What can the salvage data tell us and not tell us about Delta smelt and Longfin smelt migration in the San Francisco Estuary

Lenny Grimaldo

California Department of Water Resources
Division of Environmental Studies/Aquatic Ecology Section

University of California Davis
Wildlife and Fisheries Conservation Biology-PhD candidate

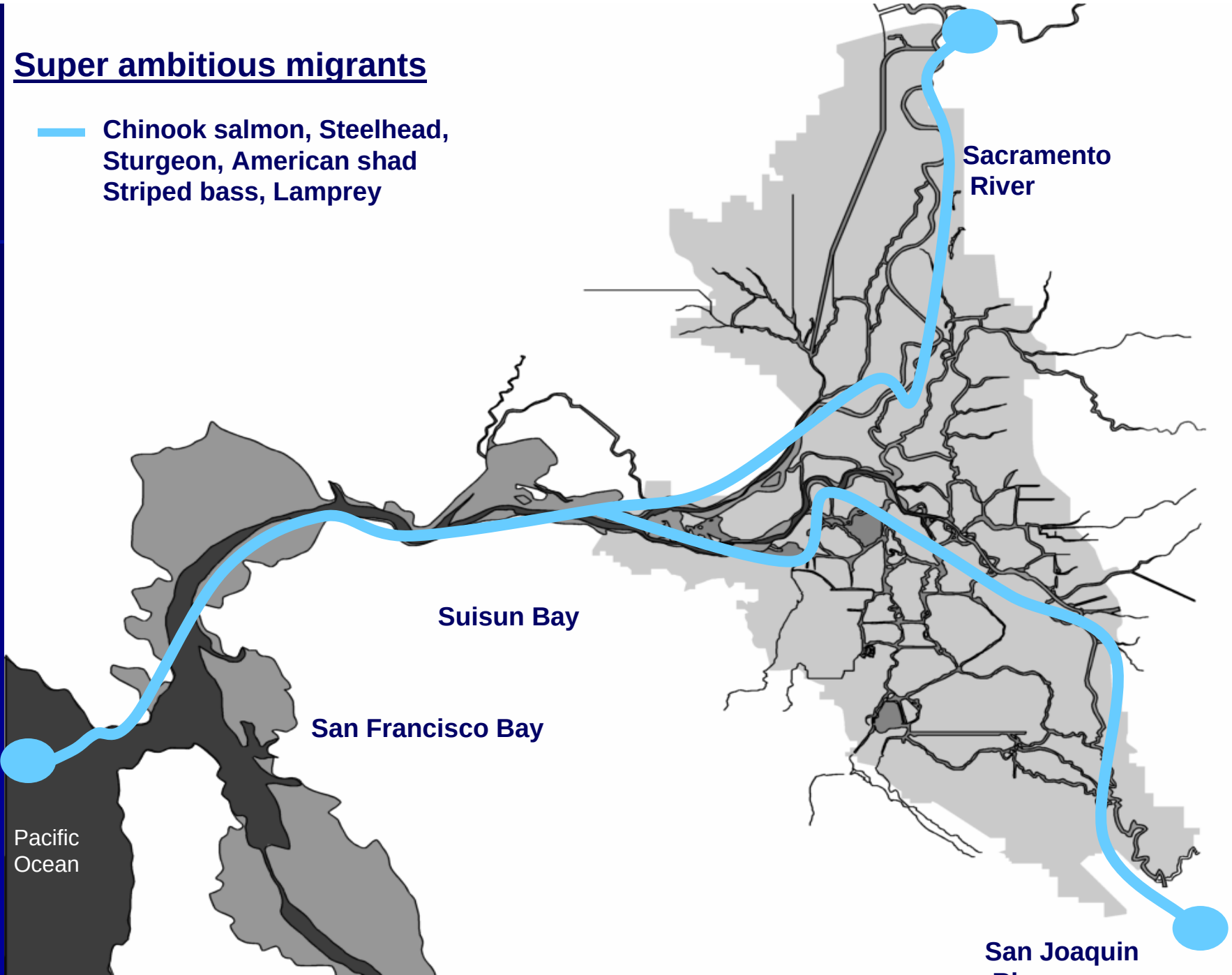
Acknowledgements

Matt Nobriga
Ted Sommer
Nick van Ark
Erika Holland
Gardner Jones
Fred Feyrer
Bruce Herbold
Pete Smith
Cathy Ruhl
Dave Fullerton
Russ Gartz
Mark Holderman
Delta Smelt Working Group

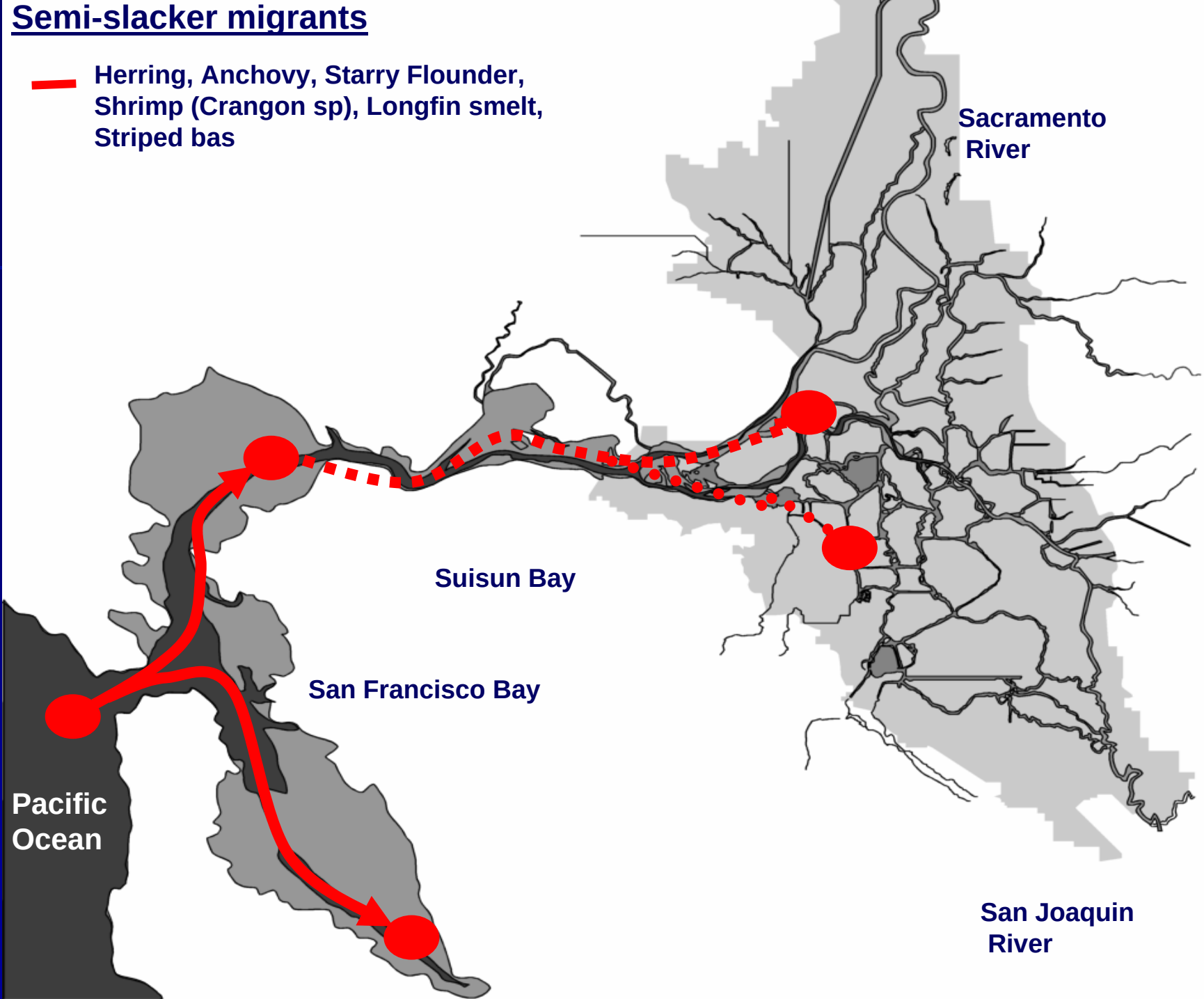
Funding source: DWR's South Delta Program
Interagency Ecological Program

