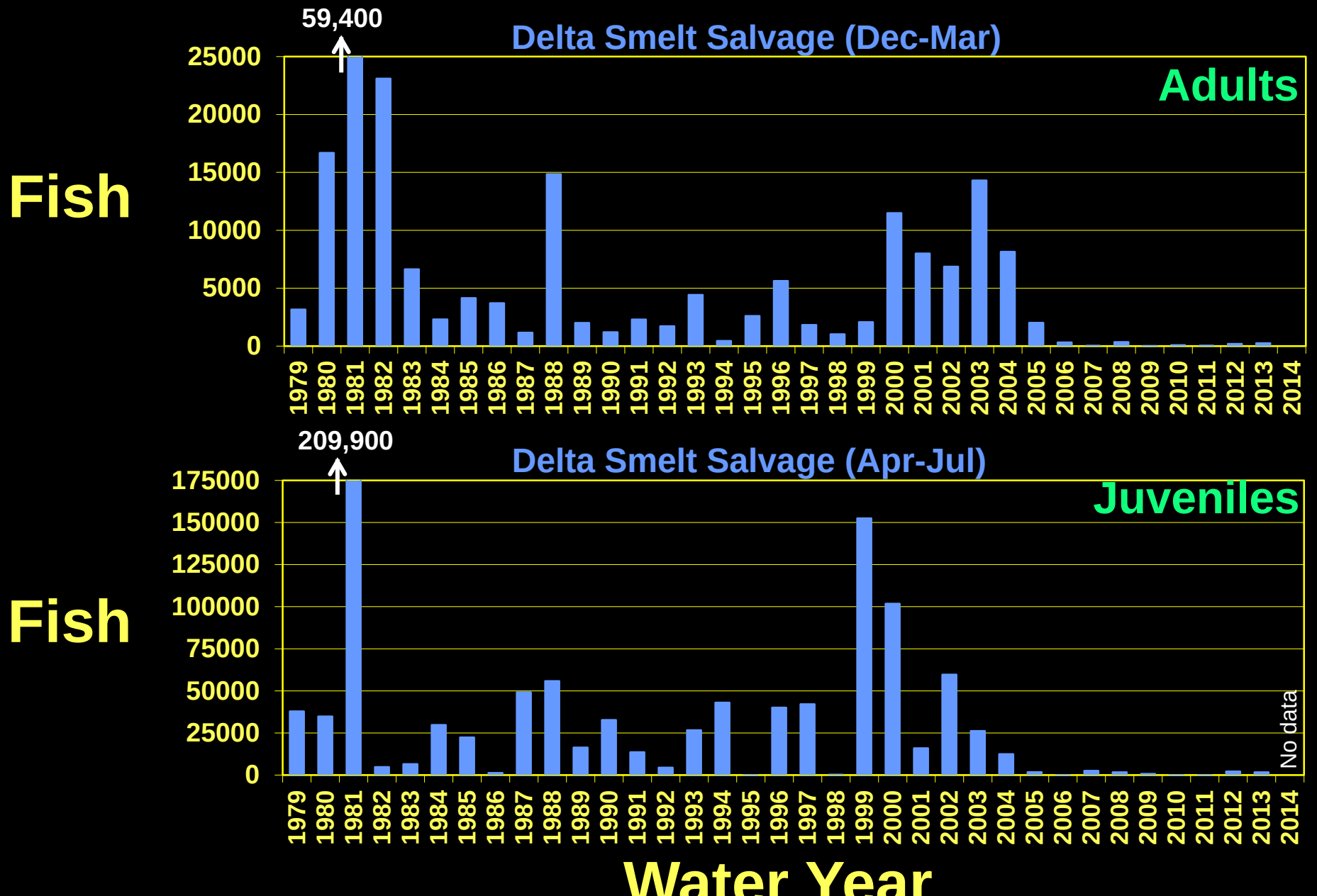
Tracy Fish Facility (USBR)

Average Delta Smelt Salvage by Month

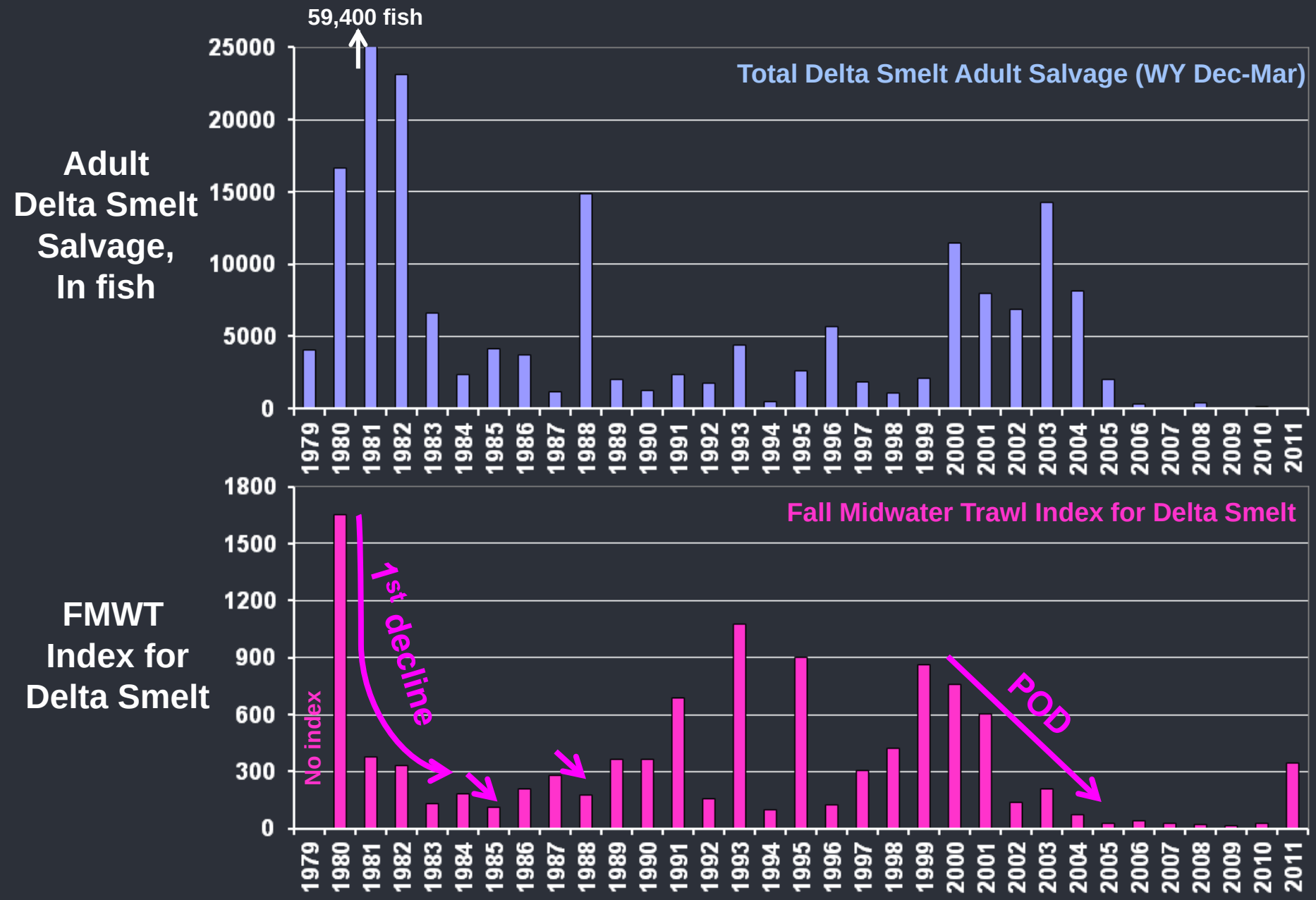


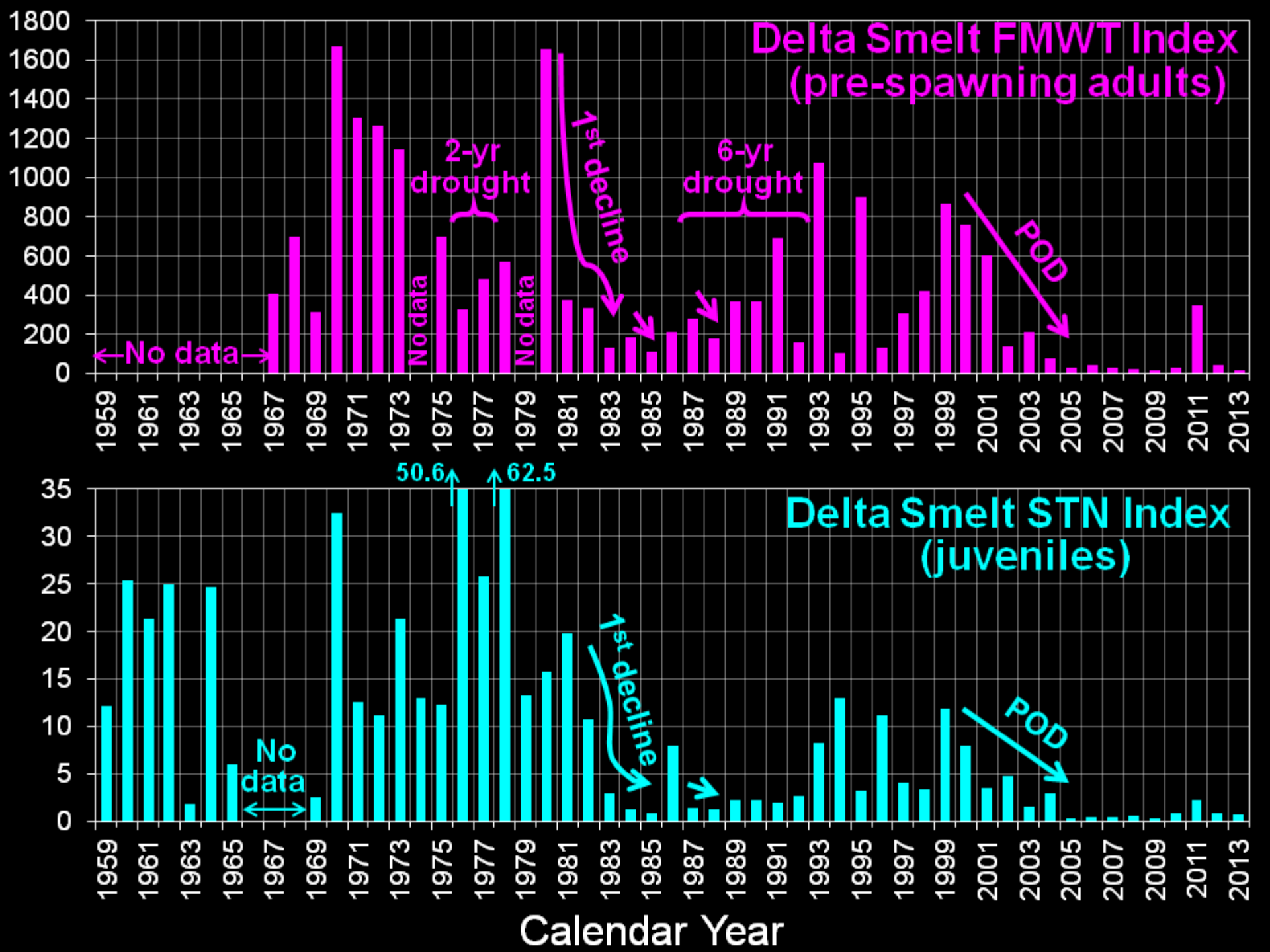
Note: Only fish 20 millimeters or larger are counted in salvage

