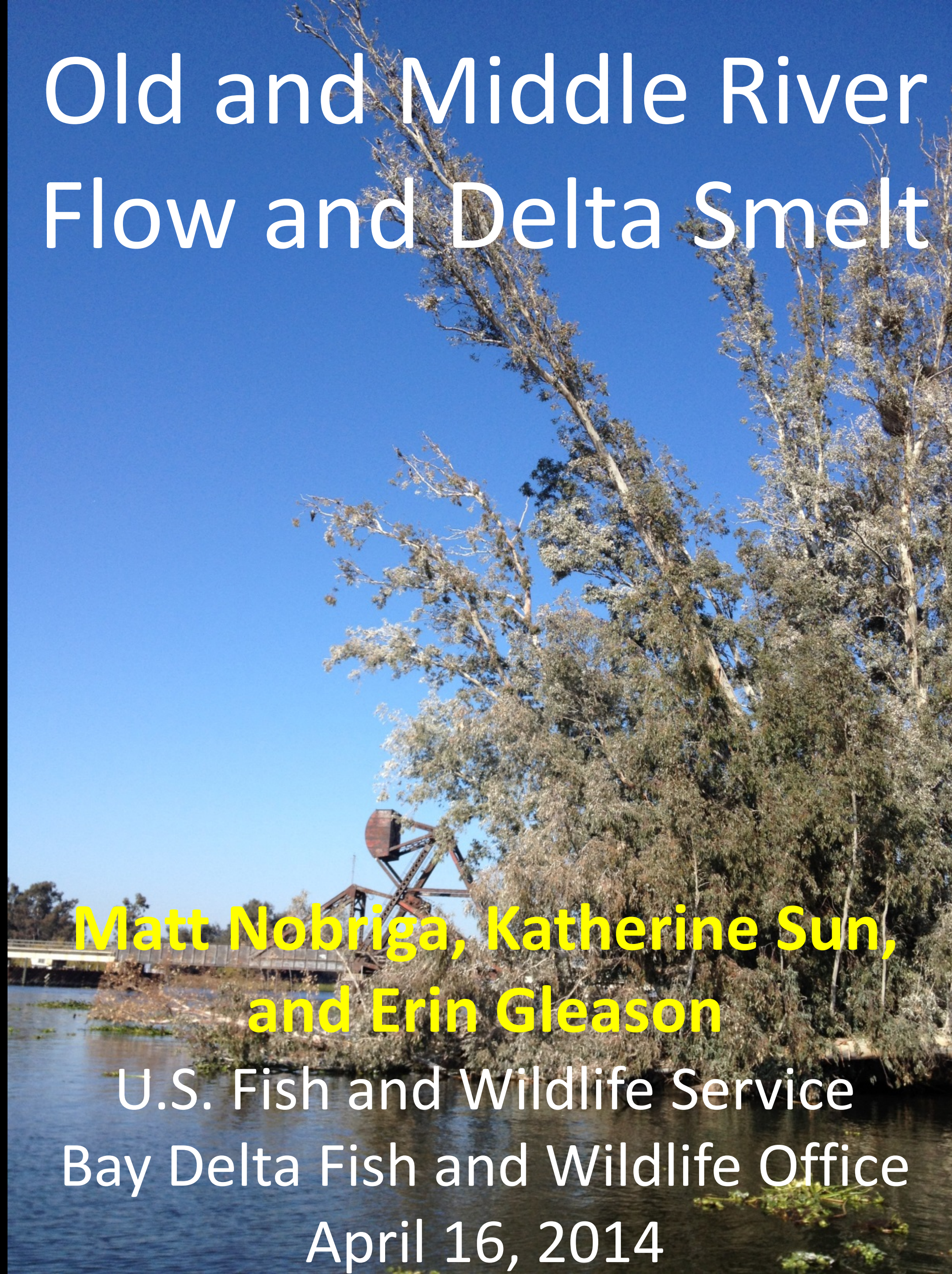
Old and Middle River Flow and Delta Smelt