Migrations are very common in the animal world

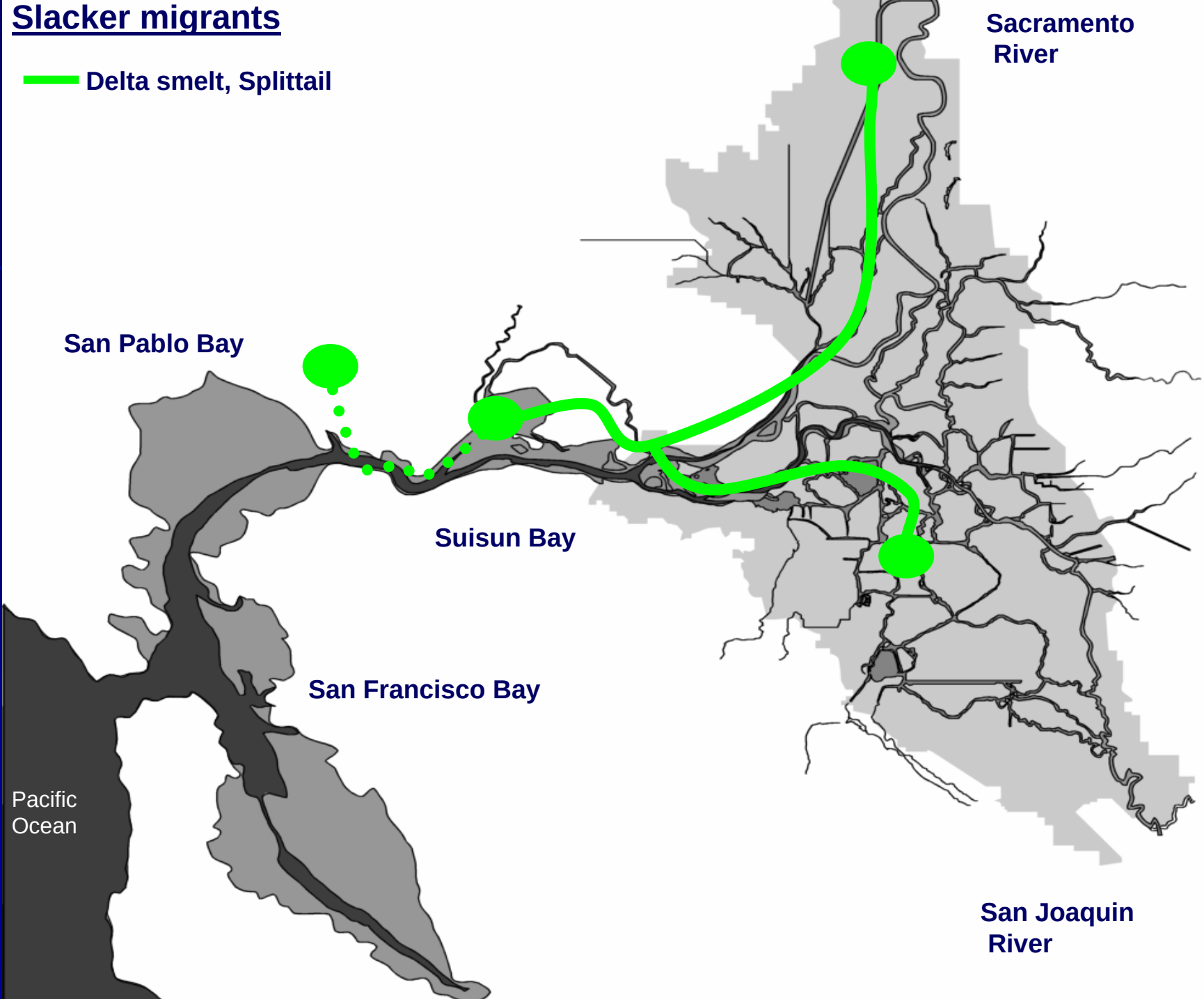
Super ambitious migrants



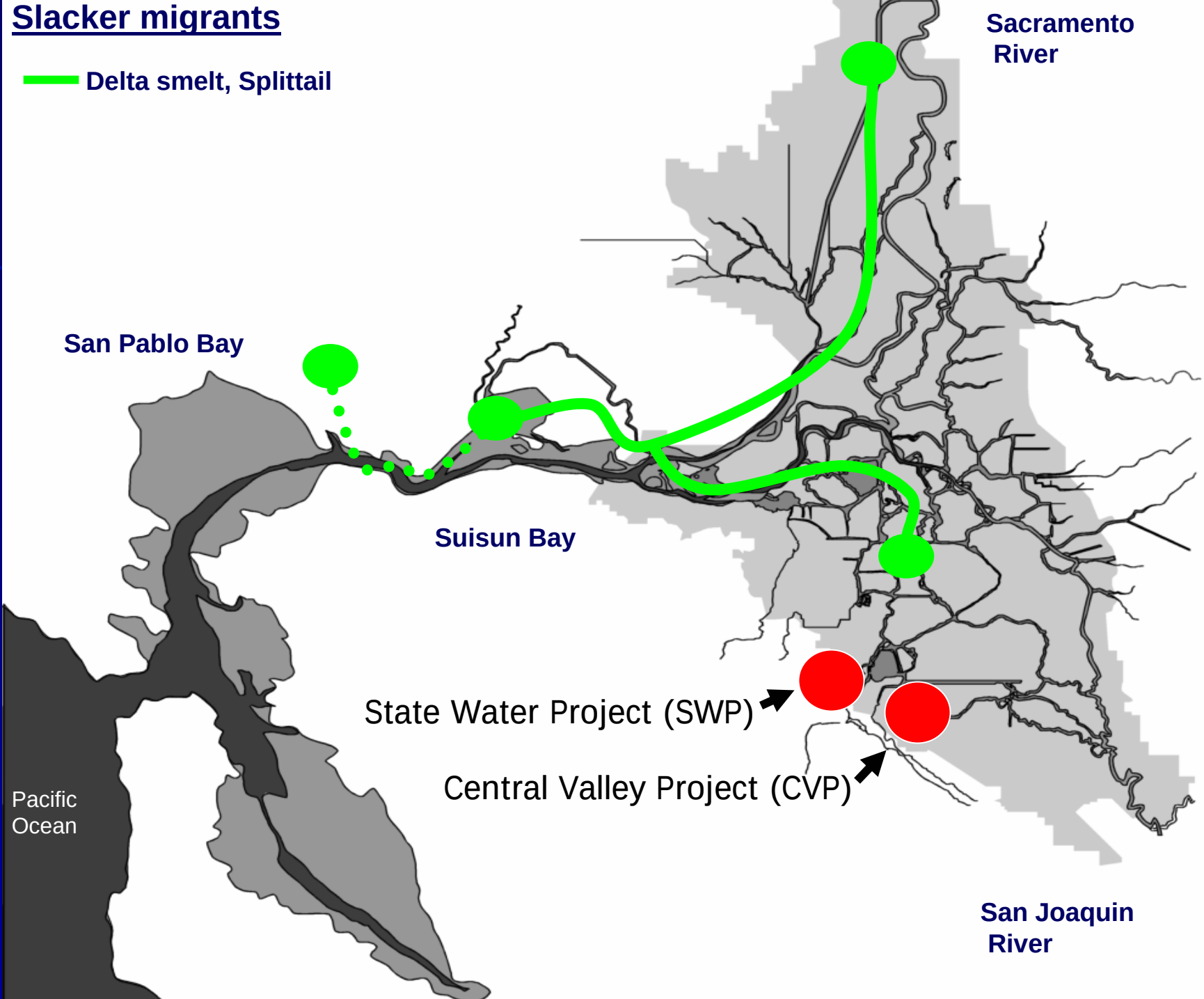
Semi-slacker migrants



Slacker migrants

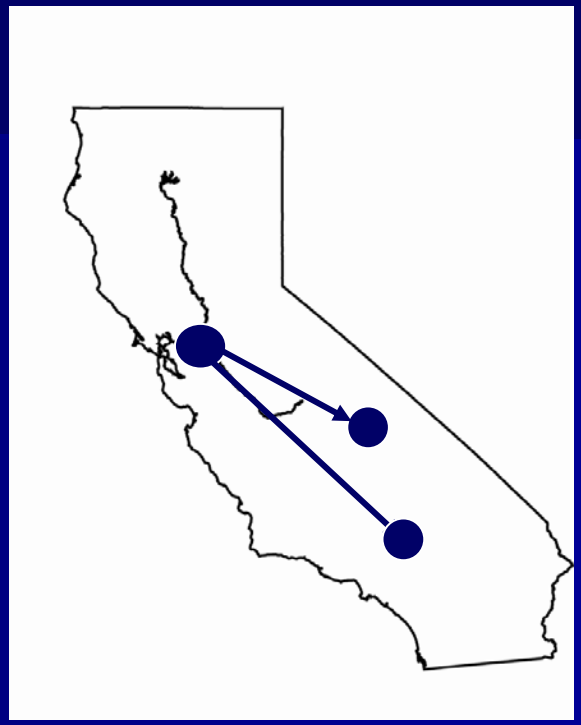


Slacker migrants



A couple of the largest water diversions in the world

SWP pumping plant (max 292 m^3/s)



CVP pumping plant (max 130 m^3/s)

~ up to 8 billion m^3/y exported
(over 2 trillion gallons)
~ 25 billion dollar agricultural industry
~ 23 million Californians

A couple of the largest water diversions in the world

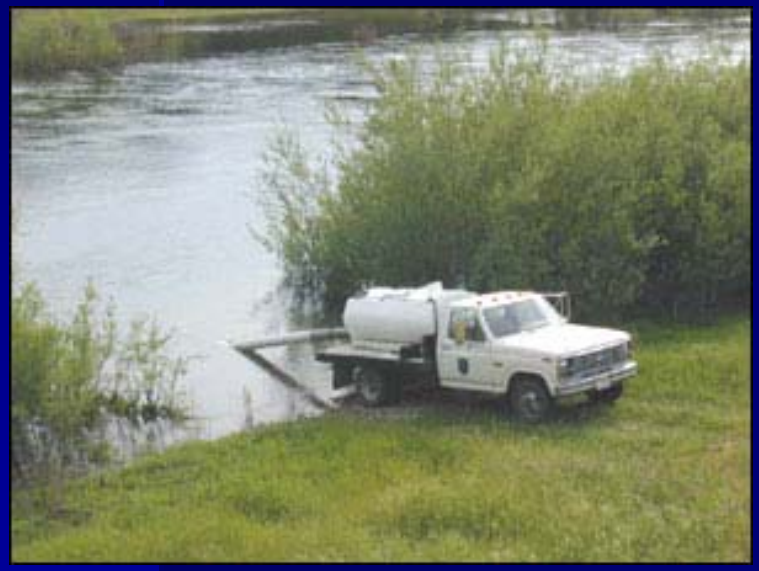
SWP pumping plant (max 292 m^3/s)

CVP pumping plant (max 130 m^3/s)

~ up to 8 billion m^3/y exported
(over 2 trillion gallons)
~ 25 billion dollar agricultural industry
~ 23 million Californians

A couple of the largest sampling devices in the world

Tracy fish facility (CVP) and
Skinner fish facility (SWP)



- Daily Fish Counts
  - -every 2 hours
  - -identified, counted, measured
  - -total counts are extrapolated per day (estimated entrainment)
  - -40 year database, most reliable for smelts after 1993

- Fish are trucked back to the Delta: salvage=impingement

- Salvage database relatively untapped (Stevens and Miller 1983, Stevens et al. 1985; Brown et al. 1996; Sommer et al. 1997; Bennett 2005; Kimmerer submitted manuscript)

My three questions today

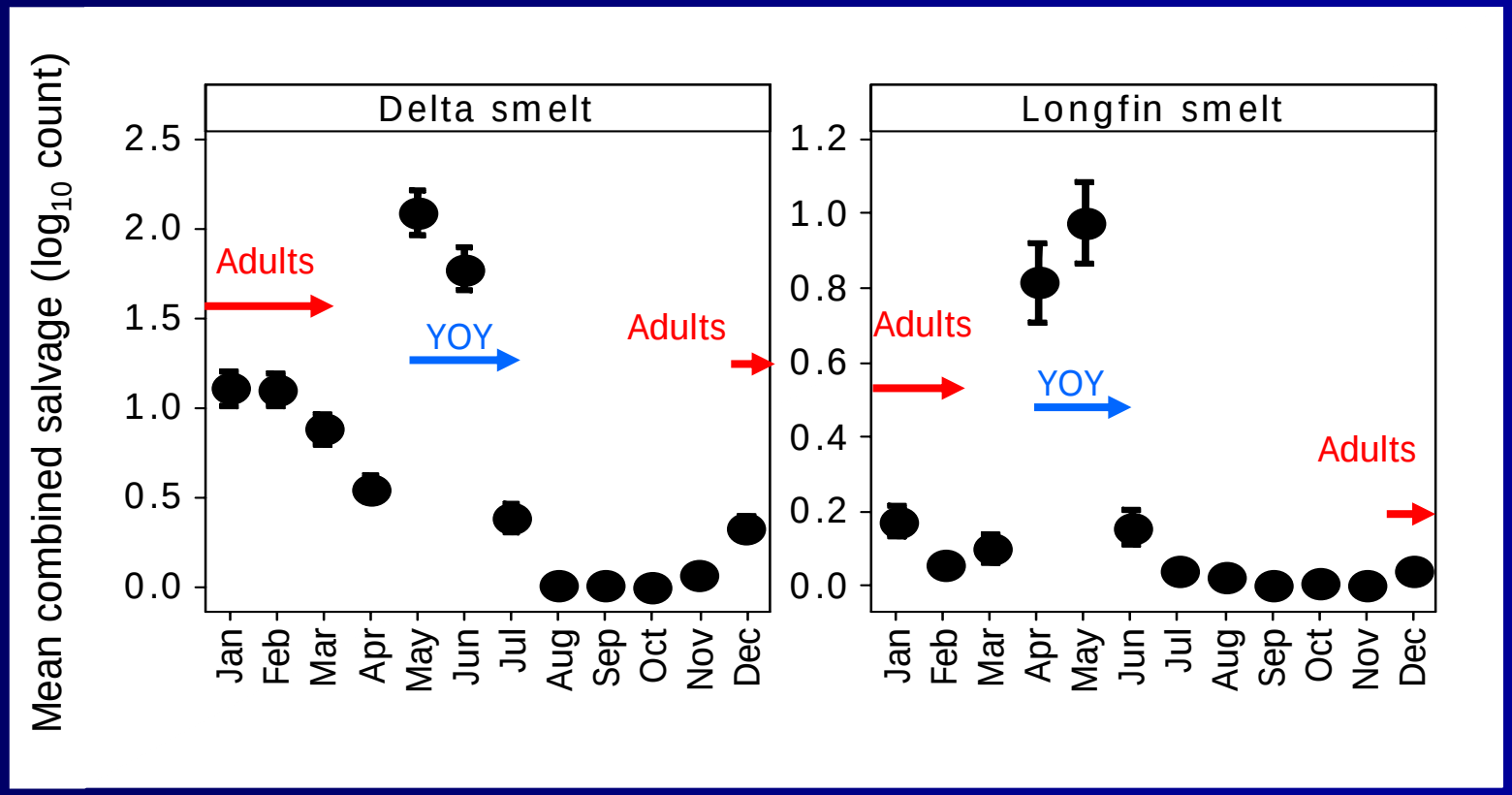
1. What can we learn (or not) about the migration of delta smelt and longfin smelt from the salvage database?