36-Year Trends in Delta Smelt Salvage



Adult Delta Smelt Salvage and FMWT Index

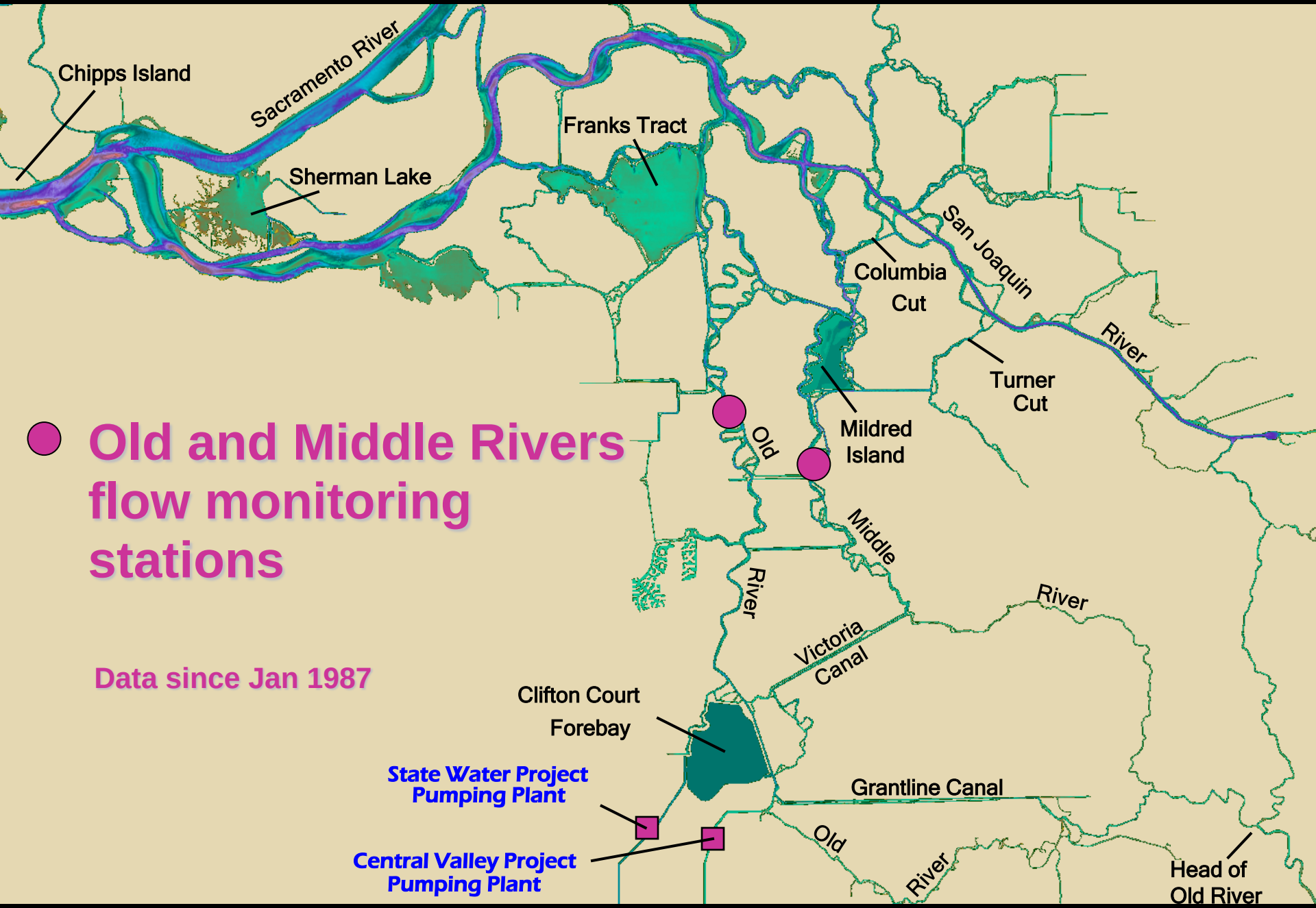



Delta Smelt FMWT Index
(pre-spawning adults)
1800
1600
1400
1200
1000
800
600
400
200
0
←No data→
2-yr drought
1st decline
No data
No data
6-yr drought
POD
1959
1961
1963
1965
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
Delta Smelt STN Index
(juveniles)
50.6
62.5
35
30
25
20
15
10
5
0
No data
1st decline
POD
Calendar Year

Three Covariates to Simulate Adult Delta Smelt Entrainment

- OMR flows
- Turbidity
- Population in the South Delta

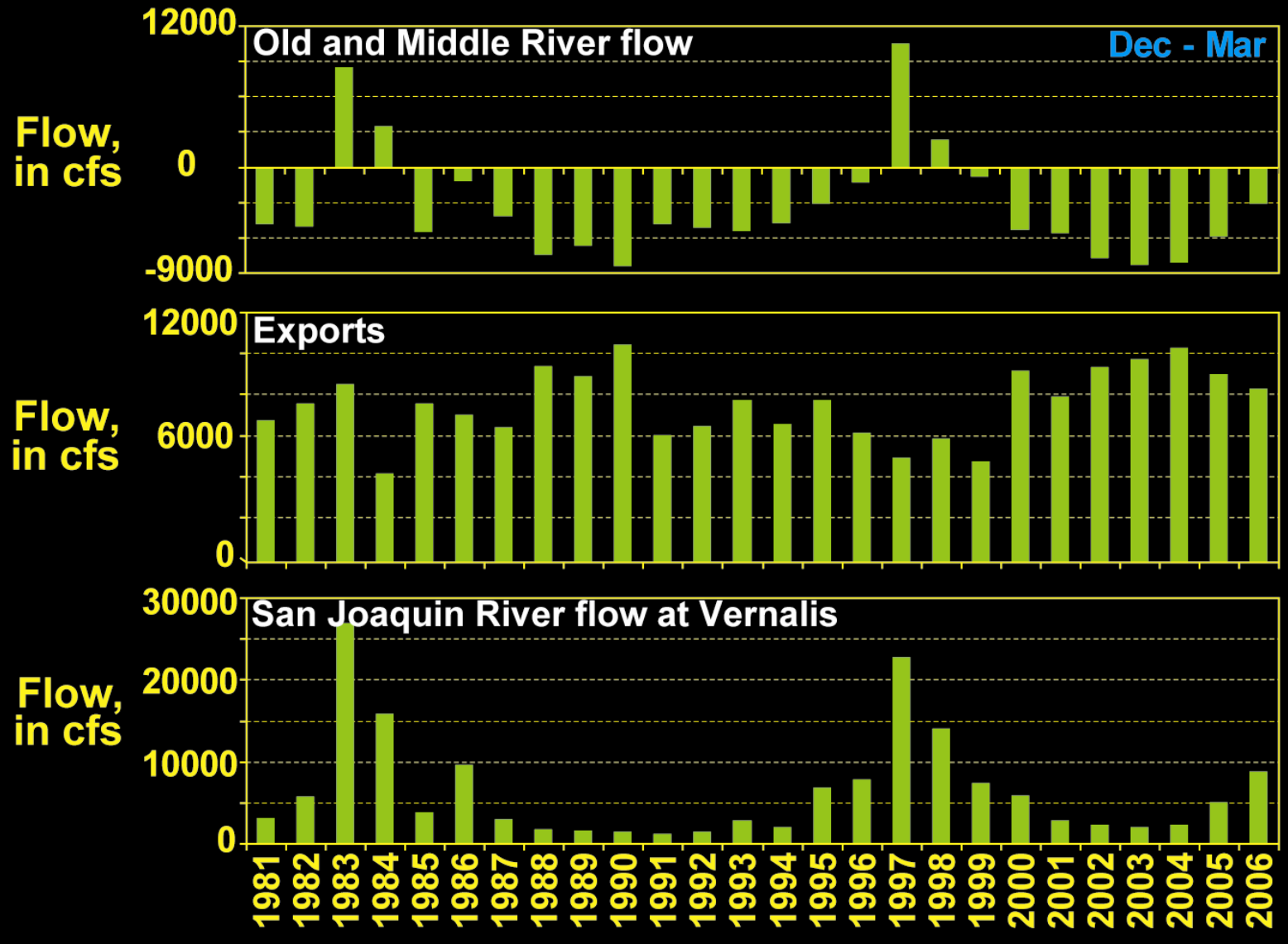
OMR Flows



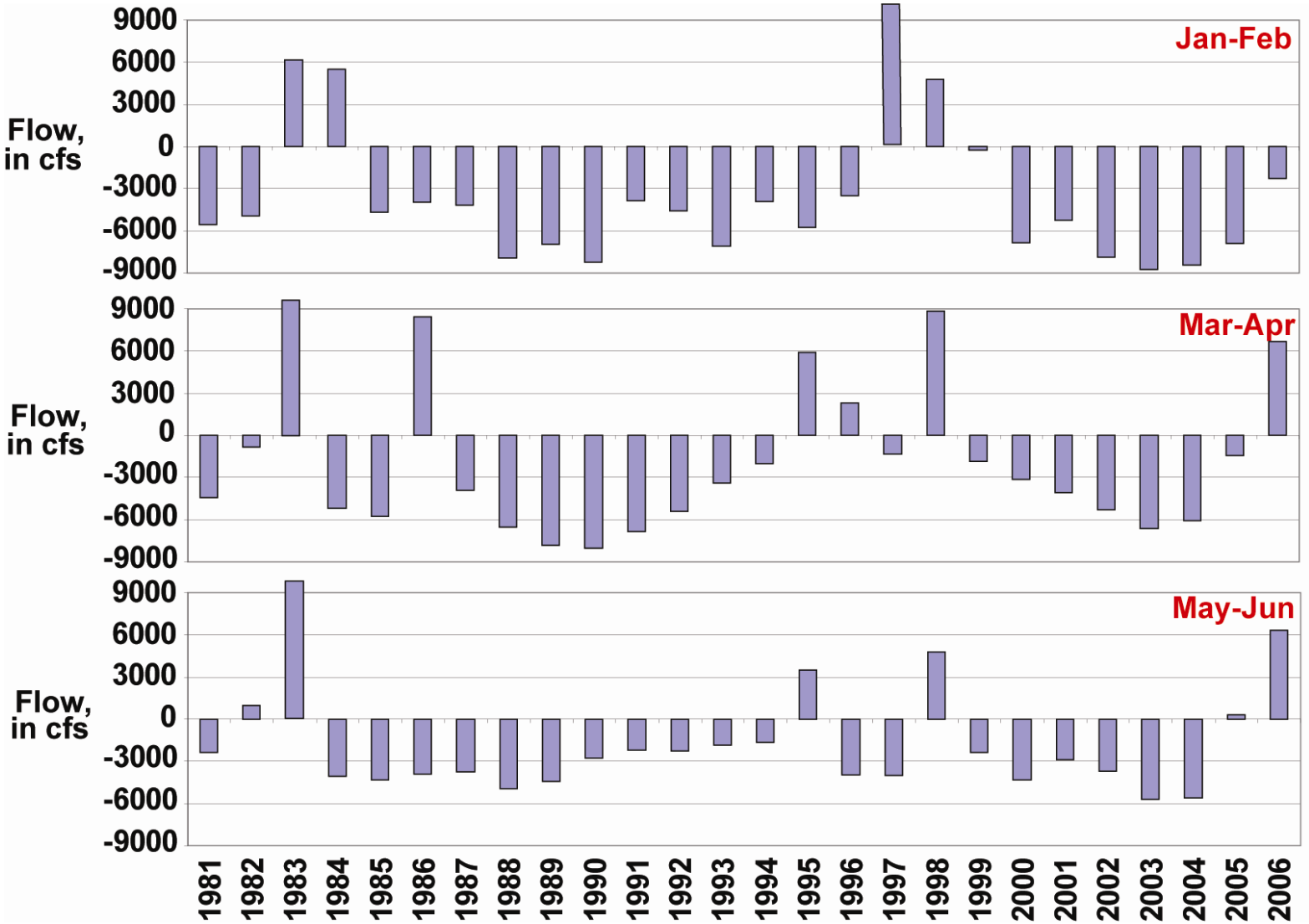
- **Old and Middle Rivers flow monitoring stations**

Data since Jan 1987

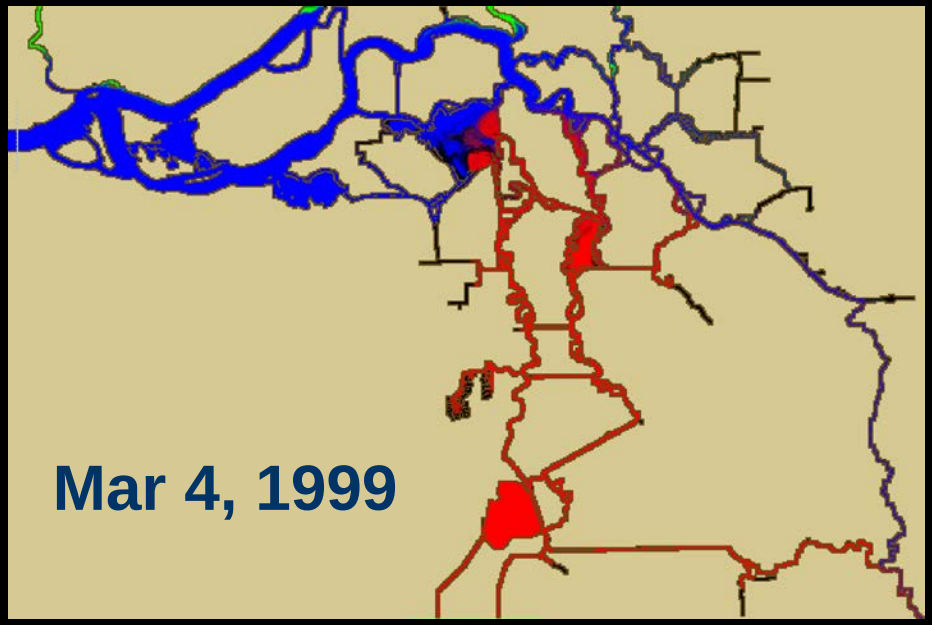
Old and Middle River Flows, Exports, and San Joaquin River Flows