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U.S. Fish and Wildlife Service
Bay Delta Fish and Wildlife Office

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Overview

- What is OMR flow?
- The “universe” of stressors in the Bay-Delta
- The intersection CVP/SWP operations with delta smelt biology
- Why the Service used OMR in the OCAP BiOp

Take home points

- It’s a clam’s estuary
- The OCAP BiOp RPA focuses on OMR and Delta outflow because Project Operations were the scope of the consultation
- OMR is the best available flow metric to characterize/conceptualize entrainment risk for delta smelt

What is OMR flow?

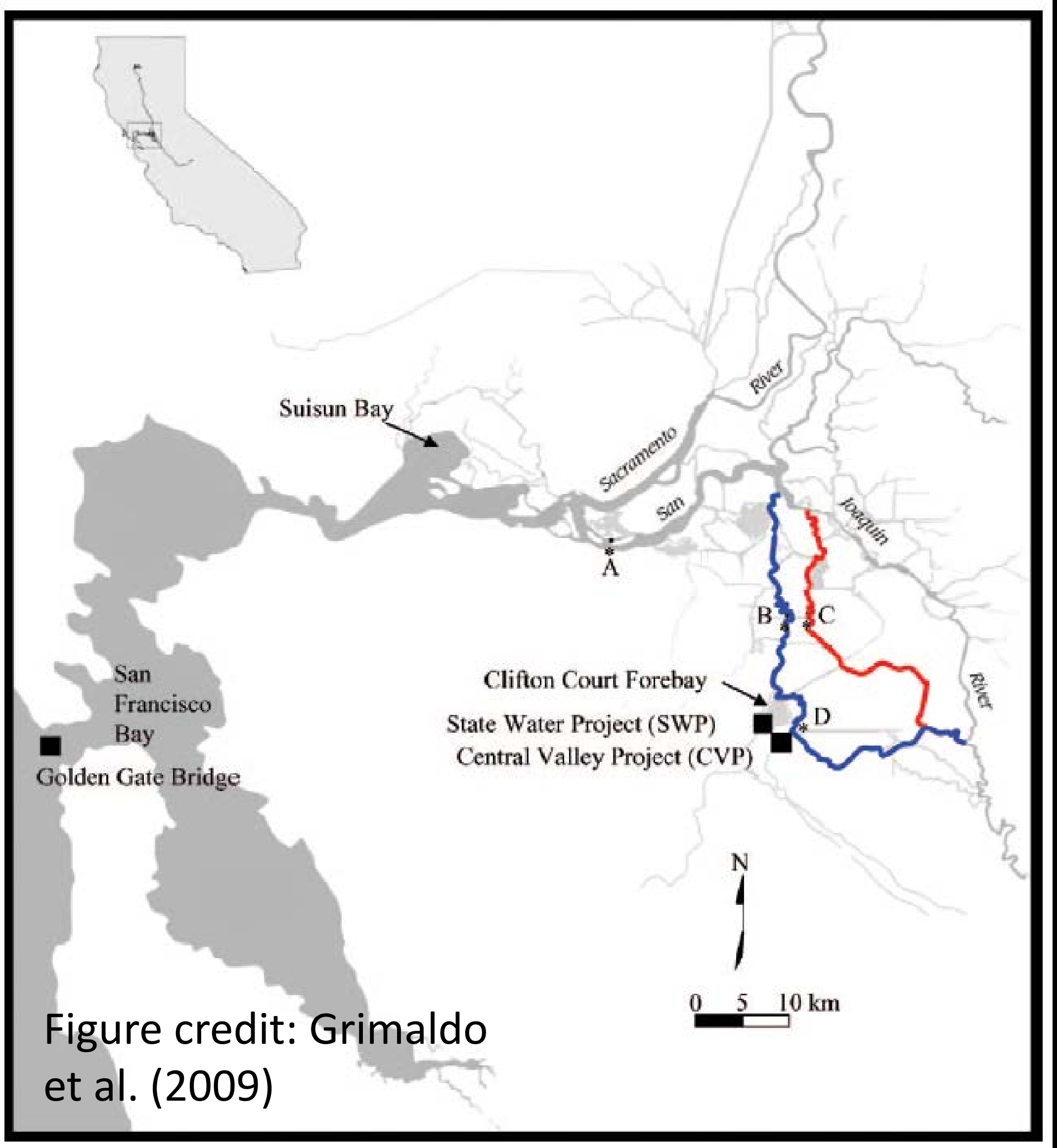
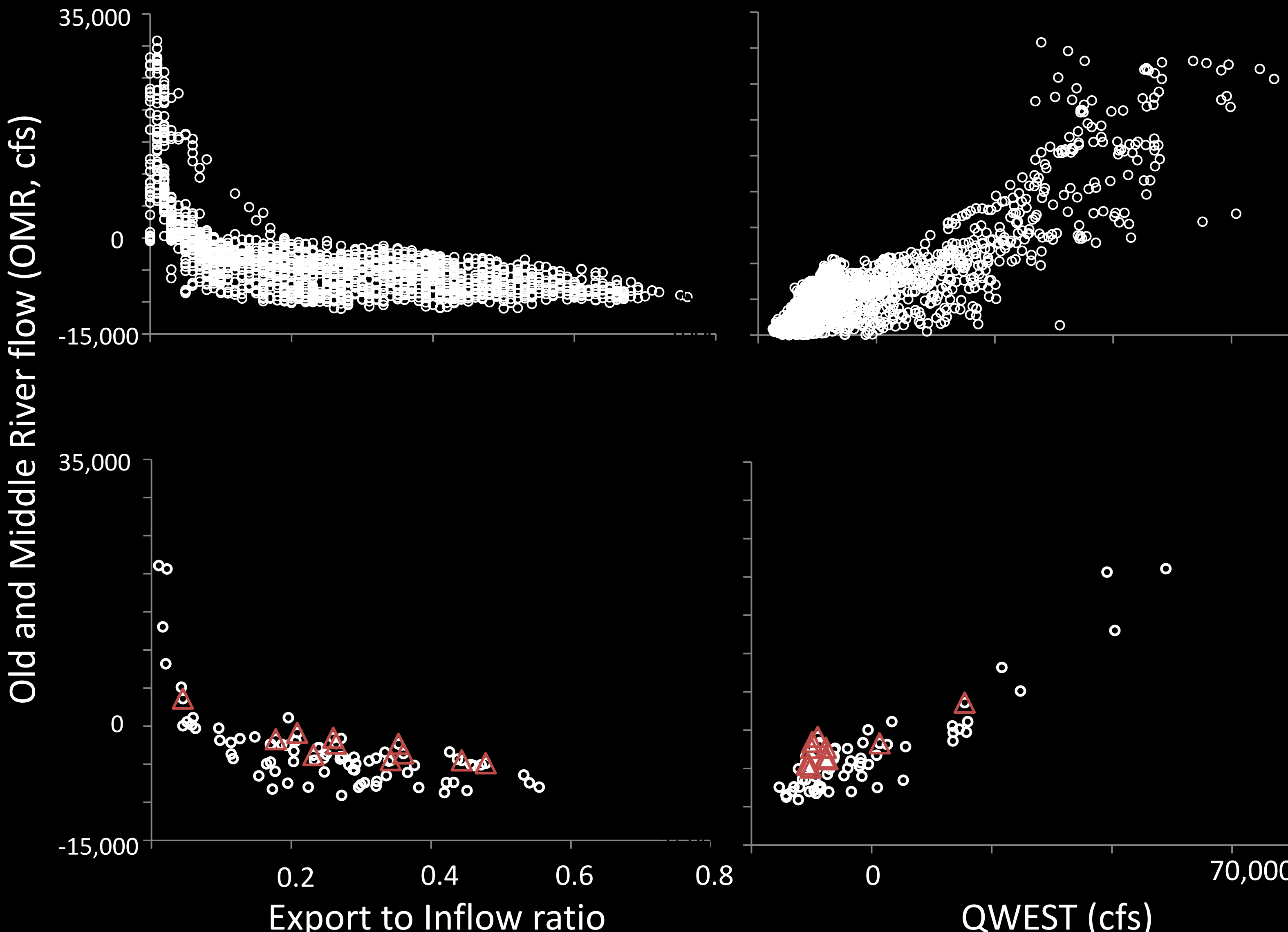