2. What are the management implications of these analyses?
   - Exports can entrain thousands of smelt (ESA concern)
   - Strategies to reduce take are needed

3. What future research is needed?

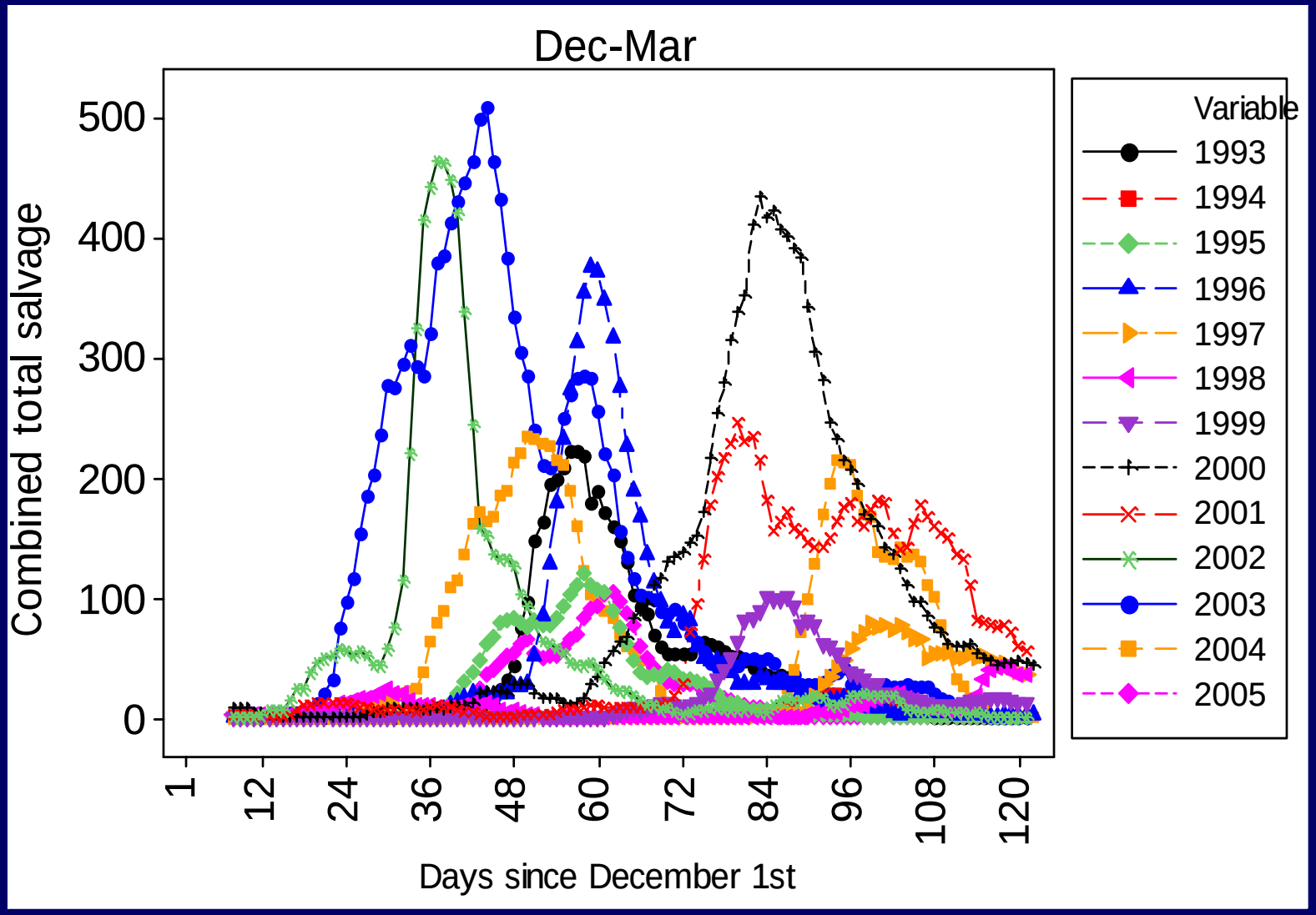
What can we learn (or not) about the migration of delta smelt and longfin smelt from the salvage database?

Salvage facilities help us identify many patterns



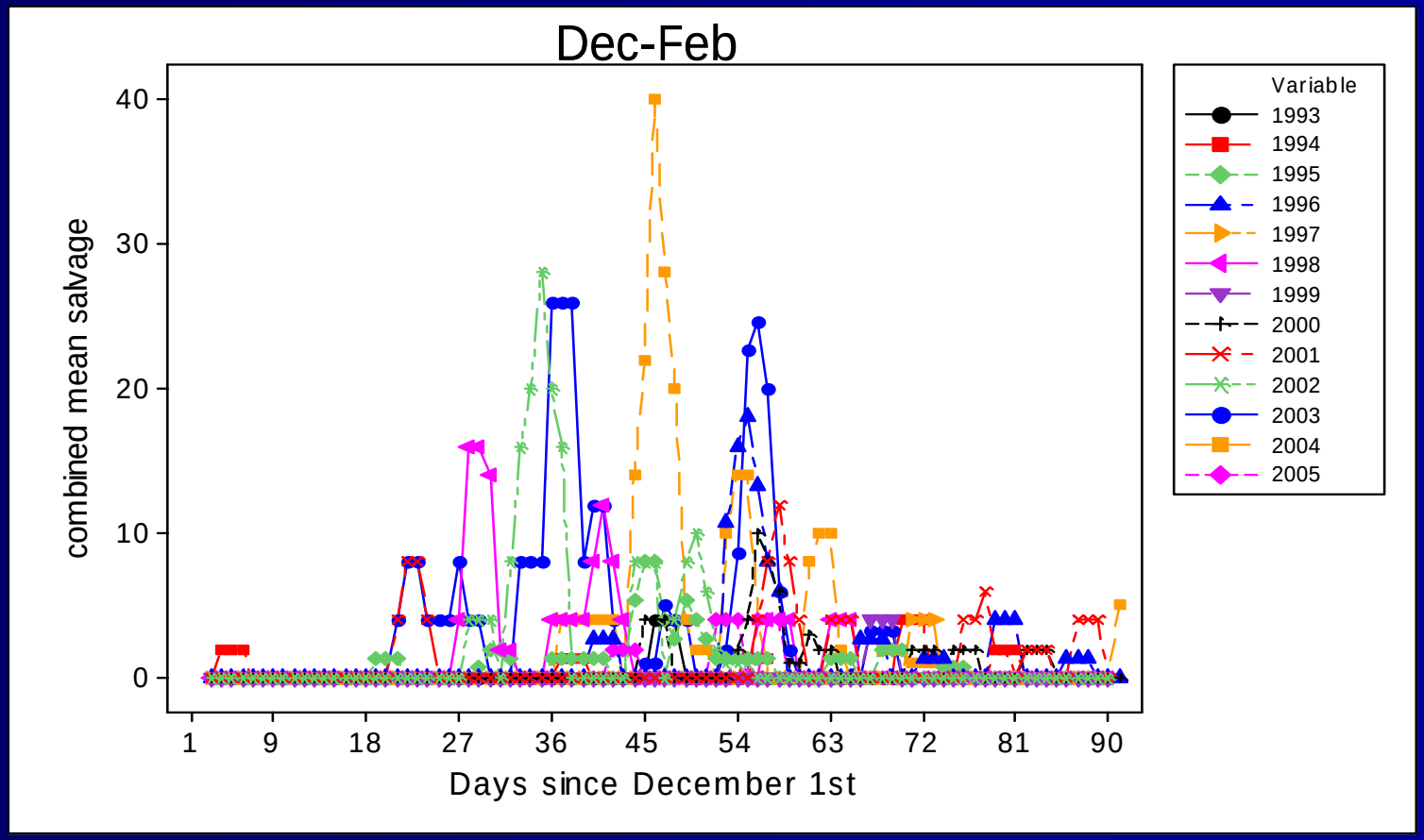
All data between 1993 and 2005

Annual adult delta smelt salvage distributions



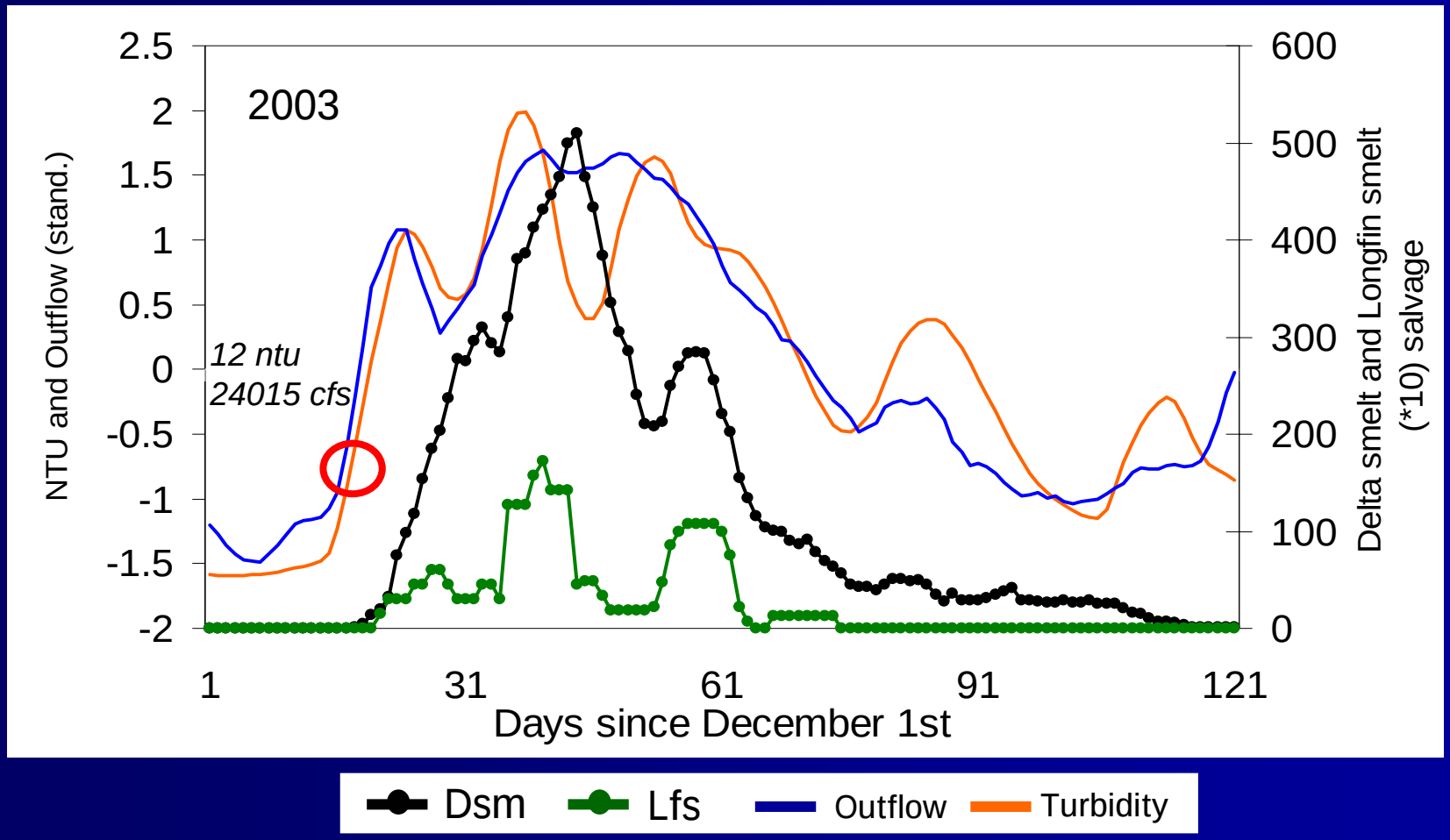
Unimodal (except 1998 and 2004), variable timing, and variable duration