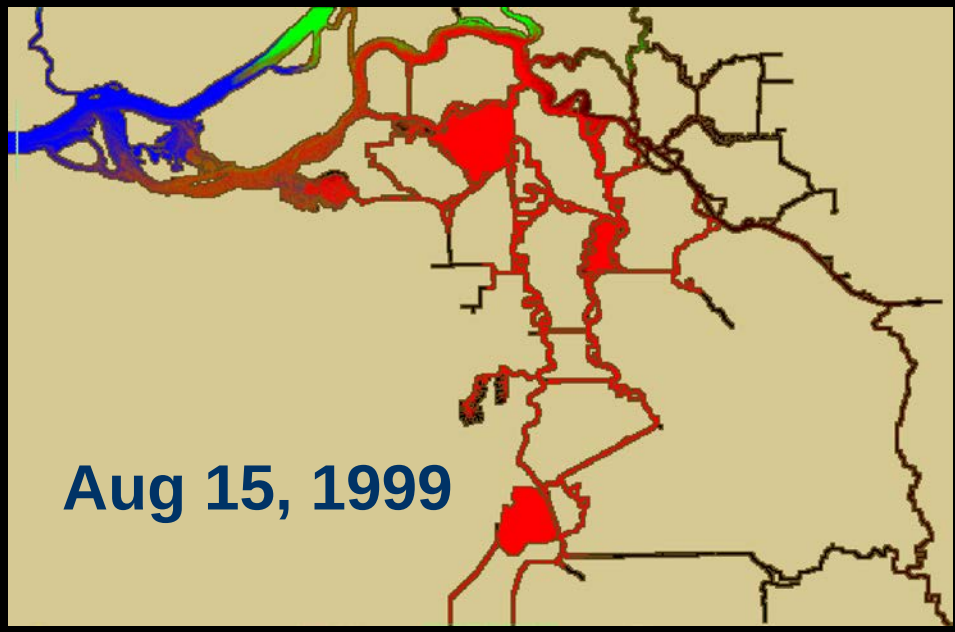


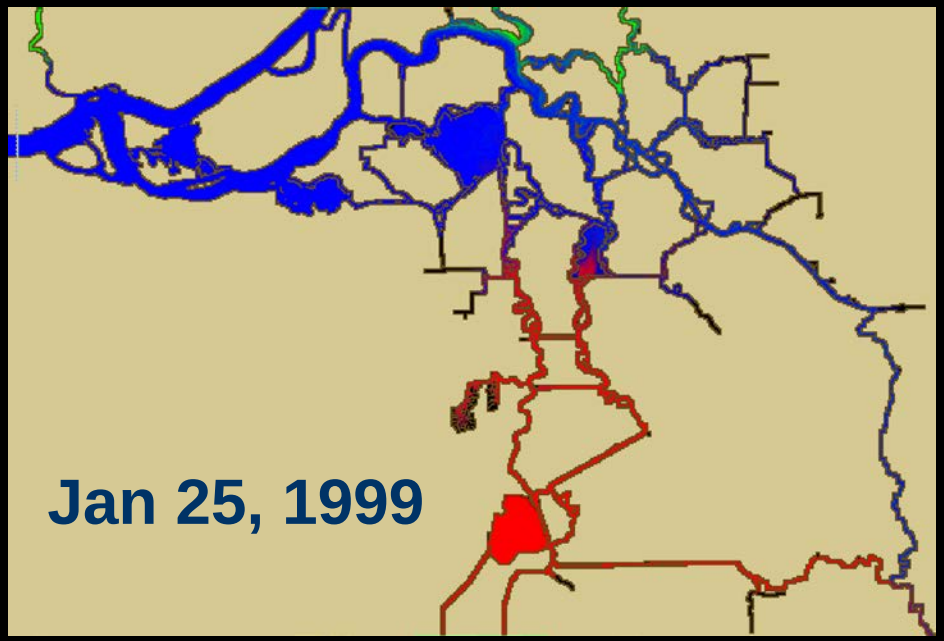
Combined Flows in Old and Middle Rivers



Compare ZOEs







Water entrained at export pumps

Water exiting northern boundaries

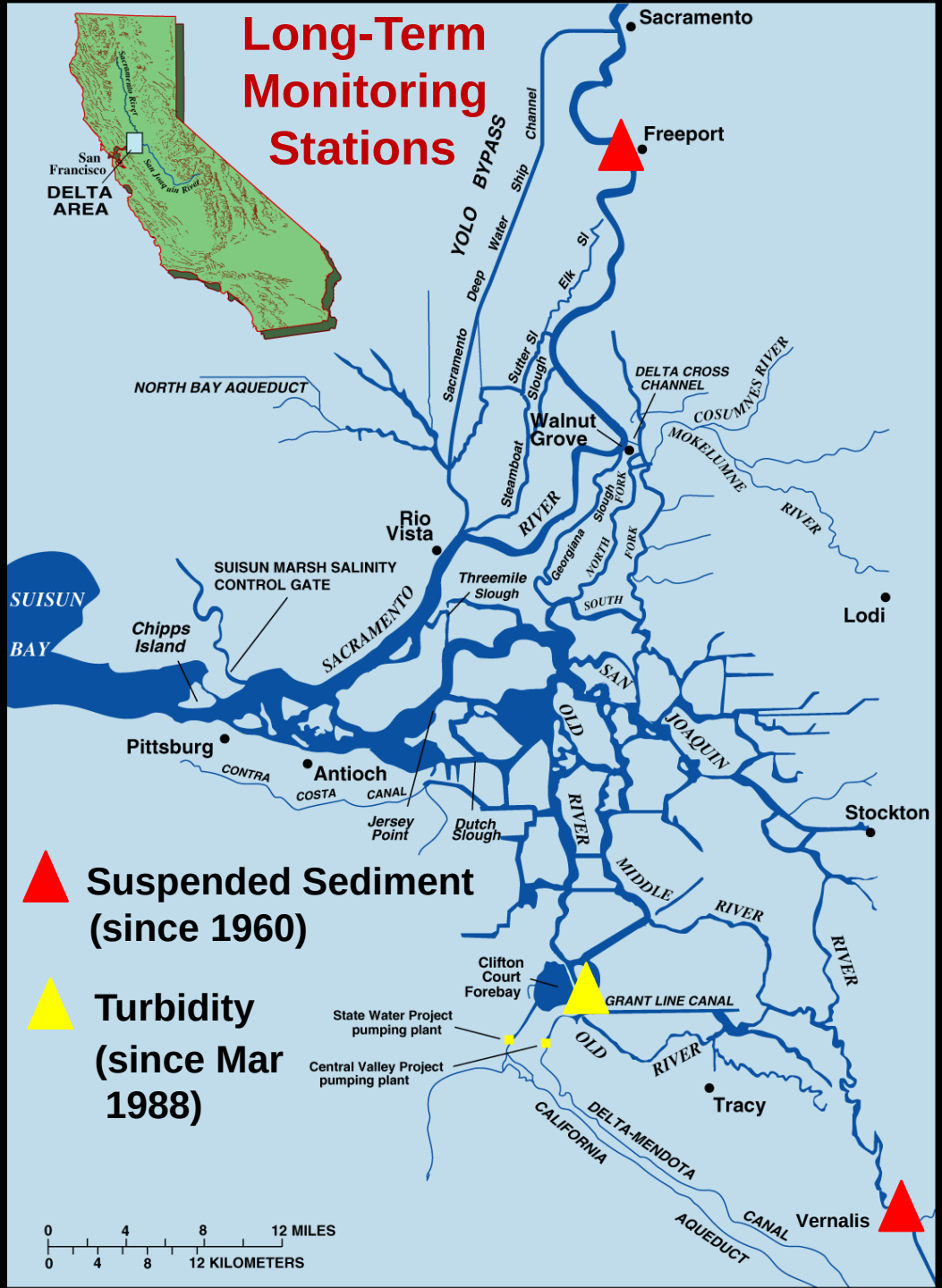
Water flowing past Chipps Island

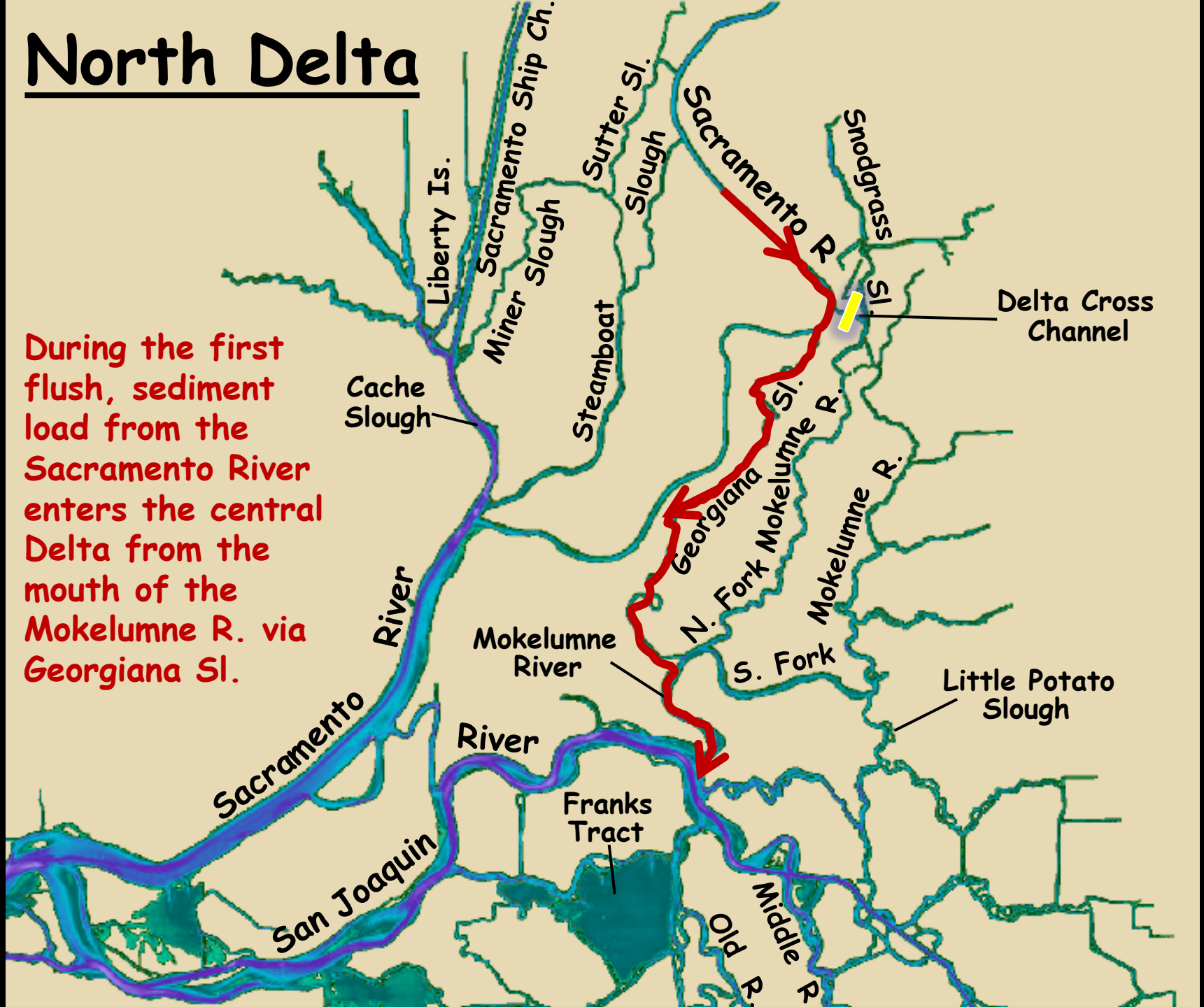
Water remaining in Delta

45 days of particle tracking

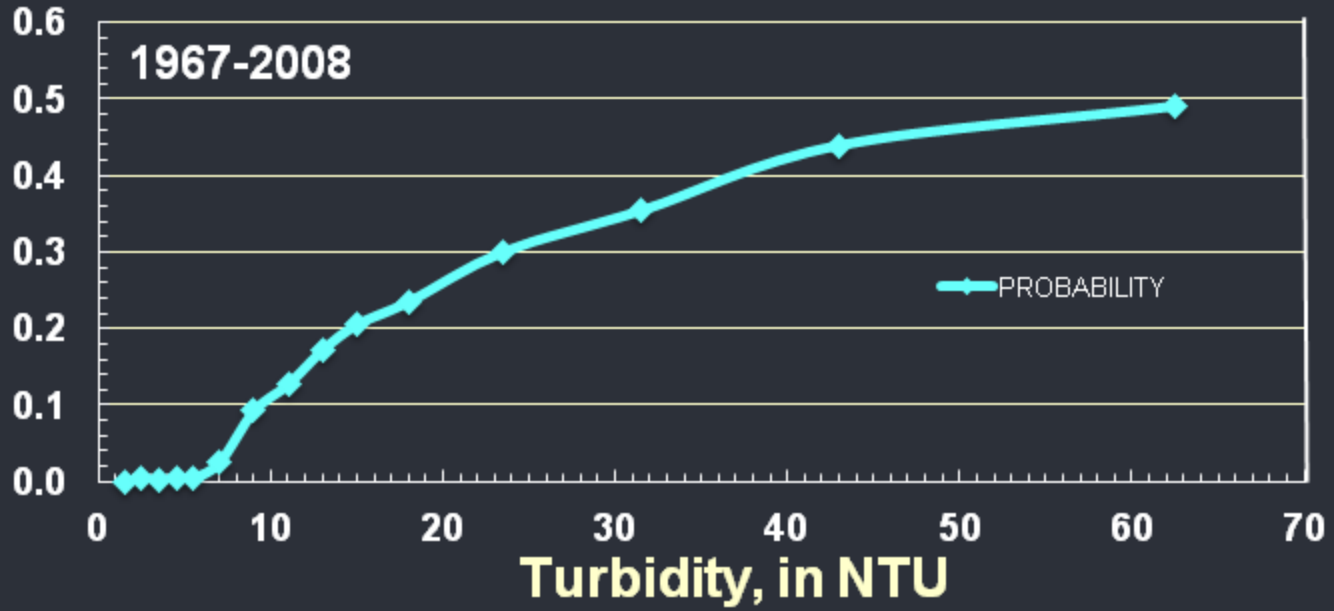
Example 3D particle tracks in the west Delta during Fall 1999 showing transport to the pumps is possible