Annual adult longfin smelt salvage distributions

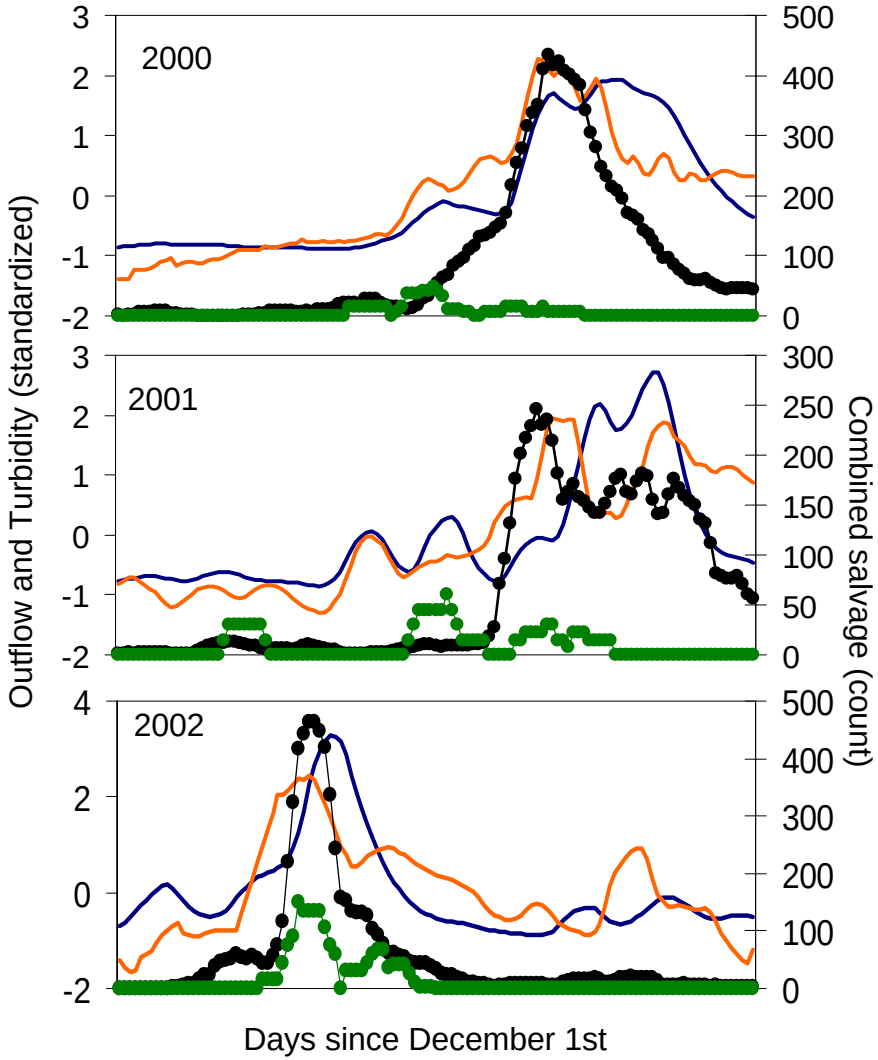


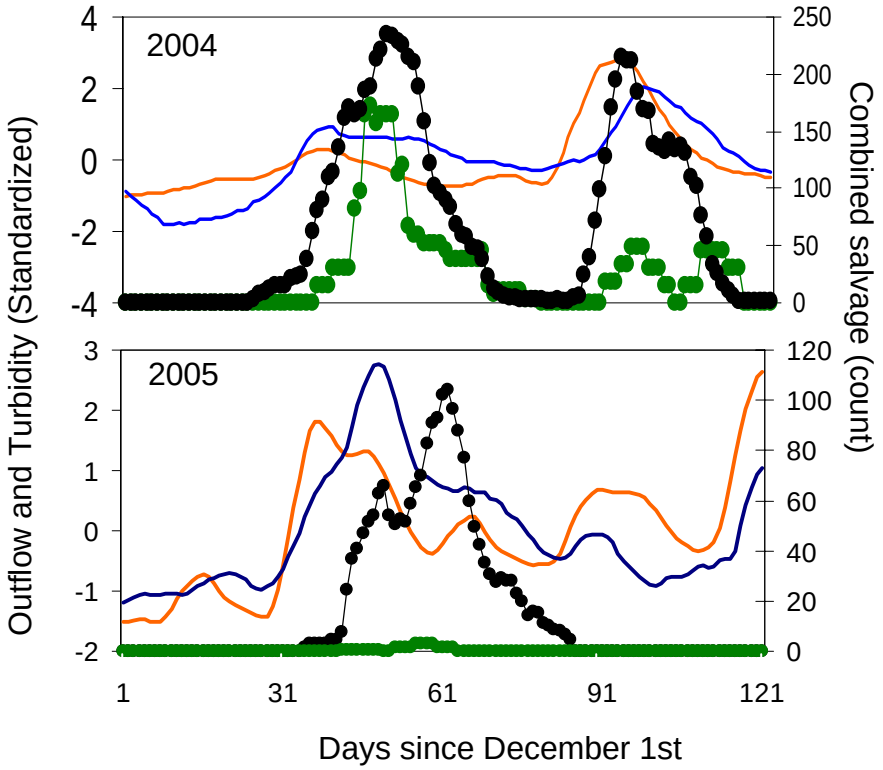
sporadic and tighter peaks

Smelt observed soon after the “First flush”



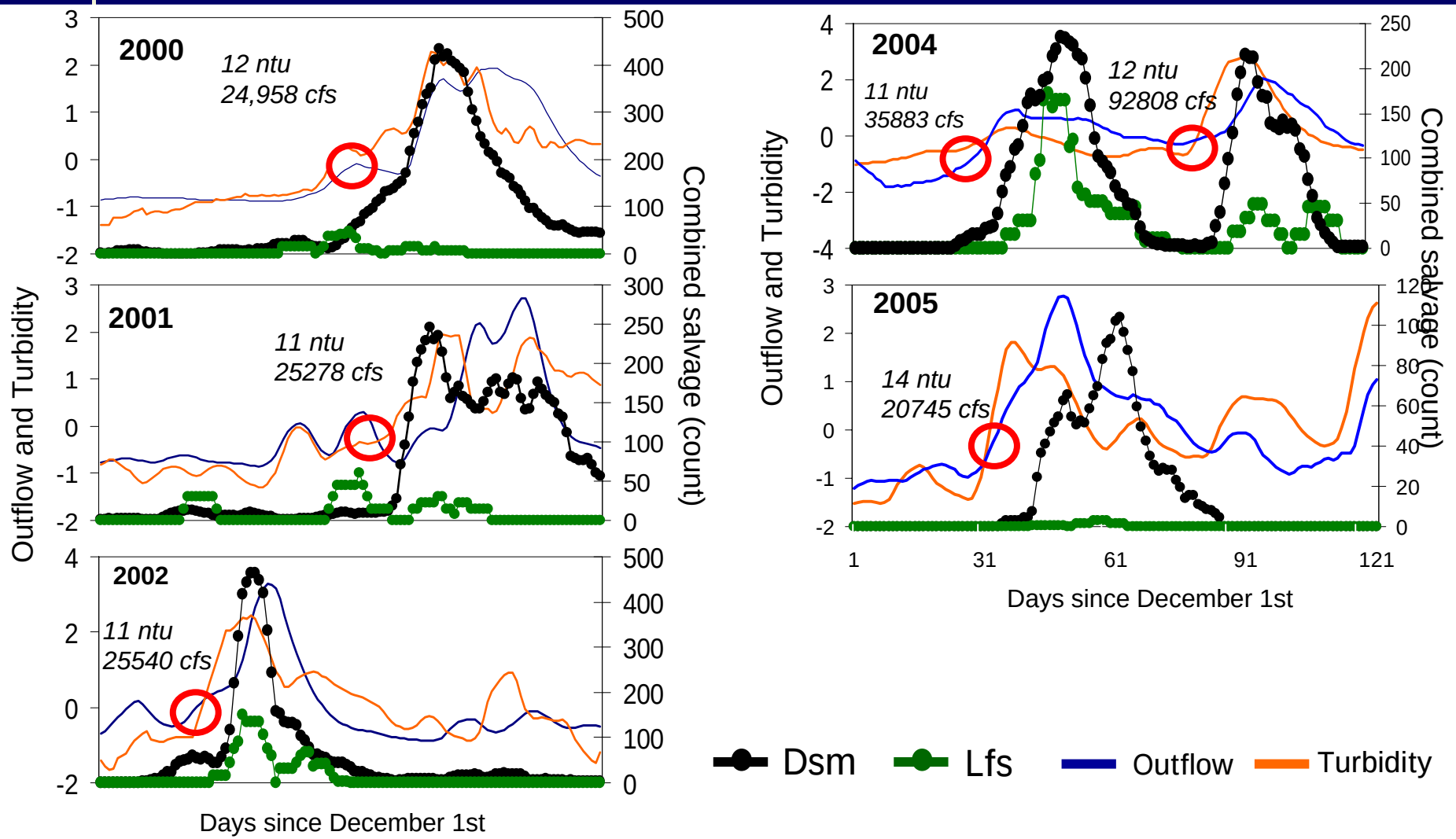
First flush evident in most years



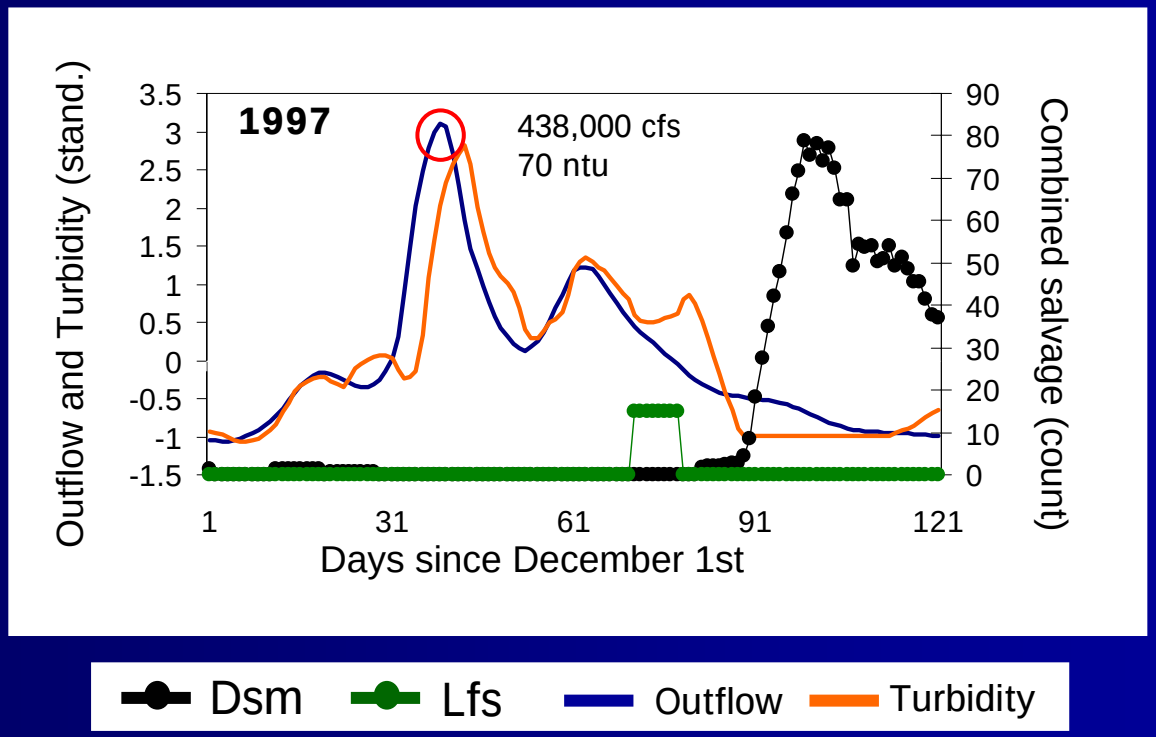


Dsm Lfs Outflow Turbidity

First flush evident in most years



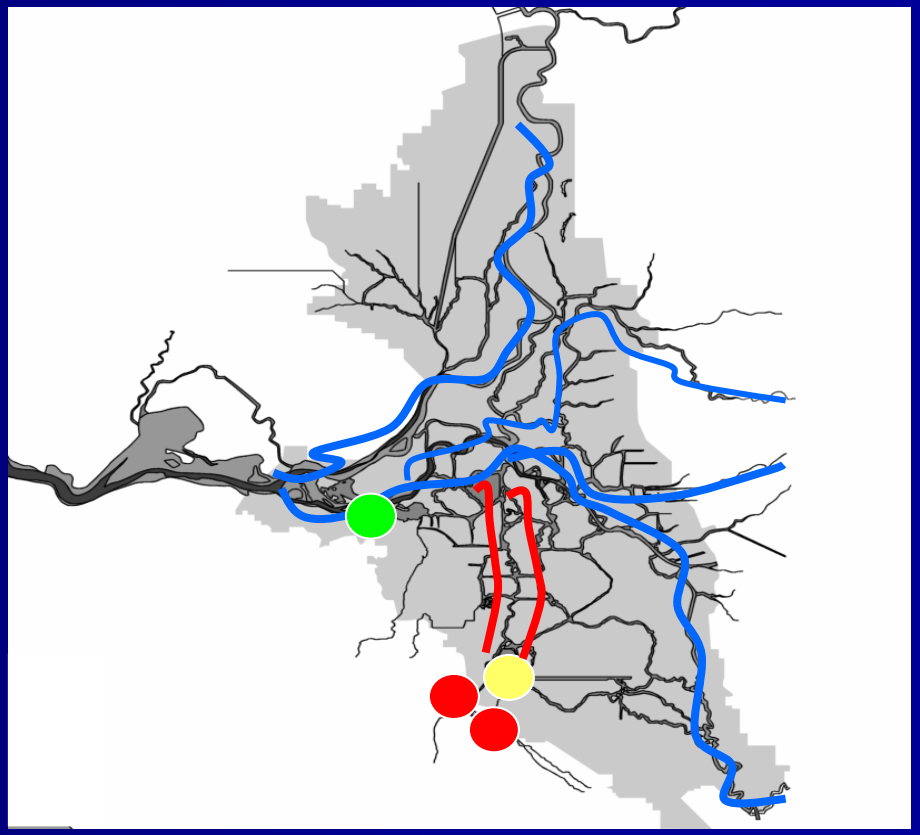
Delayed during the extreme wet years



What factors predict timing of migrations?

First step: Identify key dependent variables from the estuary

- Daily salvage
- Turbidity (1 long-term)
- Temperature and EC
- Major River flows
- Old and Middle River flows (Arthur et al. 1996; Monsen 2007)
- Estuarine-wide adult sampling CDFG FMWT (Sept-Dec)*
- Position of X_2 (Feyrer et al. 2007); *position from the preceding month (Nov-Feb)



Second Step: Identify correlation among variables

Table 2. PCA summary of independent variables used to examine salvage trends

Variables	**Axis 1**	**Axis 2**
Cumulative variance explained (%)	54	69
Flow (cfs)		
Combined Old and Middle River Flows	-0.45	-0.29
San Joaquin River	-0.49	-0.16
Sacramento River	-0.41	0.23
East Side Rivers	-0.50	-0.12
Physical		
Specific conductance (µm/s)	0.23	0.19
Water temperature (°C)	0.06	-0.84
Turbidity (ntu)	-0.30	-0.27

Previous month X_2 also used as a proxy for habitat location

Third Step: Input parameters into statistical model

General Linear Model, Least squares regression with AIC

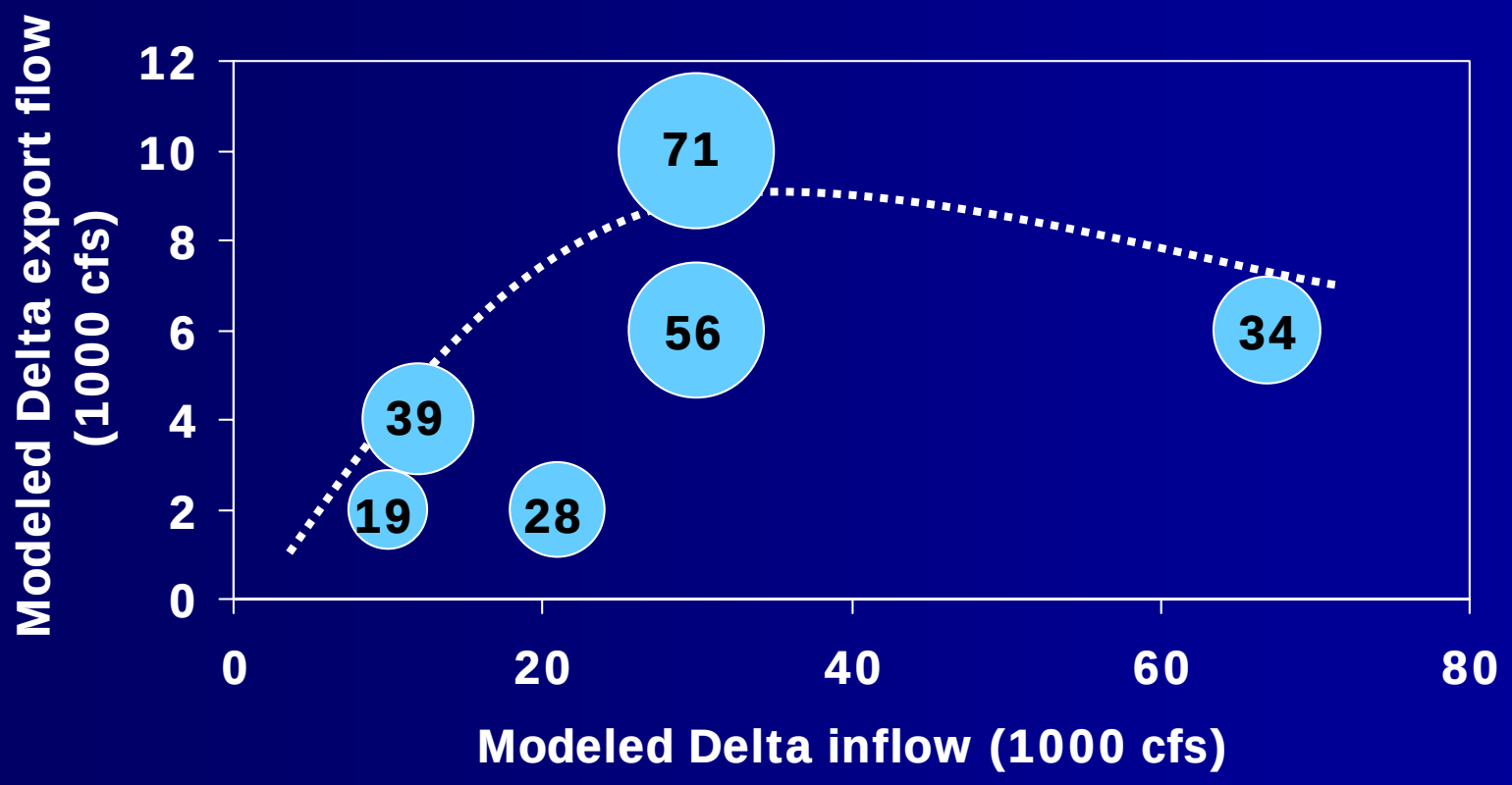
Species	Model	SS	F	M	R2	AIC	P-value
Delta smelt	**OM*X_2 + T**	**1E+08**	**8.57**	**3E+06**	**0.42**	**921**	**< 0.001**
	OM + T	1E+08	11.97	3E+06	0.33	926	< 0.001
	OM + T + WT + X_2	1E+08	6.65	3E+06	0.36	927	< 0.001
	OM*X_2	1E+08	6.92	3E+06	0.30	929	< 0.001
	OM + X_2	2E+08	6.69	3E+06	0.21	934	< 0.001
	OM	2E+08	5.03	4E+06	0.09	938	< 0.05
	OM + WT	2E+08	2.72	4E+06	0.10	941	0.07
Longfin smelt	**OM**	**783060**	**1.56**	**2.E+04**	**0.11**	**654**	**<0.05**

What the salvage facilities can't tell us about smelt migration

- Migration mechanisms (i.e., actual cues)
- Spawning habitats or timing of spawning (lunar period and temperature, Bennett 2005)
- → Modes of transport (swim against current vs. use tides)
- → Not much about longfin smelt

*We can indirectly address the last two bullets using other tools...

Are behavior and/or tides important?



* Consistent with other Osmerids (Murawski 1980; Martin et al. 2001)

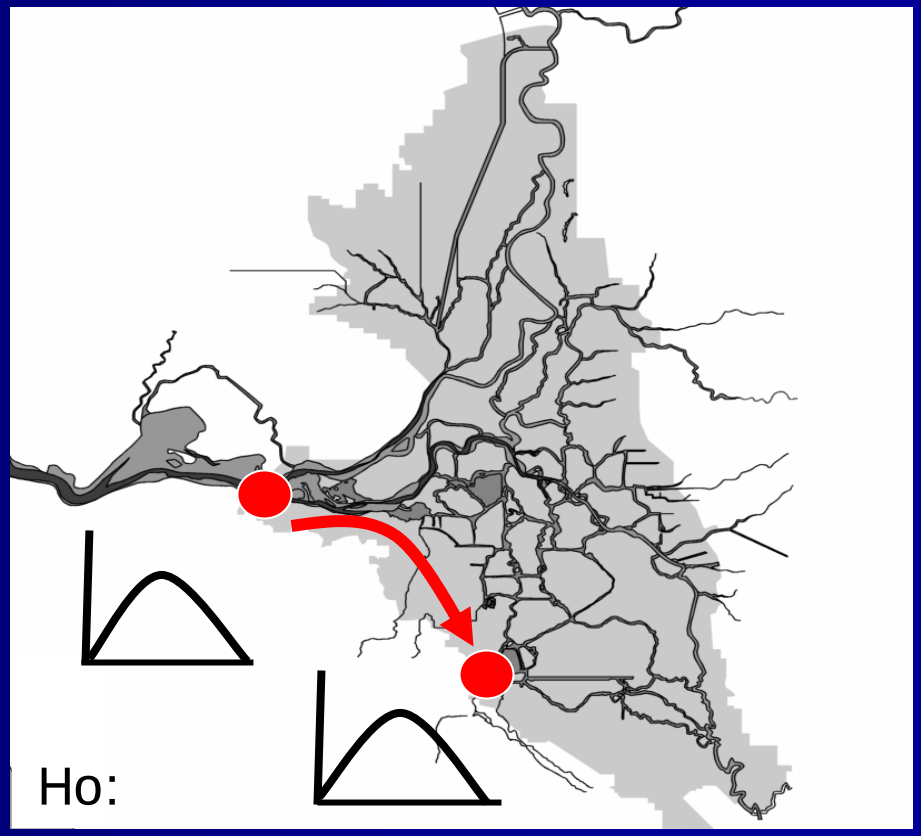
Can the Chipps Trawl data tell us anything about transport times?

USFWS Chipps Island Midwater Trawl Survey

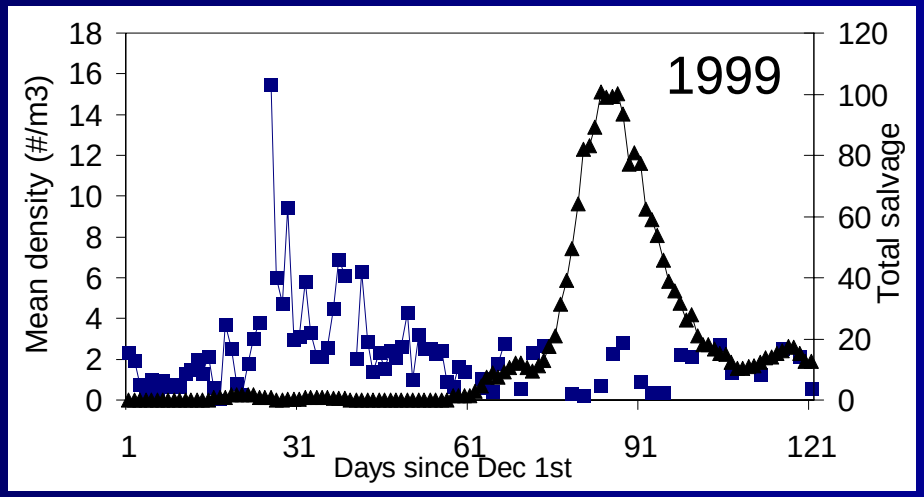
-monitor juvenile salmon emigration almost *daily* (winter-spring)

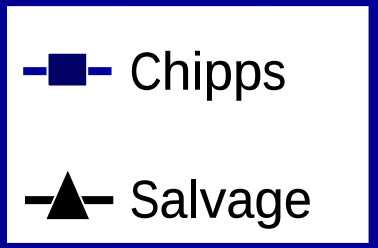
-4.6 m x 9.1 m net

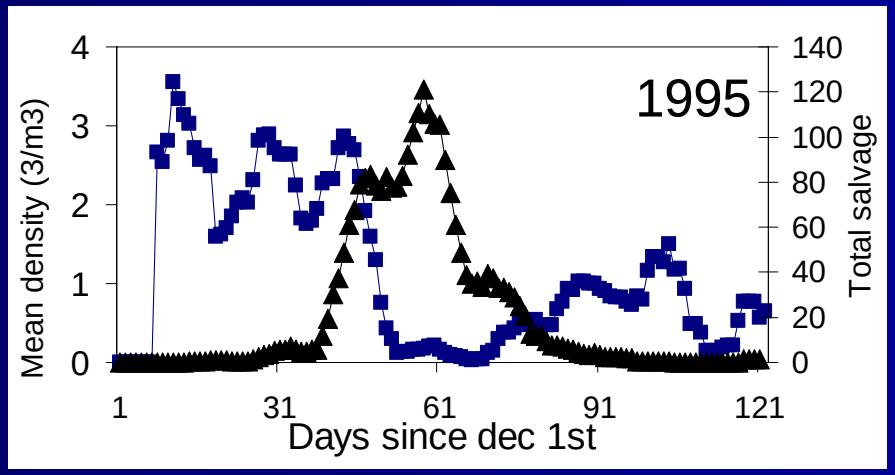
-most years, 3-7 days per week, ten tows (20 min.)