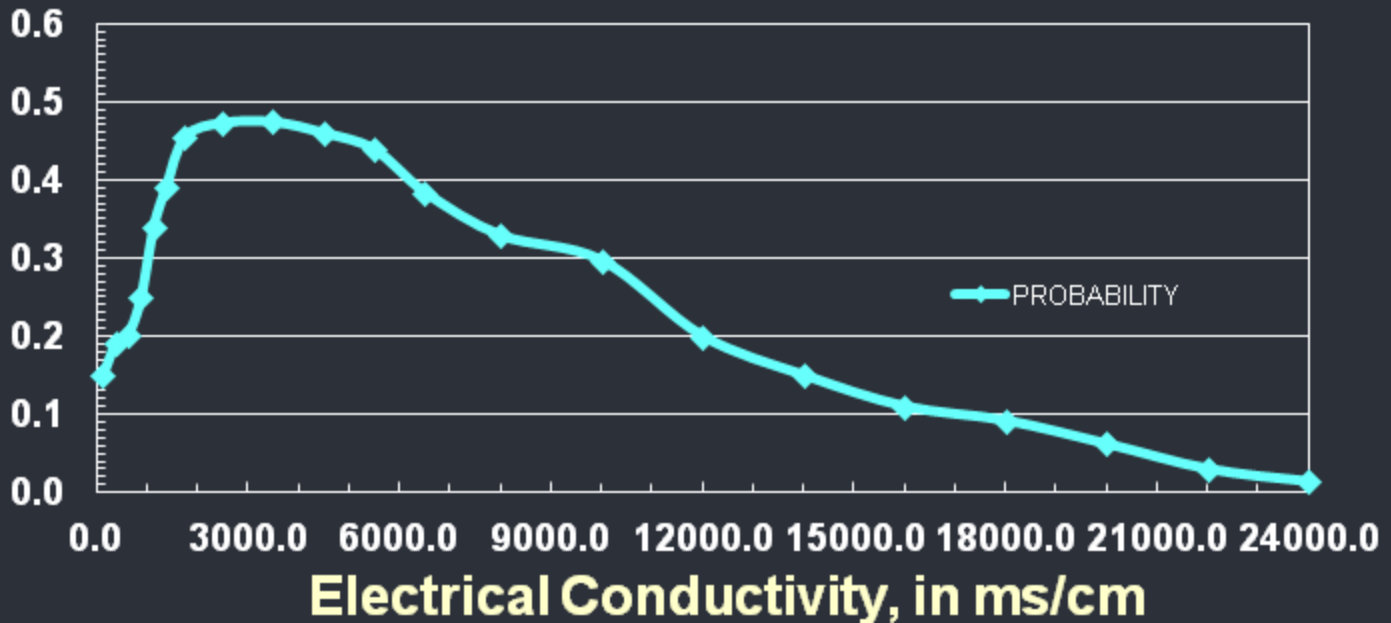
Turbidity


Long-Term Monitoring Stations
San Francisco
DELTA AREA
Sacramento River
San Joaquin River
Sacramento
Freeport
YOLO BYPASS
Ship Channel
Deep Water Ship Channel
Elk Slough
Sutter Slough
NORTH BAY AQUEDUCT
DELTA CROSS CHANNEL
Walnut Grove
COSUMNES RIVER
MOKELUMNE RIVER
Steamboat Slough
Rio Vista
SUISUN MARSH SALINITY CONTROL GATE
Threemile Slough
Georgiana Slough
NORTH FORK
SOUTH FORK
Lodi
SUISUN BAY
Chipps Island
SACRAMENTO RIVER
SAN JOAQUIN RIVER
OLD RIVER
Pittsburg
Antioch
CONTRA COSTA CANAL
Jersey Point
Dutch Slough
Stockton
MIDDLE RIVER
Clifton Court Forebay
GRANT LINE CANAL
State Water Project pumping plant
Central Valley Project pumping plant
Tracy
CALIFORNIA AQUEDUCT
DELTA-MENDOTA CANAL
Vernalis
Suspended Sediment (since 1960)
Turbidity (since Mar 1988)
0 4 8 12 MILES
0 4 8 12 KILOMETERS

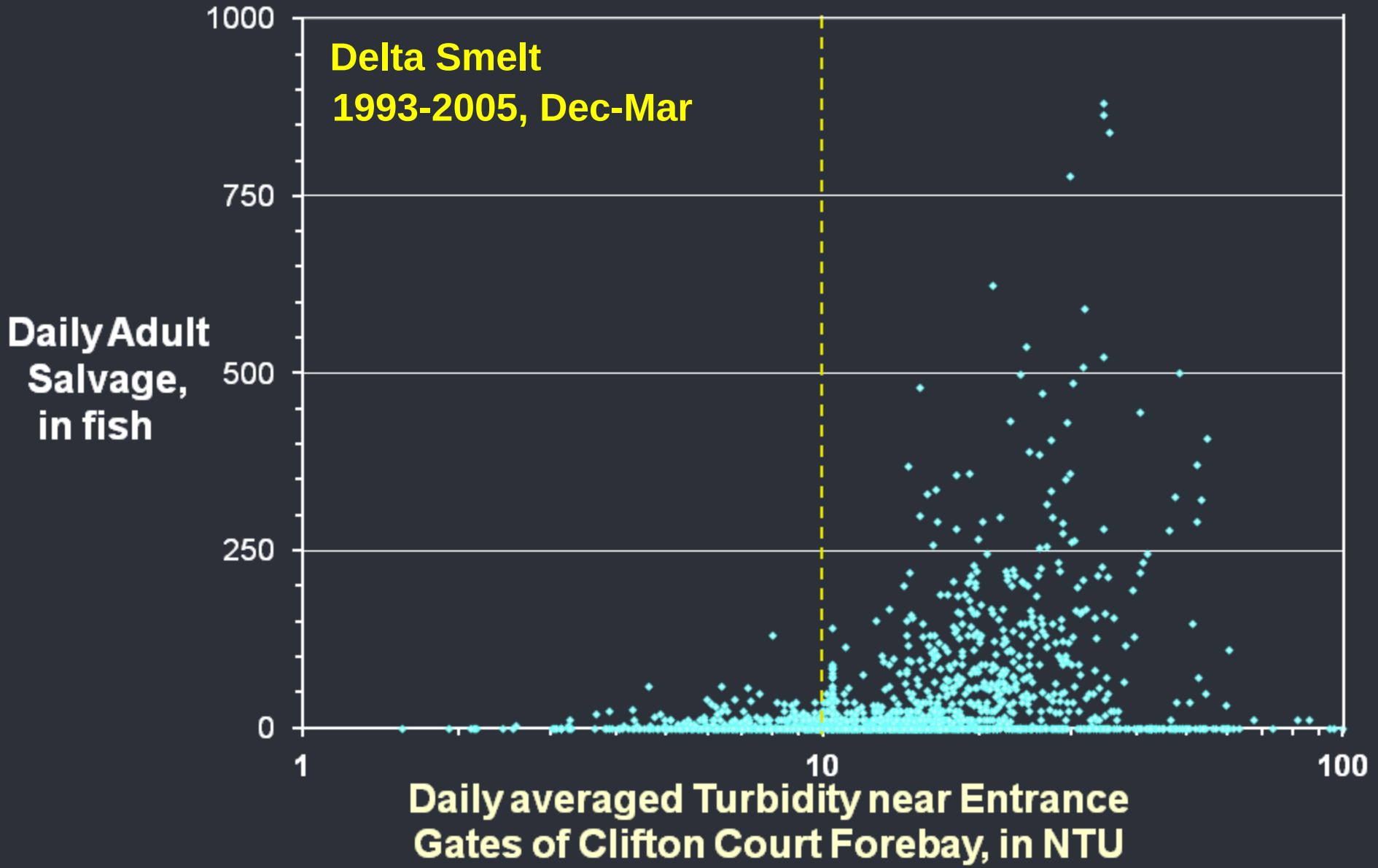

North Delta
During the first flush, sediment load from the Sacramento River enters the central Delta from the mouth of the Mokelumne R. via Georgiana Sl.
Liberty Is.
Sacramento Ship Ch.
Miner Slough
Sutter Sl.
Slough
Steamboat
Sacramento R
Snodgrass
Sl.
Delta Cross Channel
Cache Slough
Sl.
Georgiana
N. Fork Mokelumne R.
Mokelumne R.
River
Mokelumne River
S. Fork
Little Potato Slough
Sacramento
River
San Joaquin
Franks Tract
Old R.
Middle R.

Probability of Catching Delta Smelt in FMWT



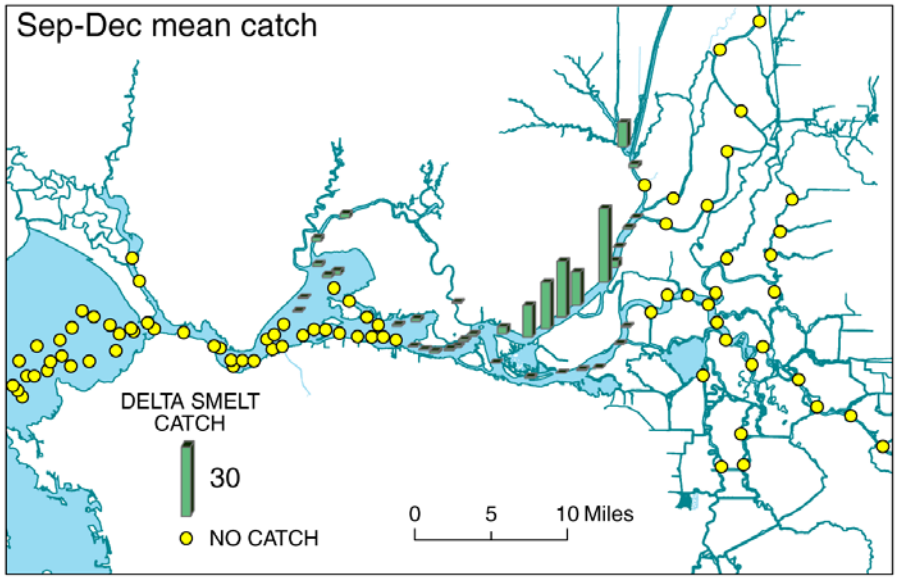


Turbidity vs Adult Delta Smelt Salvage

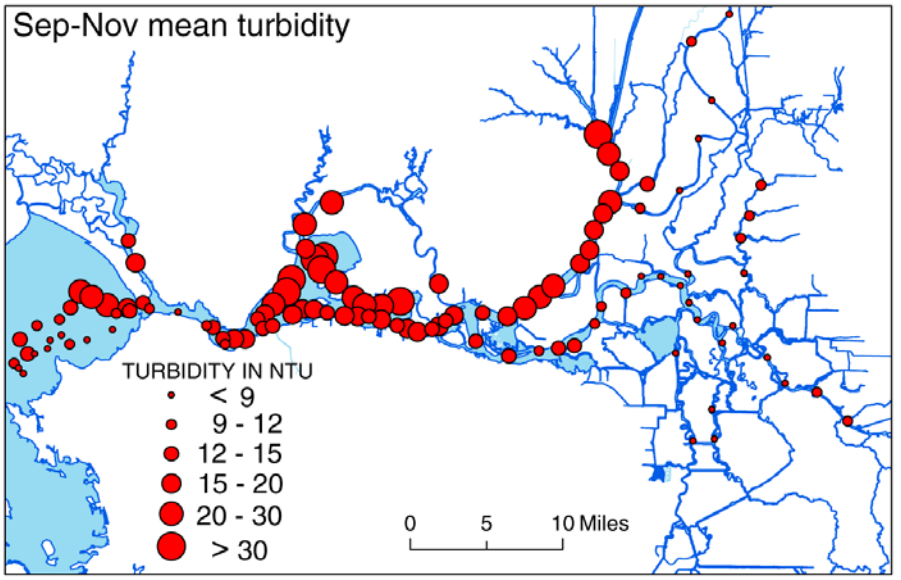


Typical Change in Delta Smelt and Turbidity Distributions from Fall to Winter during a POD Year

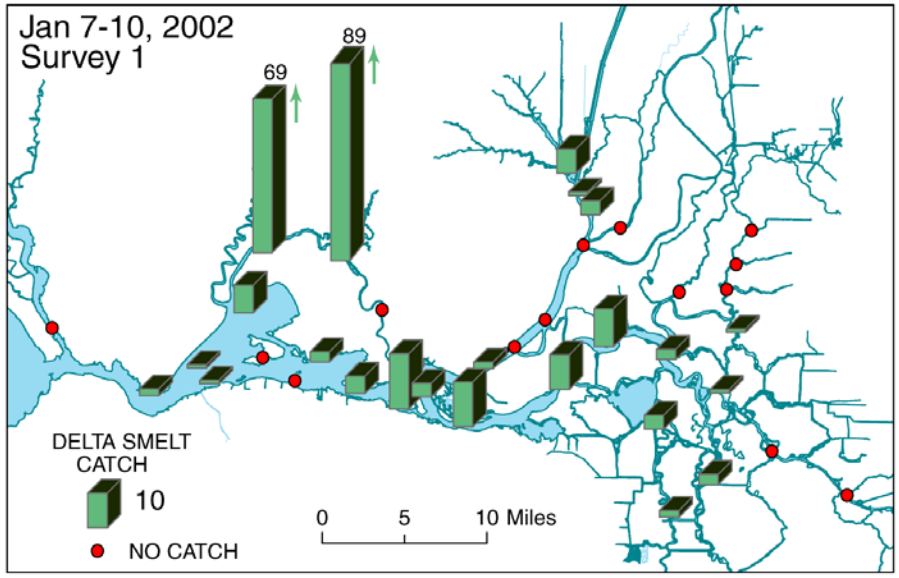
2001 Fall Mid-Water Trawl



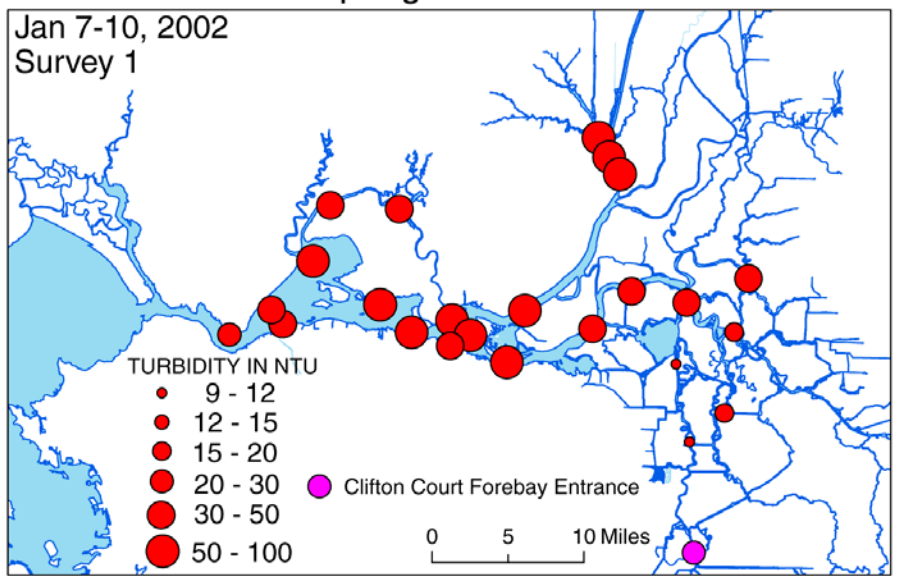
2001 Fall Mid-Water Trawl



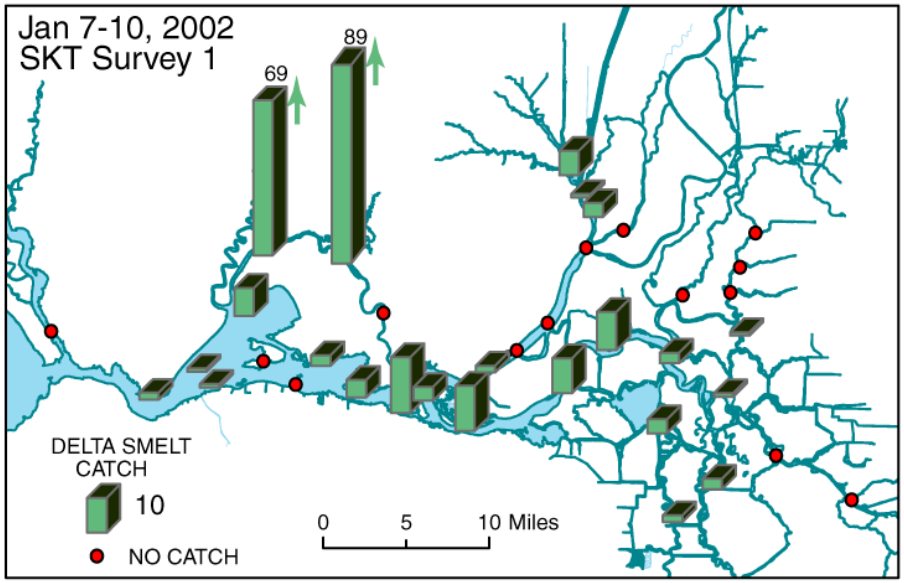
2002 Spring Kodiak Trawl

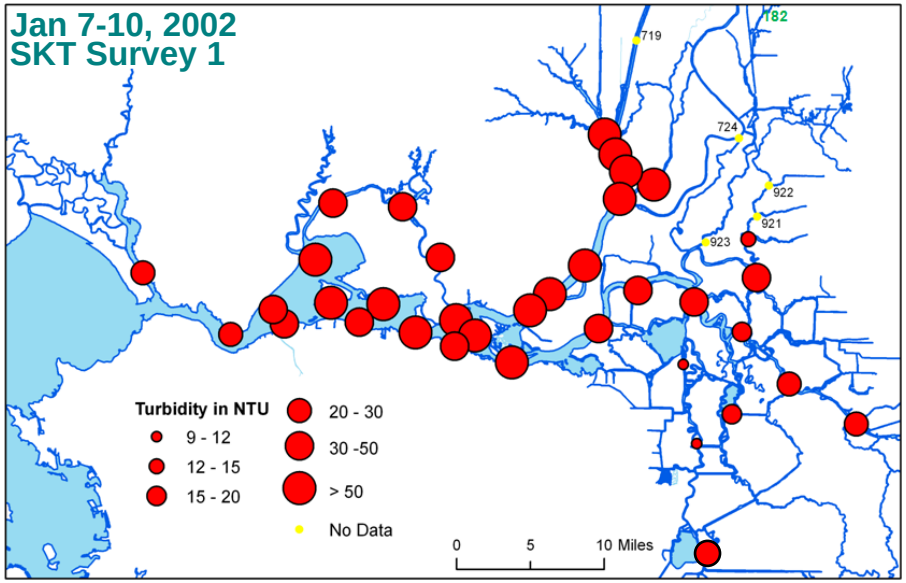


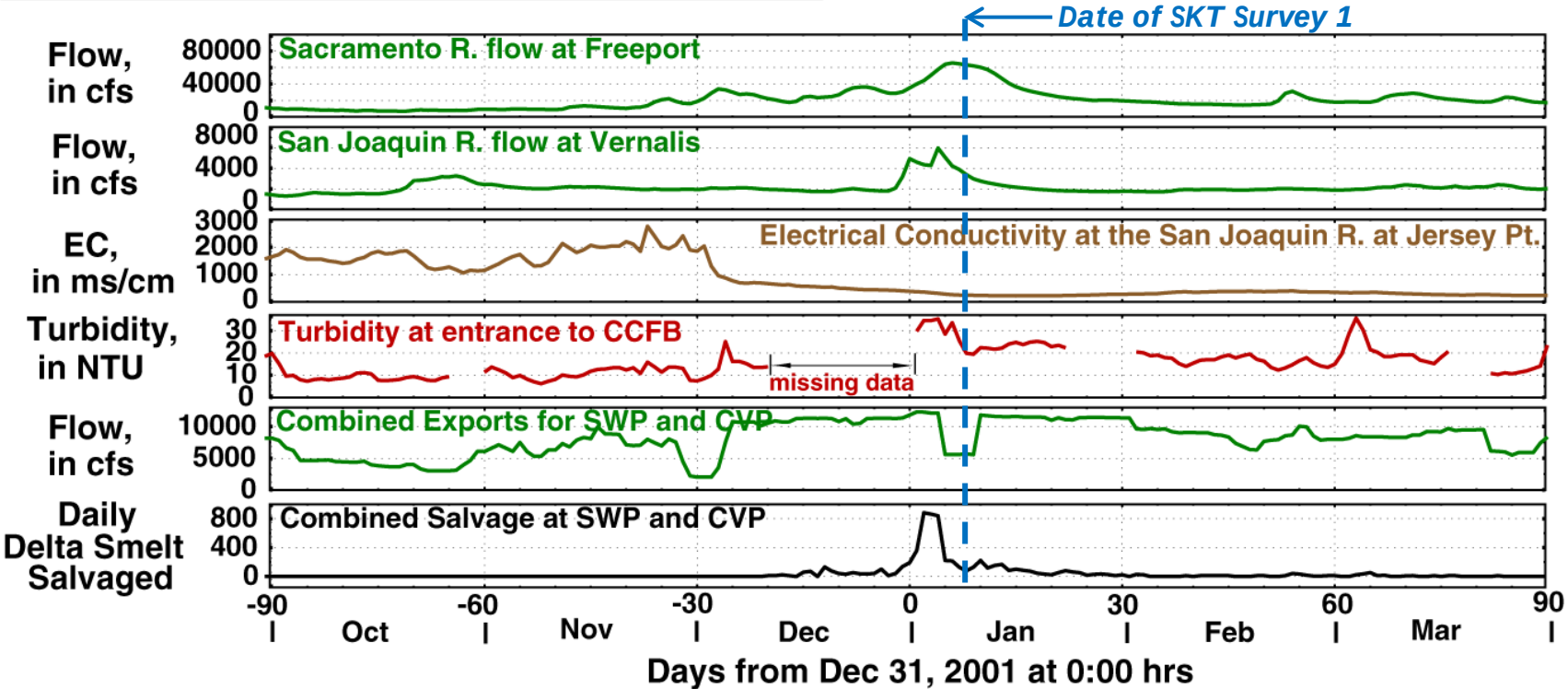
2002 Spring Kodiak Trawl



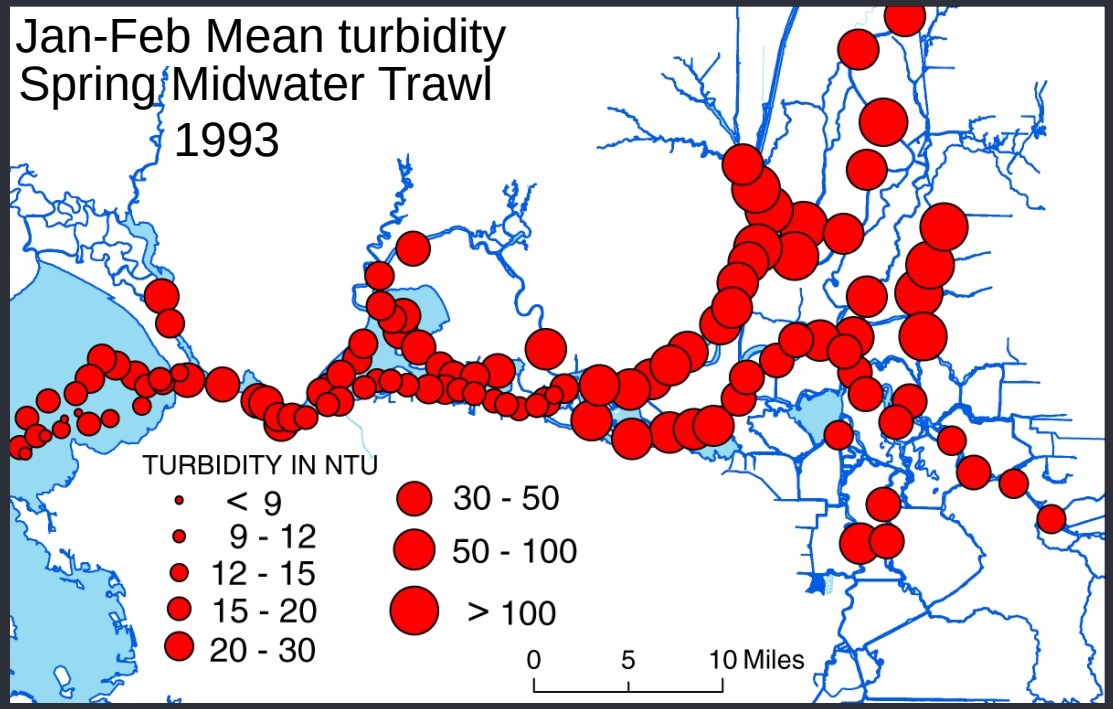
WY 2002

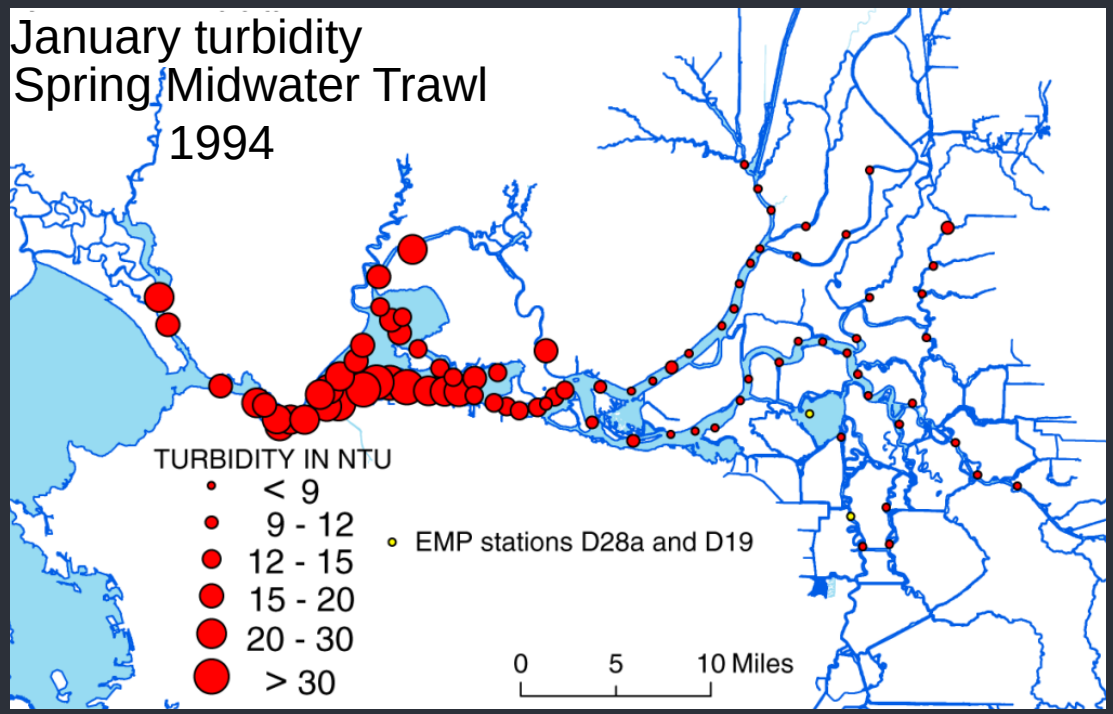

Jan 7-10, 2002
SKT Survey 1
69
89
DELTA SMELT CATCH
10
NO CATCH
0 5 10 Miles

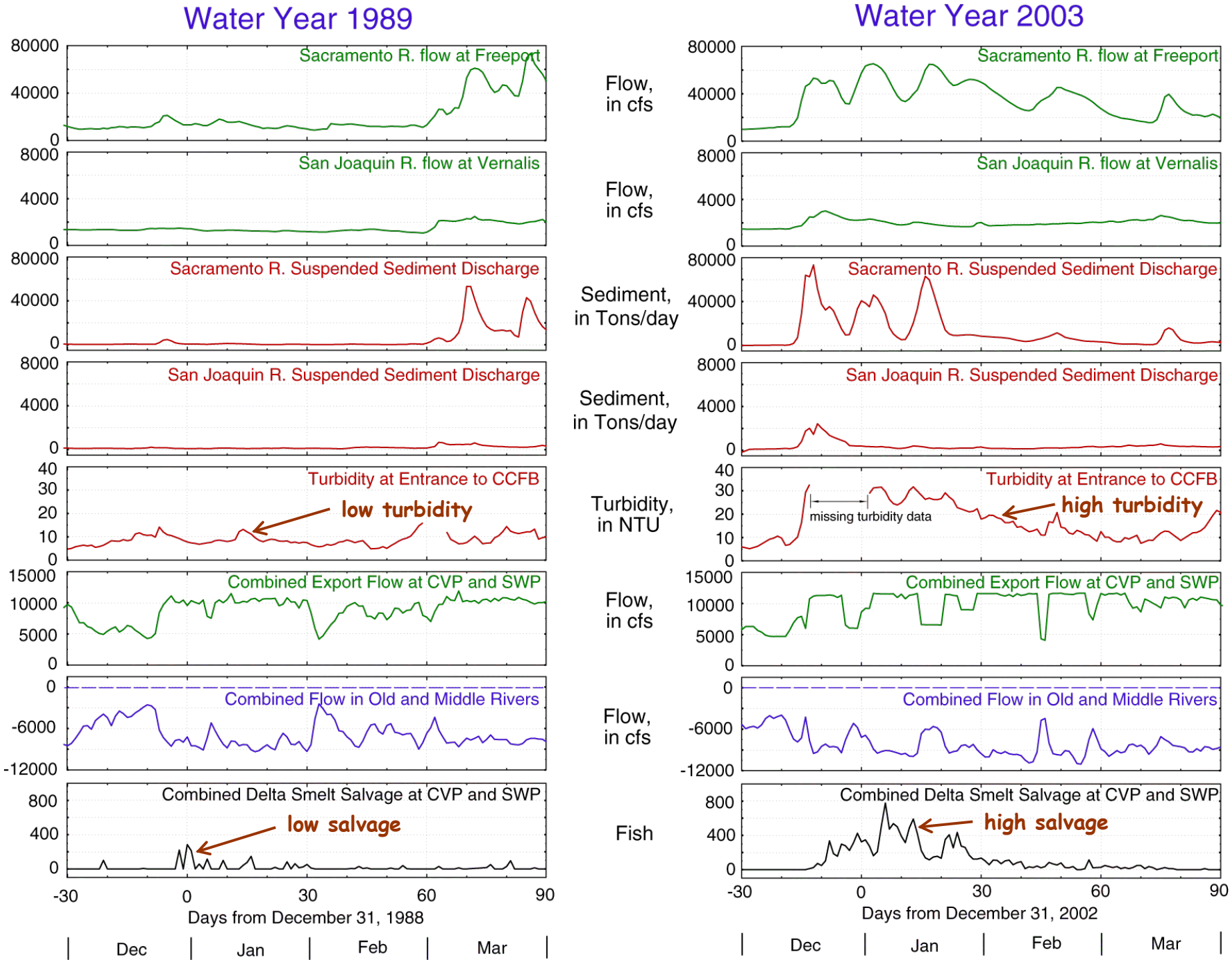

Jan 7-10, 2002
SKT Survey 1
719
724
922
921
923
Turbidity in NTU
9 - 12
12 - 15
15 - 20
20 - 30
30 -50
> 50