Some years were promising…



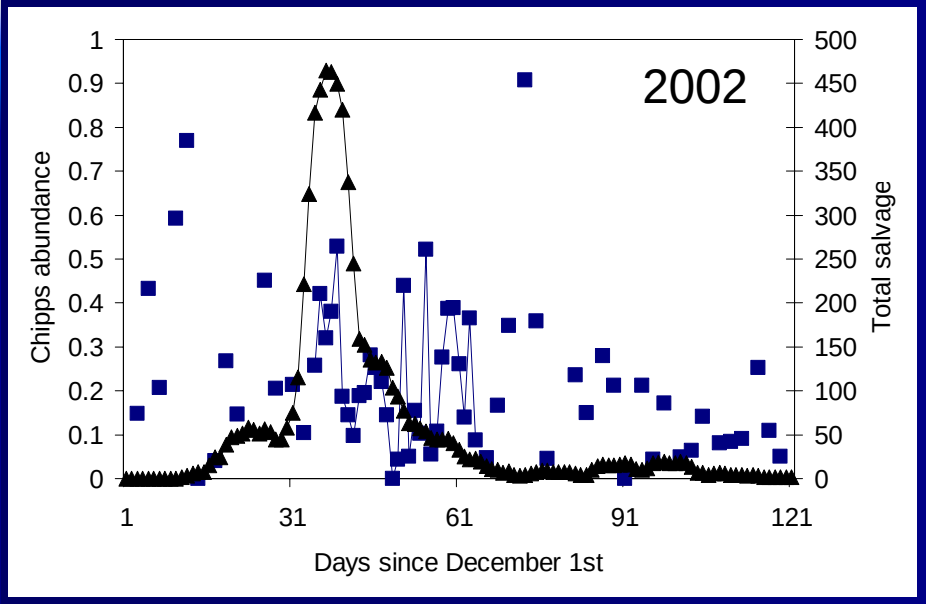


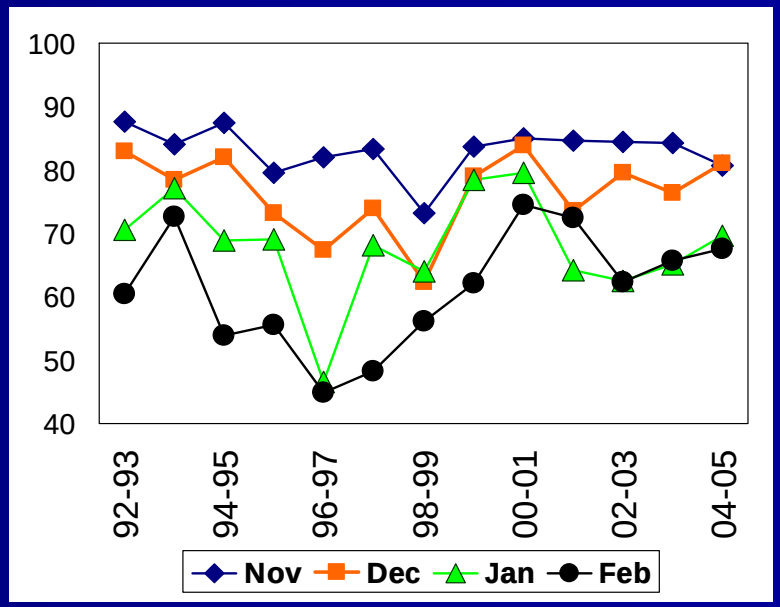


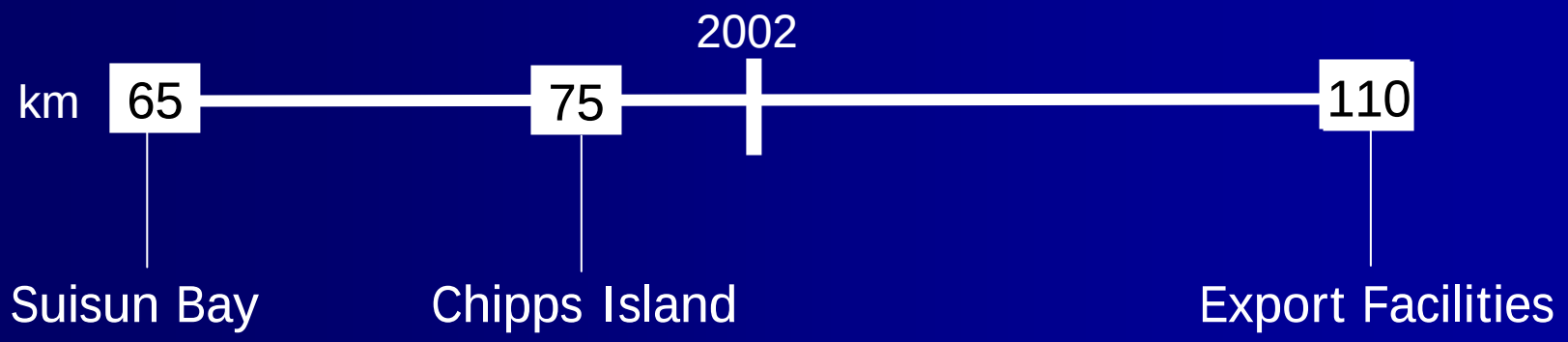
Variable timing

Year	Days between Chipps and Salvage peaks
1995	10
1996	13
1997	60
1998	7
1999	60

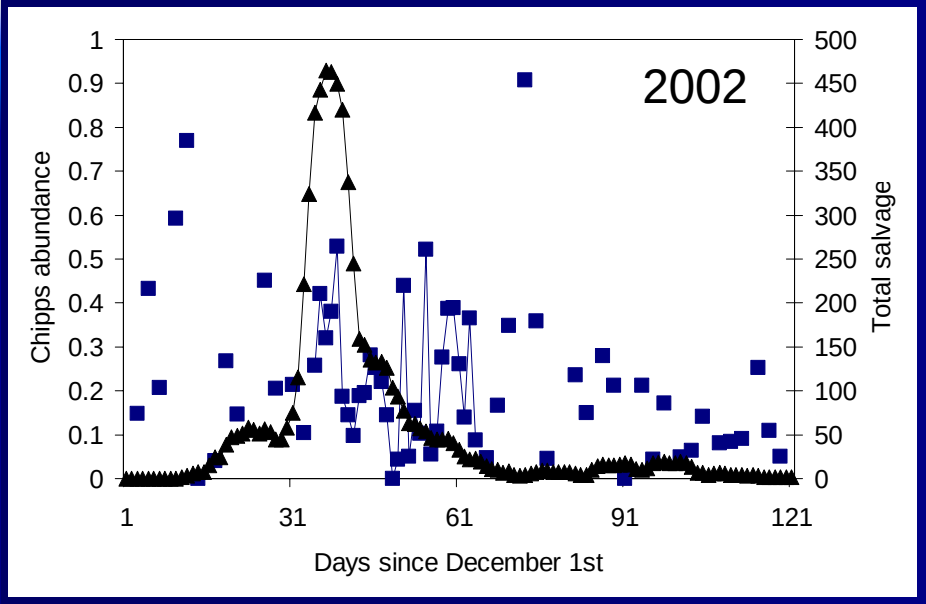
Chipps not a good predicator of salvage when X_2 upstream