No Data
0 5 10 Miles


Date of SKT Survey 1
Flow, in cfs
Sacramento R. flow at Freeport
80000
40000
0
Flow, in cfs
San Joaquin R. flow at Vernalis
8000
4000
0
EC, in ms/cm
Electrical Conductivity at the San Joaquin R. at Jersey Pt.
3000
2000
1000
0
Turbidity, in NTU
Turbidity at entrance to CCFB
missing data
30
20
10
0
Flow, in cfs
Combined Exports for SWP and CVP
10000
5000
0
Daily Delta Smelt Salvaged
Combined Salvage at SWP and CVP
800
400
0
-90 Oct -60 Nov -30 Dec 0 Jan 30 Feb 60 Mar 90
Days from Dec 31, 2001 at 0:00 hrs

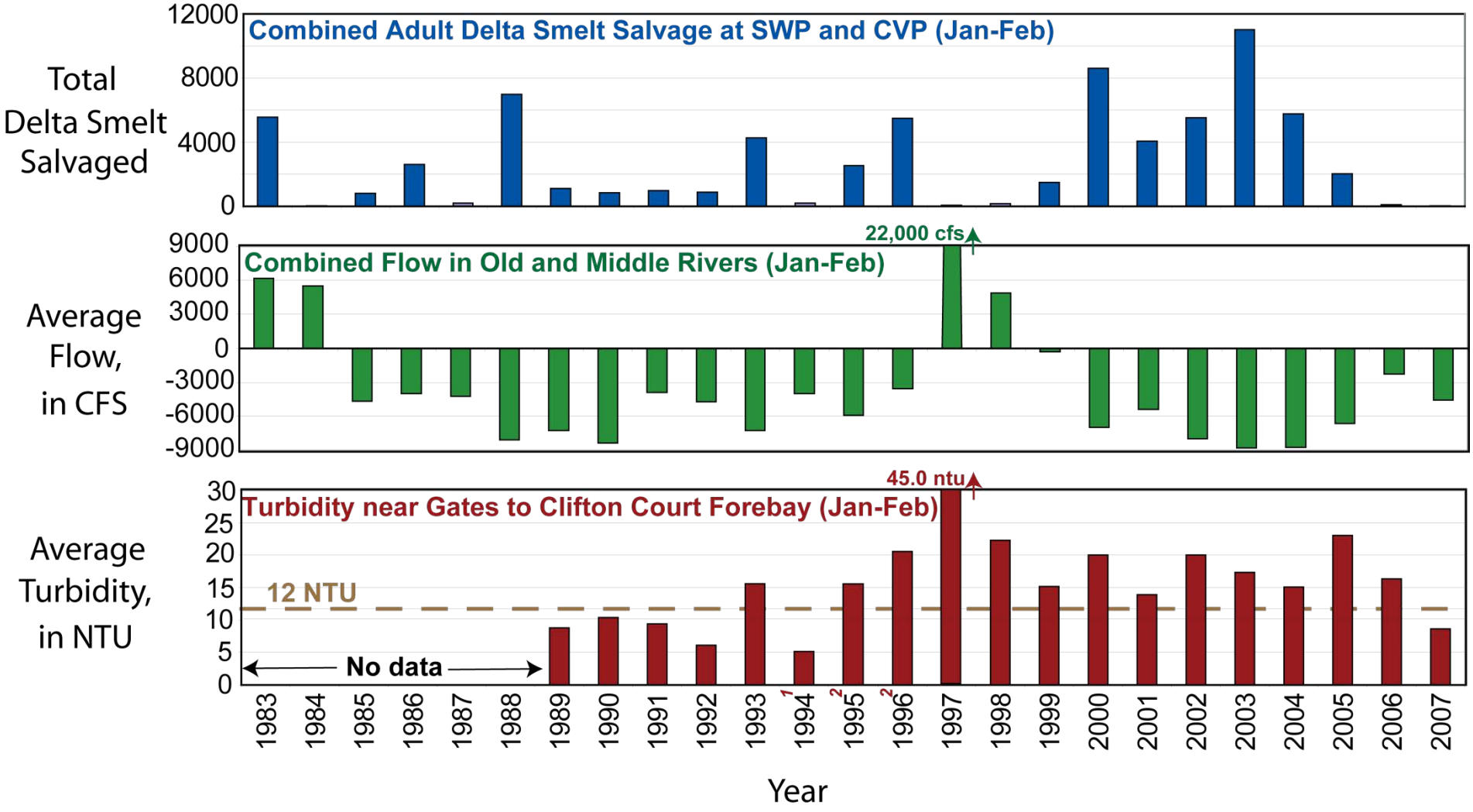
The difference between a wet and dry winter can be dramatic






Water Year 1989
Water Year 2003
Sacramento R. flow at Freeport
San Joaquin R. flow at Vernalis
Sacramento R. Suspended Sediment Discharge
San Joaquin R. Suspended Sediment Discharge
Turbidity at Entrance to CCFB
low turbidity
Combined Export Flow at CVP and SWP
Combined Flow in Old and Middle Rivers
Combined Delta Smelt Salvage at CVP and SWP
low salvage
Flow, in cfs
Sediment, in Tons/day
Turbidity, in NTU
Fish
missing turbidity data
high turbidity
high salvage
80000
40000
0
8000
4000
40
30
20
10
15000
10000
5000
-6000
-12000
800
400
-30
0
30
60
90
Days from December 31, 1988
Days from December 31, 2002
Dec
Jan
Feb
Mar

Salvage, OMR Flows, and South Delta Turbidity

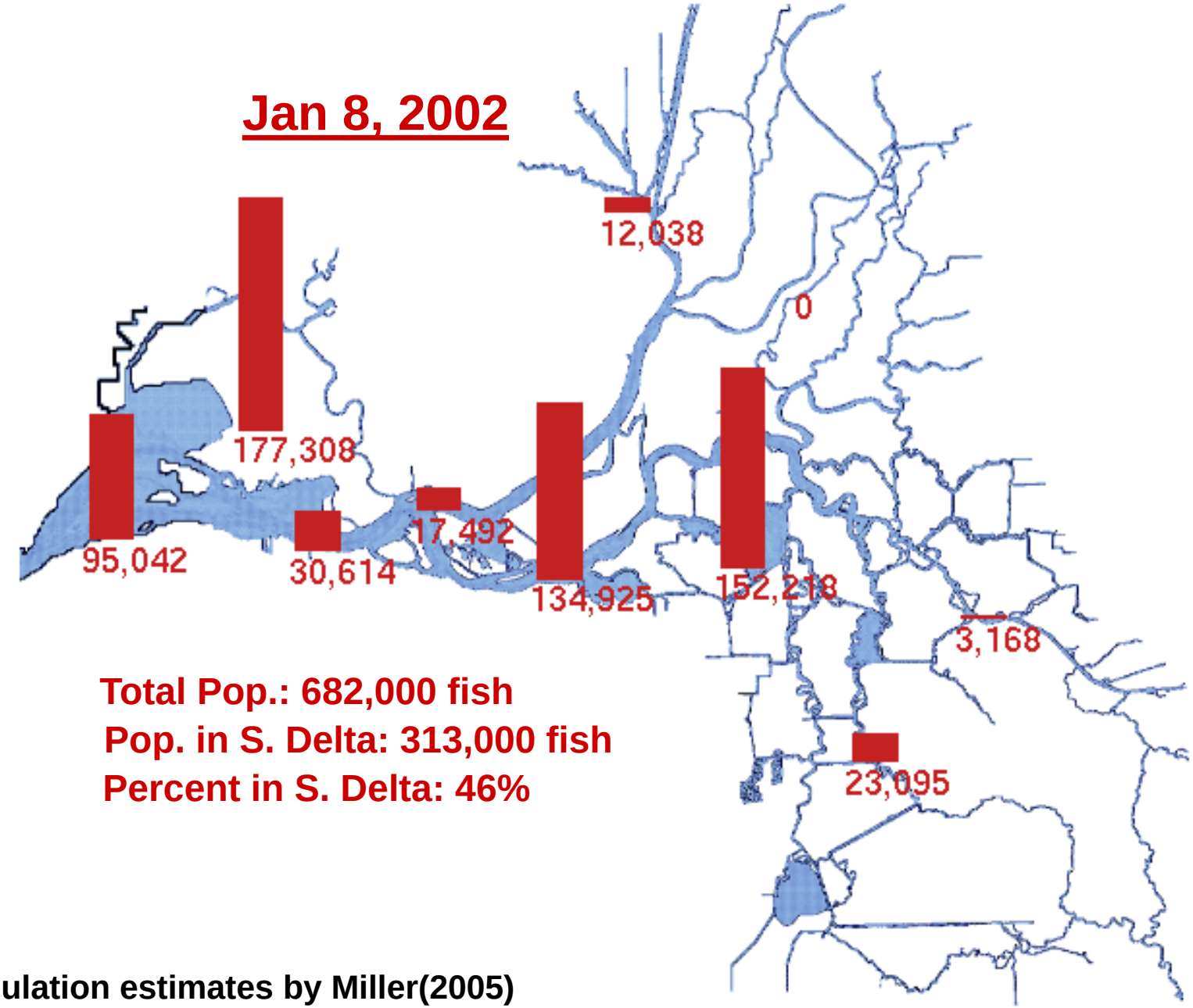


Note: Delta smelt population size, SJR flow, and XGEO also can affect the magnitude of winter salvage

Population in the South Delta

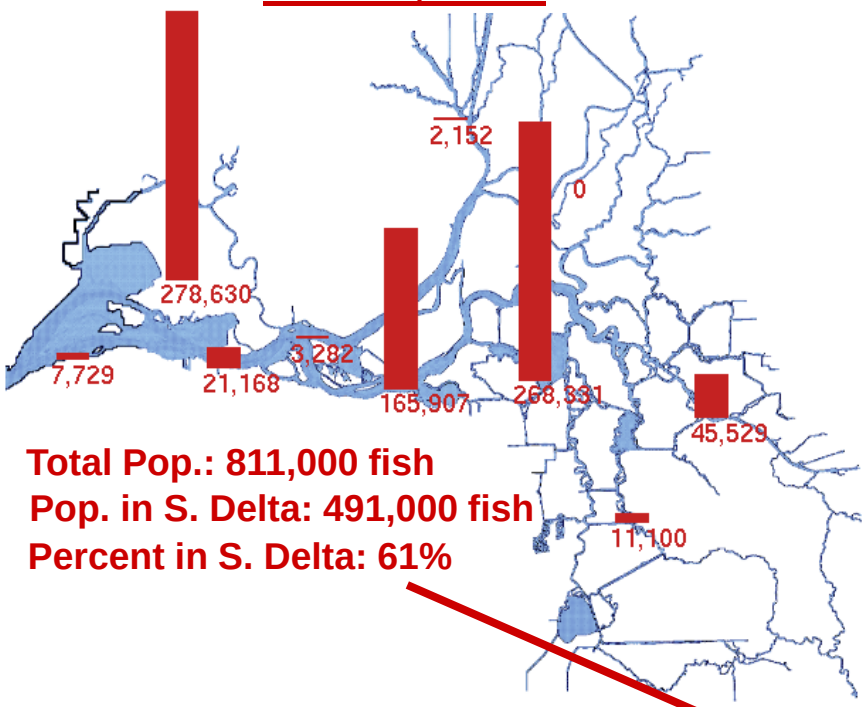
Are there periods when the number of Delta Smelt within the zone of entrainment of the pumps are a sizeable percentage of the population?

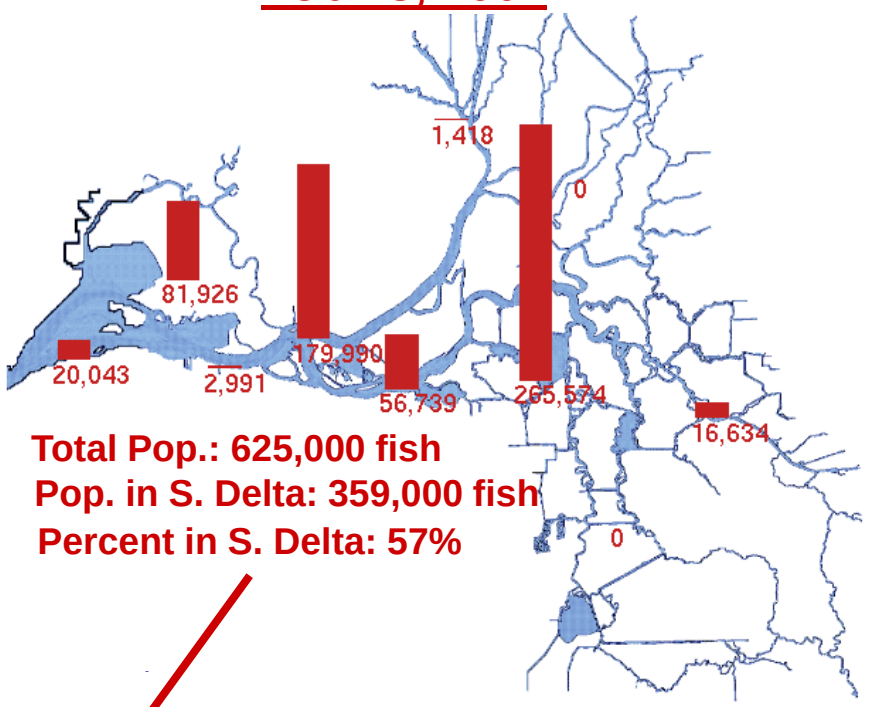
Delta Smelt Population Estimates by Area

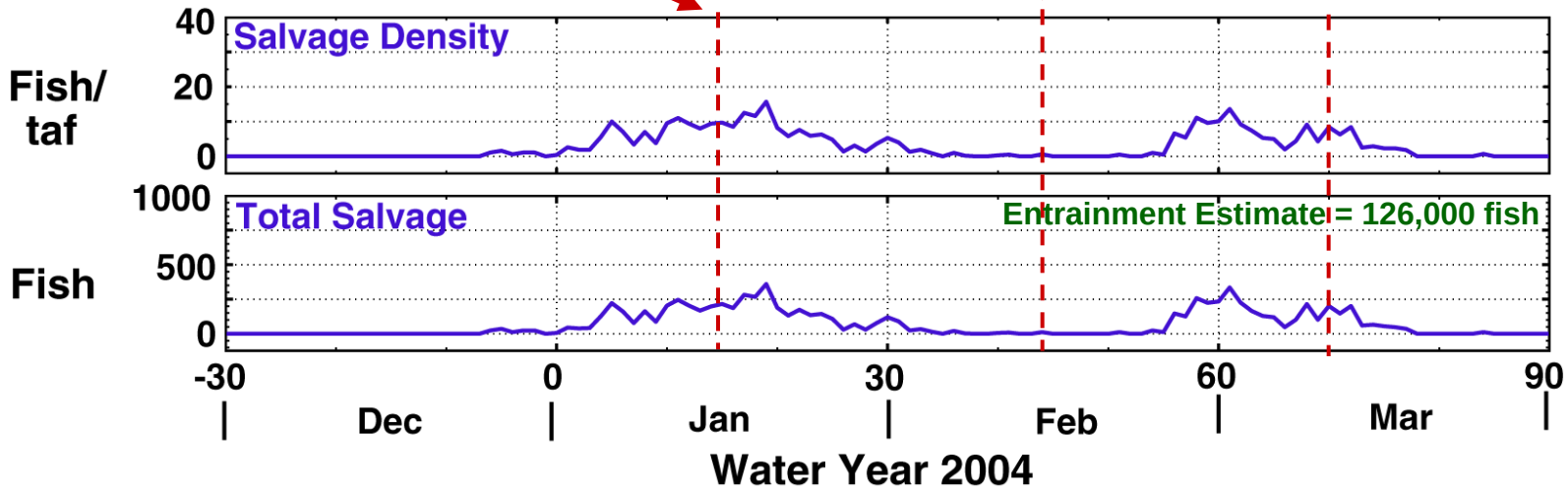


Note: Population estimates by Miller(2005)