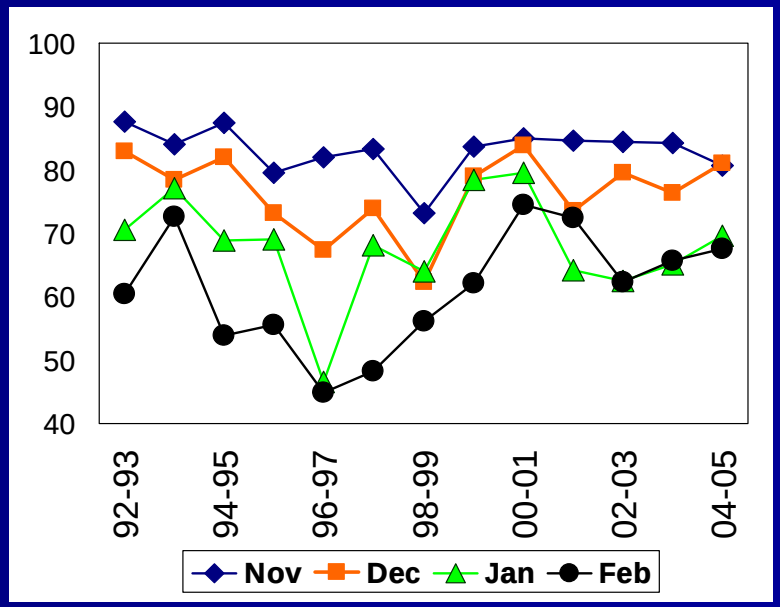


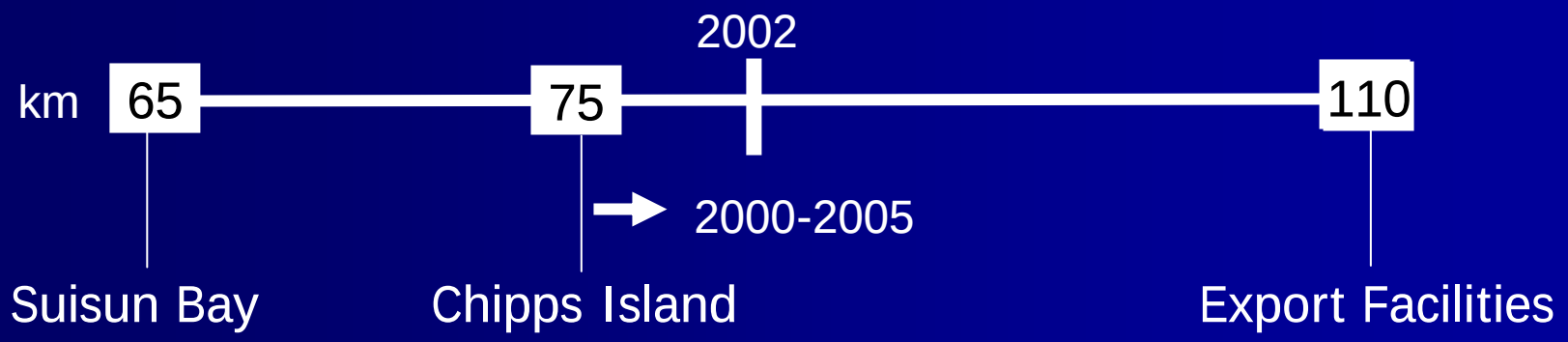




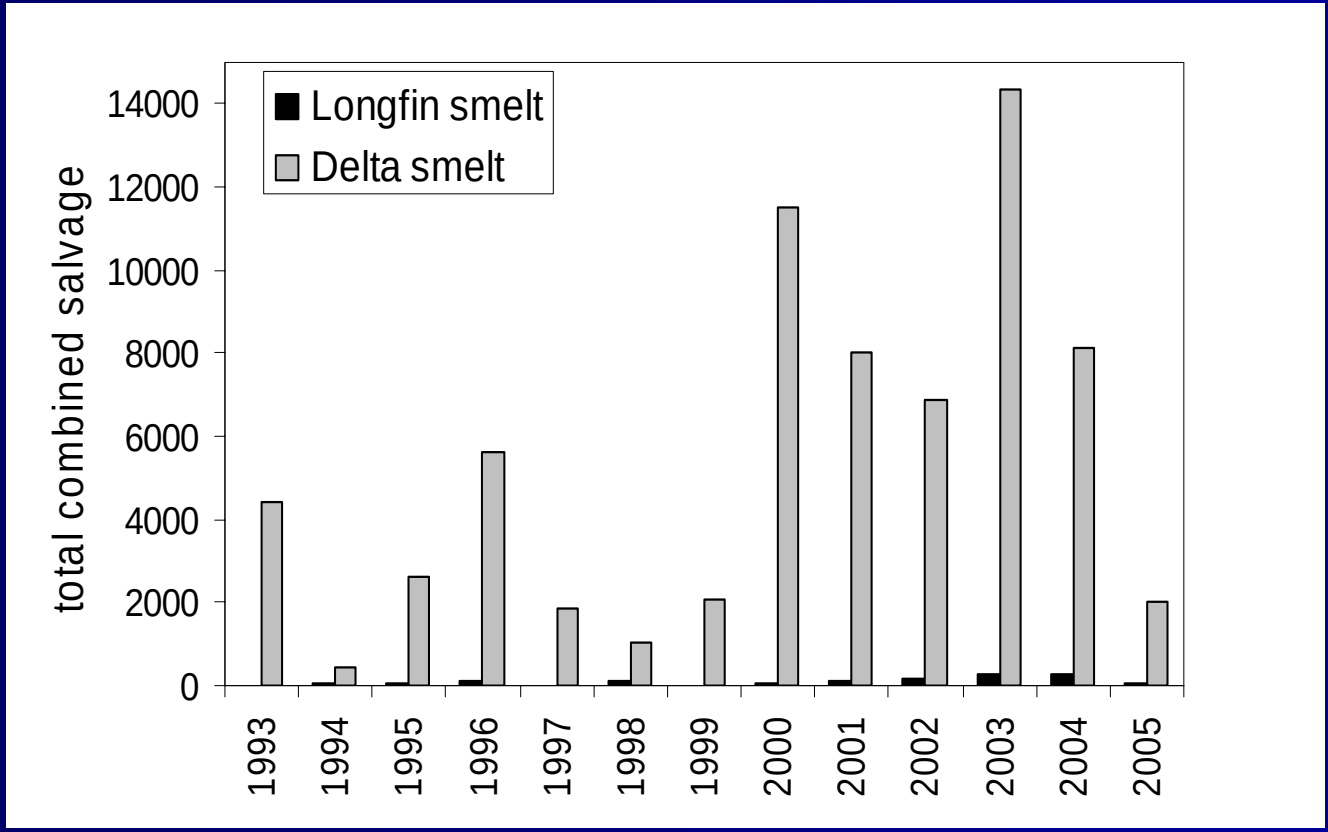
Scrap that idea, we need a field study



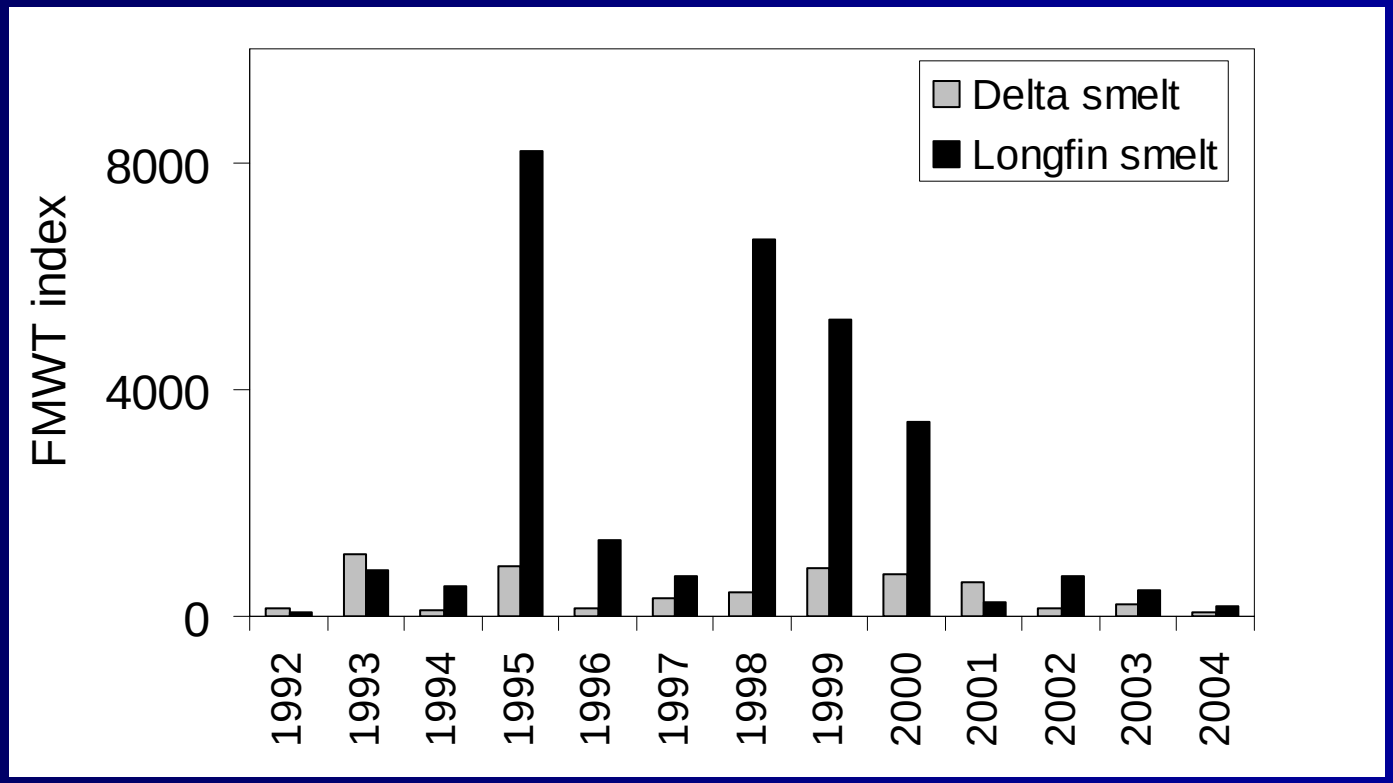




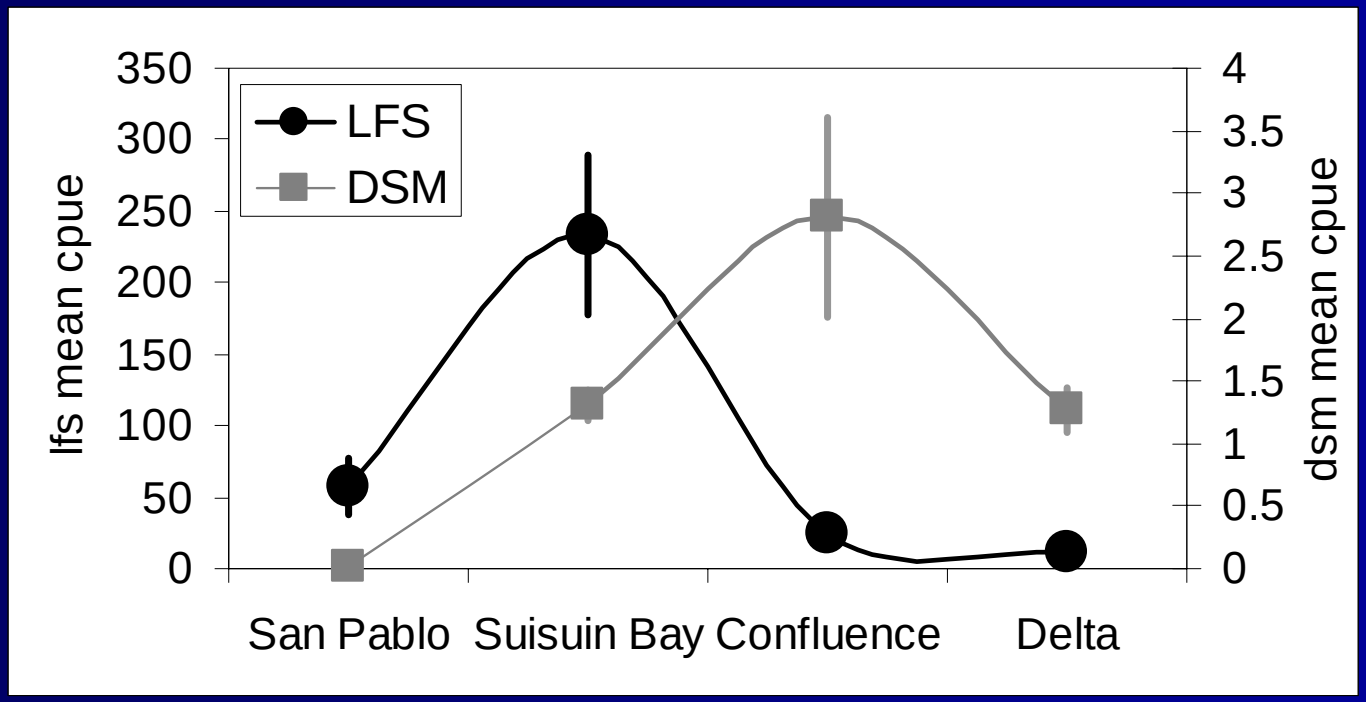
Why are fewer adult longfin smelt salvaged



It's not because there are fewer...



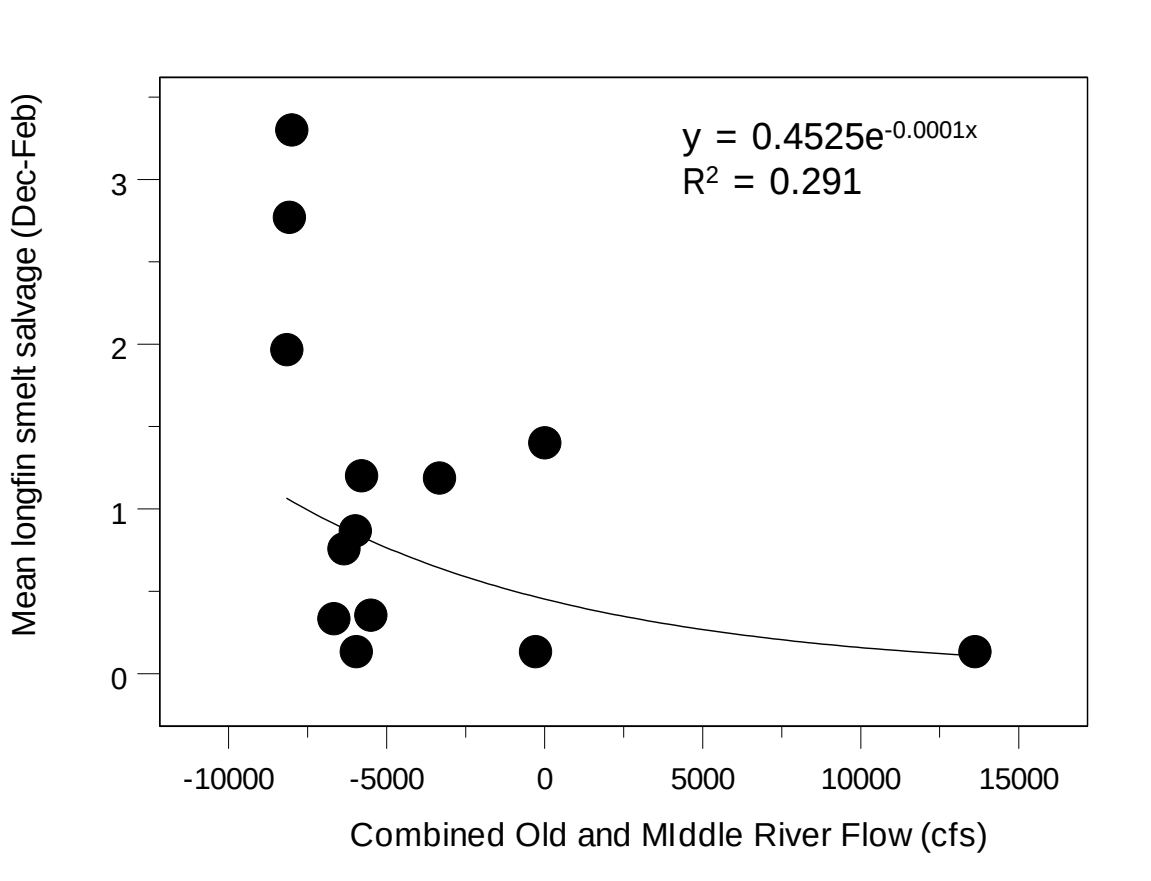
It's because they are distributed further downstream



Downstream → **Upstream**

FMWT data (1993-2005) all months averaged

Mostly vulnerable when reverse flows are high



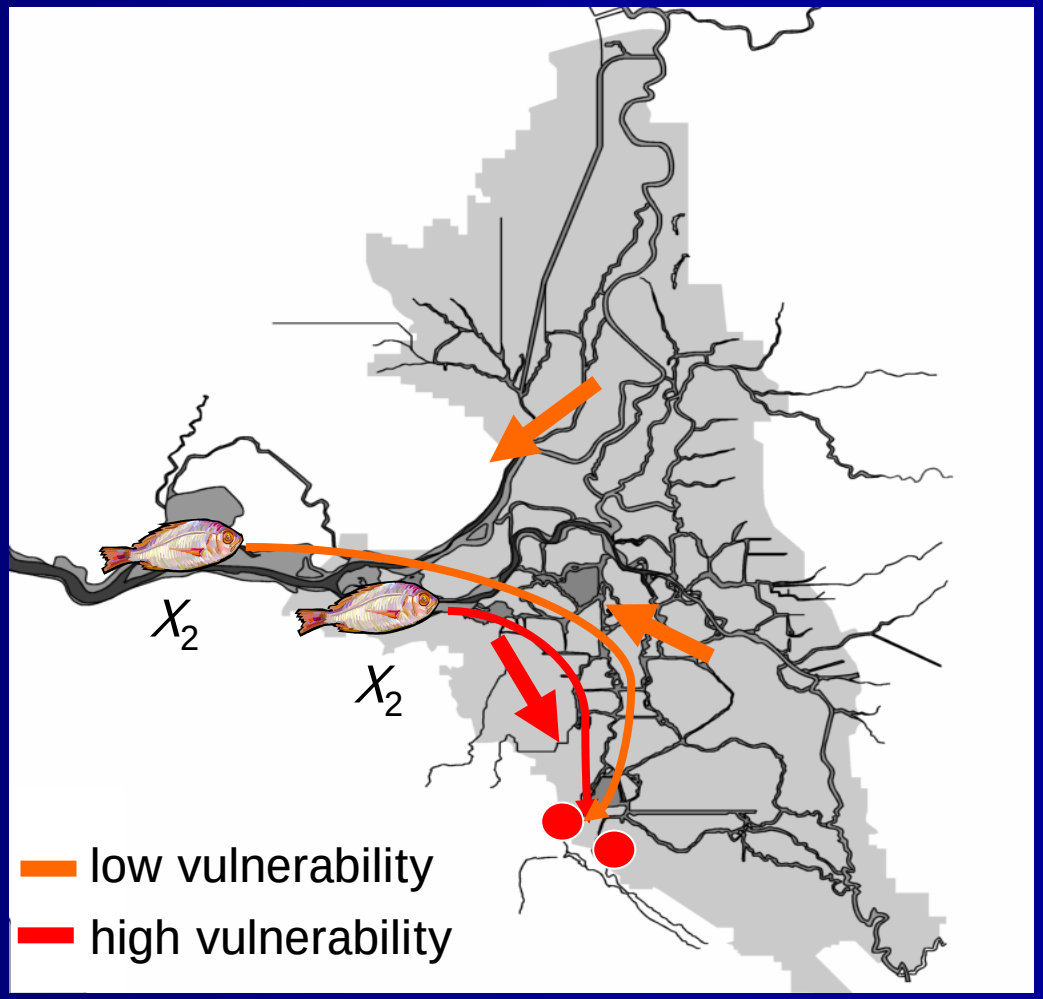
What are the management implications of these analyses?