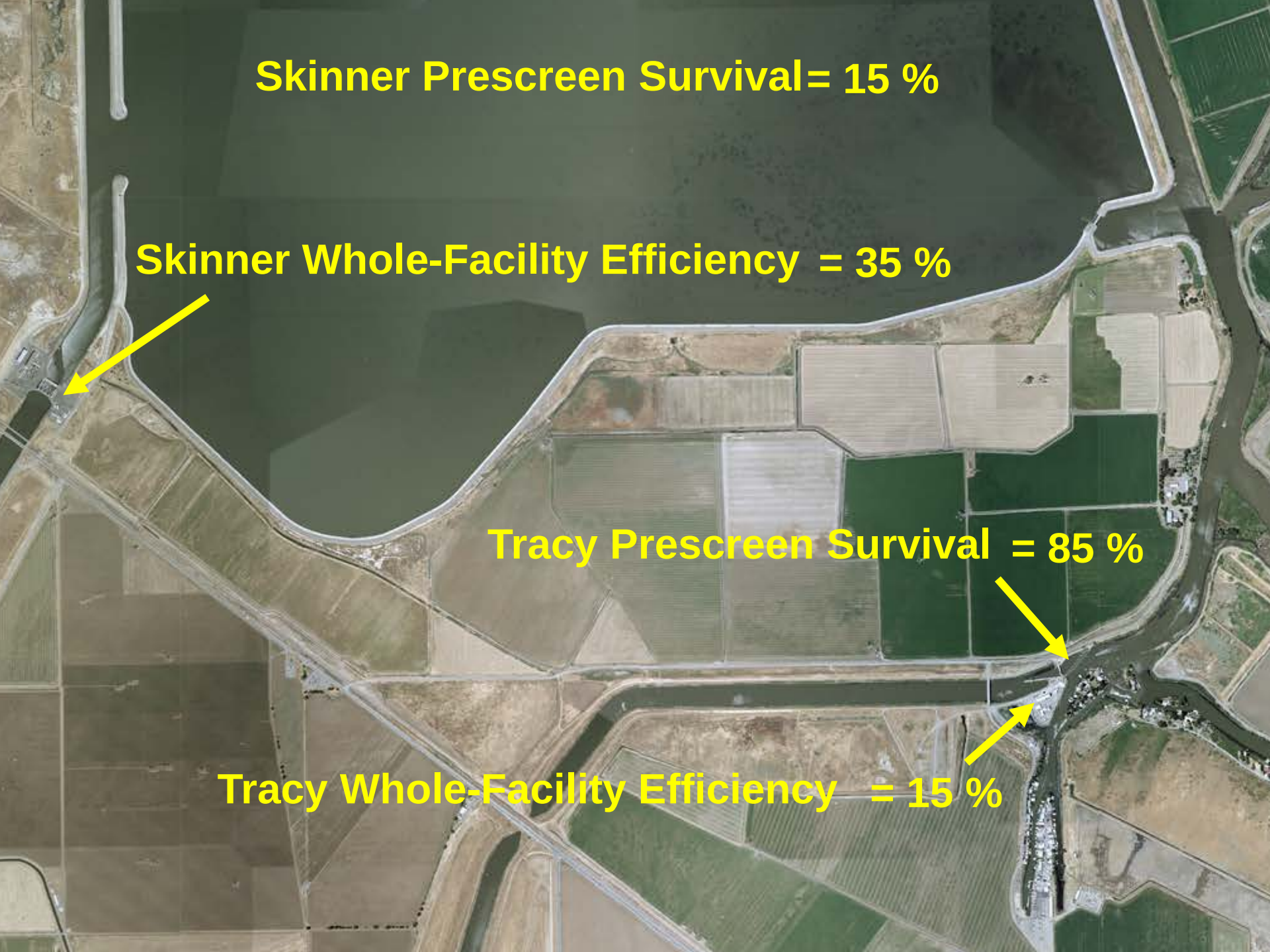
2004 Spring Kodiak Trawl Surveys and Salvage

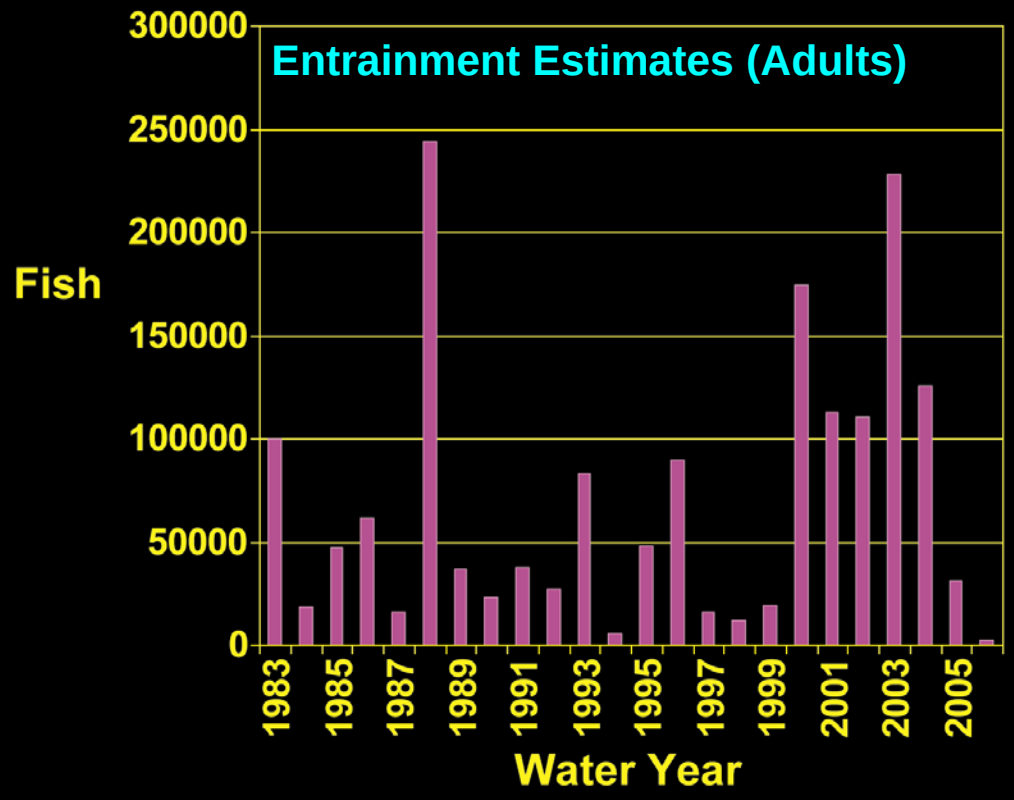


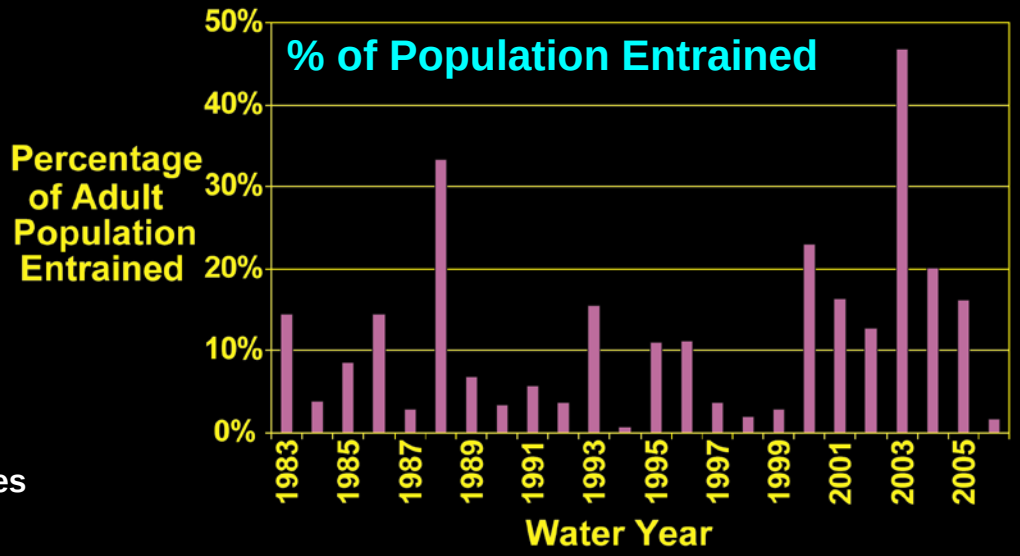




Why is it so difficult to convert salvage and distribution data to percent of the population entrained?

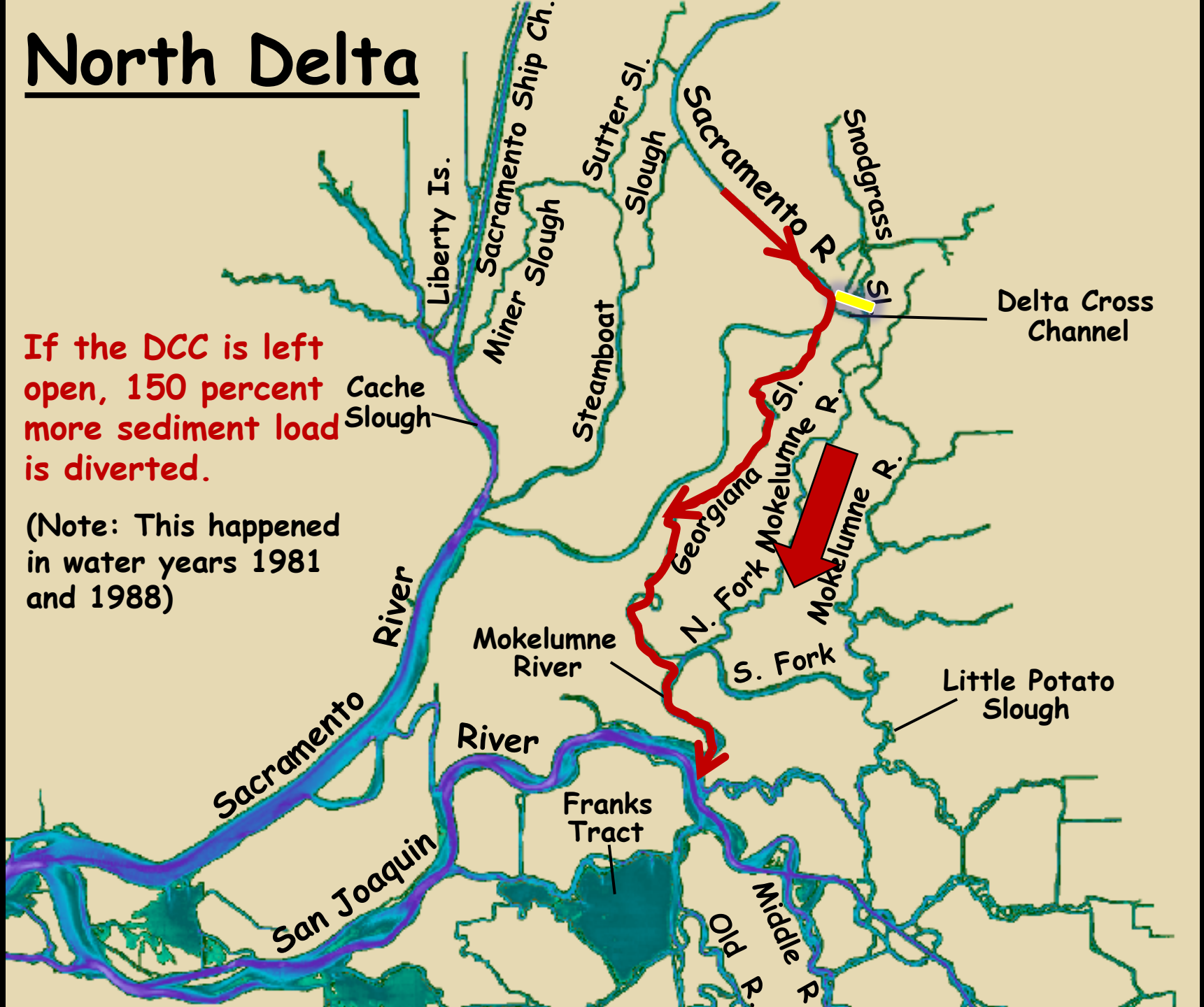

Skinner Prescreen Survival= 15 %
Skinner Whole-Facility Efficiency = 35 %
Tracy Prescreen Survival = 85 %
Tracy Whole-Facility Efficiency = 15 %





Note: Population estimates from Miller(2005)

One final comment before summarizing…


North Delta
If the DCC is left open, 150 percent more sediment load is diverted.
(Note: This happened in water years 1981 and 1988)
Liberty Is.
Sacramento Ship Ch.
Miner Slough
Sutter Sl.
Slough
Sacramento R
Snodgrass
Sl
Delta Cross Channel
Steamboat
Cache Slough
Georgiana Sl.
N. Fork Mokelumne R.
Mokelumne R.
River
Mokelumne River
S. Fork
Little Potato Slough
Sacramento
River
San Joaquin
Franks Tract
Old R
Middle R

Summary and Conclusions

1. OMR reverse flows, south Delta turbidity, and the number of delta smelt remaining in the ZOE for the pumps are a good predictor of adult delta smelt salvage.

2. In the Delta, turbidity is often highest during the “first flush” of winter when river inflows carry large suspended sediment loads.

Summary and Conclusions (cont'd)

3. Entrainment loss is most significant during years when the adult, larval, and juvenile life stages are all affected. Because no salvage data are available for larvae, either OMR flows or particle-tracking models must be used to estimate loss.

Summary and Conclusions (cont'd)

4. In the 7 years[1] since 1980 when entrainment losses are judged to be most significant, the year-over-year change in the FMWT Index was down in 6 of those years by an average of 48 percent. In the next 3 significant years,[2] the index was down in all 3 by an average of 38 percent.

[1] 7 years: 81, 88, 00, 01, 02, 03, 04

[2] Next 3 years: 82, 85, 05

Summary and Conclusions (cont'd)

5. There are years, such as 1992, 1994, and 1996, when very large year-over-year declines in the FMWT index occurred that appear to be unrelated to entrainment loss.

6. Entrainment effects on delta smelt are difficult to quantify because of uncertainty in estimating the population size and numbers of fish entrained.

Summary and Conclusions (cont'd)

7. In managing to prevent entrainment loss, it might be wise to close the DCC gates earlier during first flush and consider raising a temporary inflatable gate in Georgiana Slough for the first 1 to 2 weeks (only) of first flush to divert suspended sediment away from the south Delta.