Heed the warning signs..

- Delta smelt migrate after "first flush"
  - Turbidity elevates > 12 NTU or outflow > 20,000 cfs
  - High X_2 position

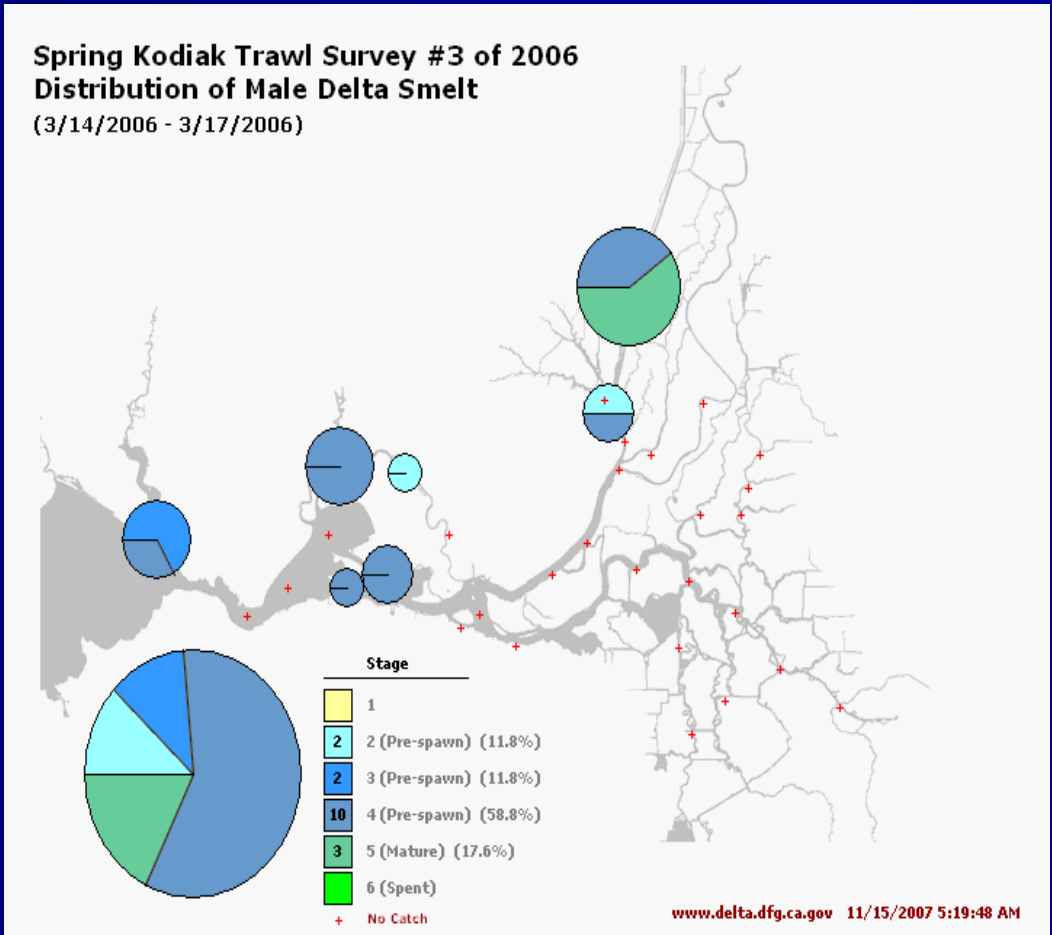
- Good time to reduce exports

- Will reducing exports get fish moving to the North?



Ideal scenario

- Simply reverse flow?
- Is it a turbidity gradient?



What are the next steps

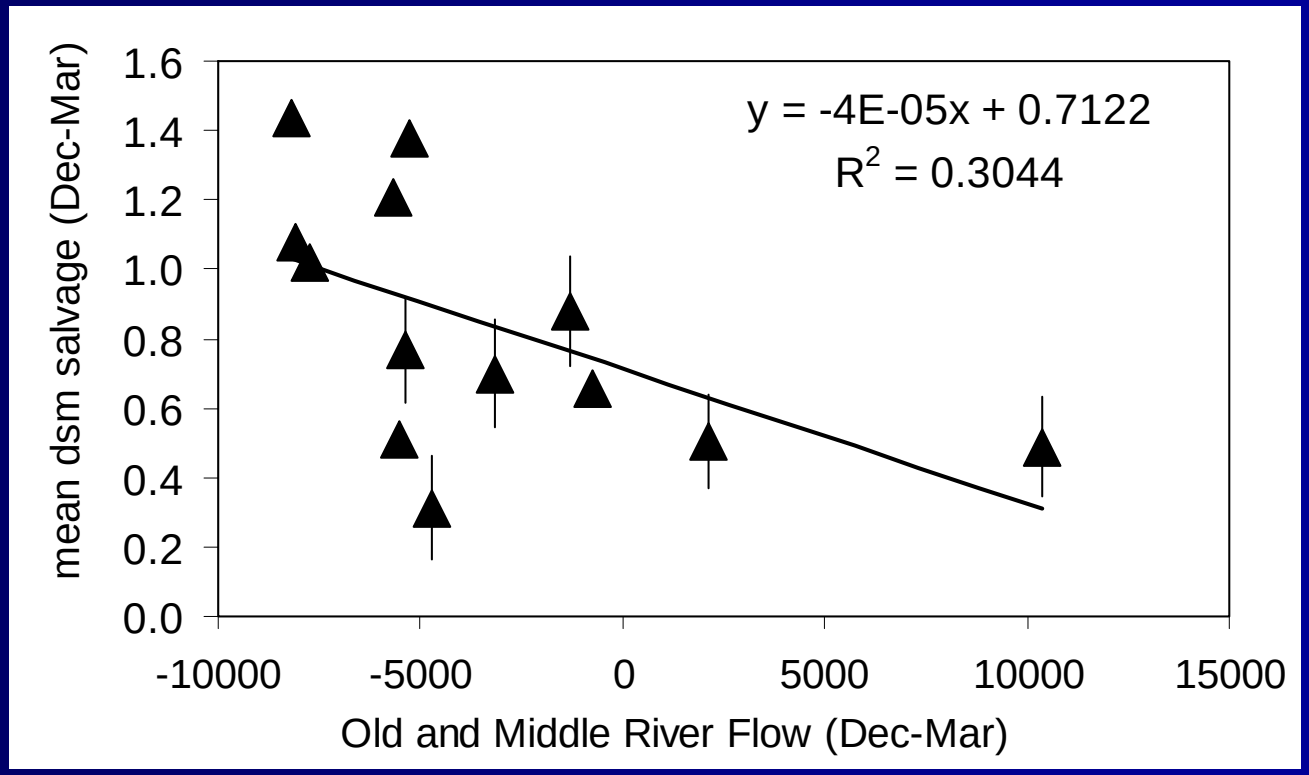
Mine the data sources a wee bit more?

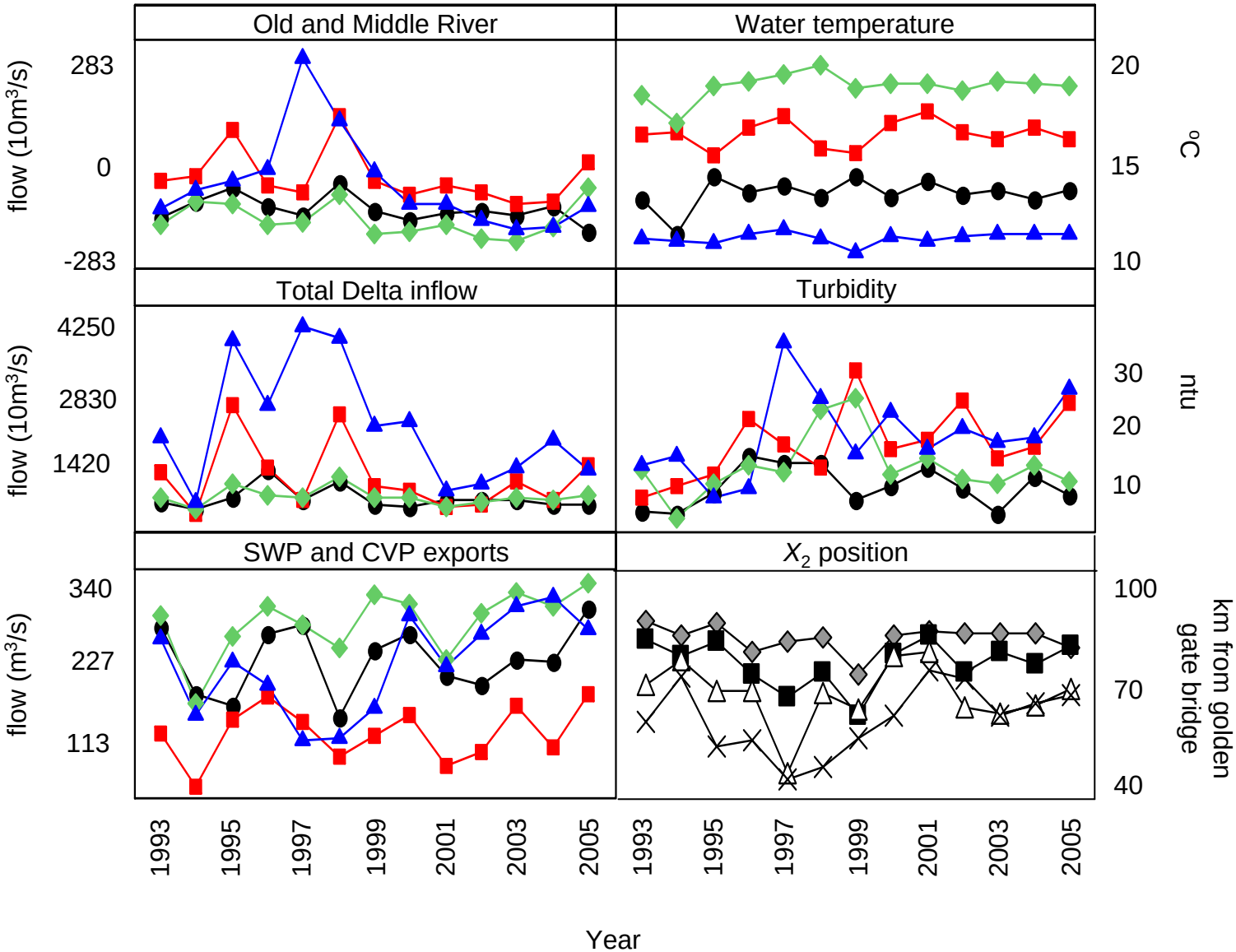
- Identify possible “staging of adults” after the migration
- Continue development of 3D PTM models (test assumptions and behavior)
- Other suggestions?

off the mark.com
by Mark Parisi
offthemark.com
the downstreamer
WHERE SLACKER SALMON GO TO SPAWN
© Mark Parisi, Permission required for use.

Back-up slides

Delta smelt-Export relationship




Old and Middle River
Water temperature
Total Delta inflow
Turbidity
SWP and CVP exports
X_2 position
flow (10m^3/s)
flow (10m^3/s)
flow (m^3/s)
283
0
-283
4250
2830
1420
340
227
113
20
15
10
°C
30
20
10
ntu
100
70
40
km from golden gate bridge
1993
1995
1997
1999
2001
2003
2005
Year