Figure credit: Grimaldo et al. (2009)

OMR vs other hydrodynamic indices

(Dec-March, 1993-2013)



Section 4 of the ESA (Recovery) ≠ Section 7 (Consultation)

Universe of stressors, impacts, ecosystem state changes, sources of incidental mortality, etc.

= "Environmental Baseline"

The overbite clam rearranged the estuary's food web

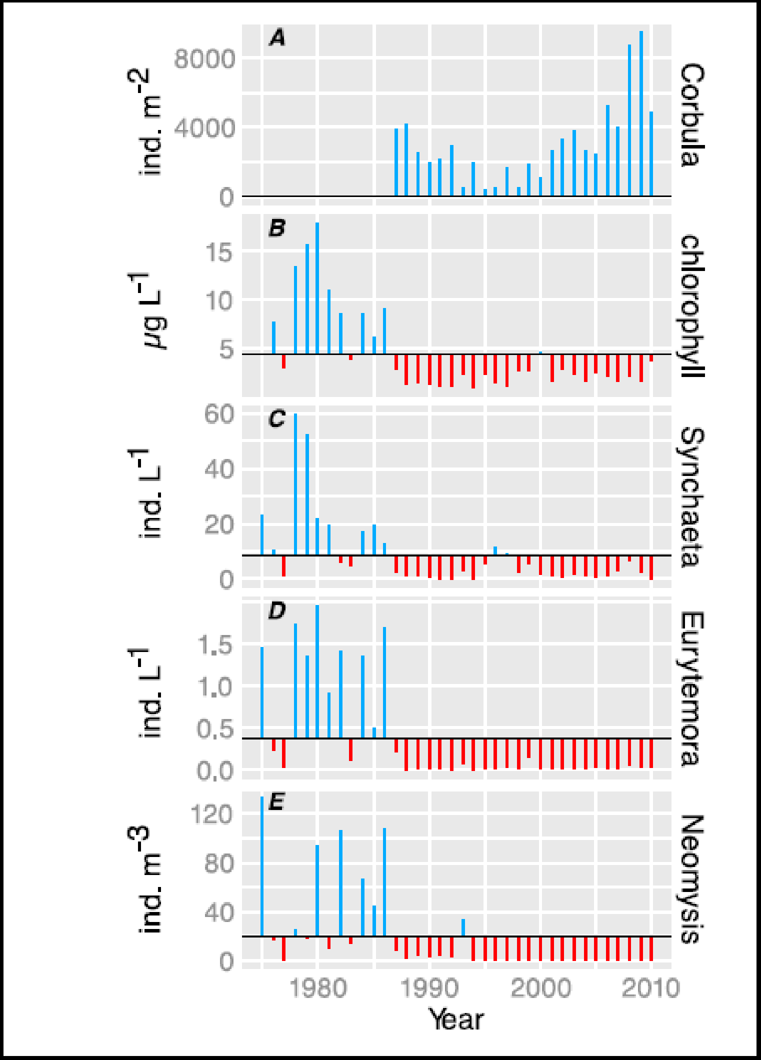
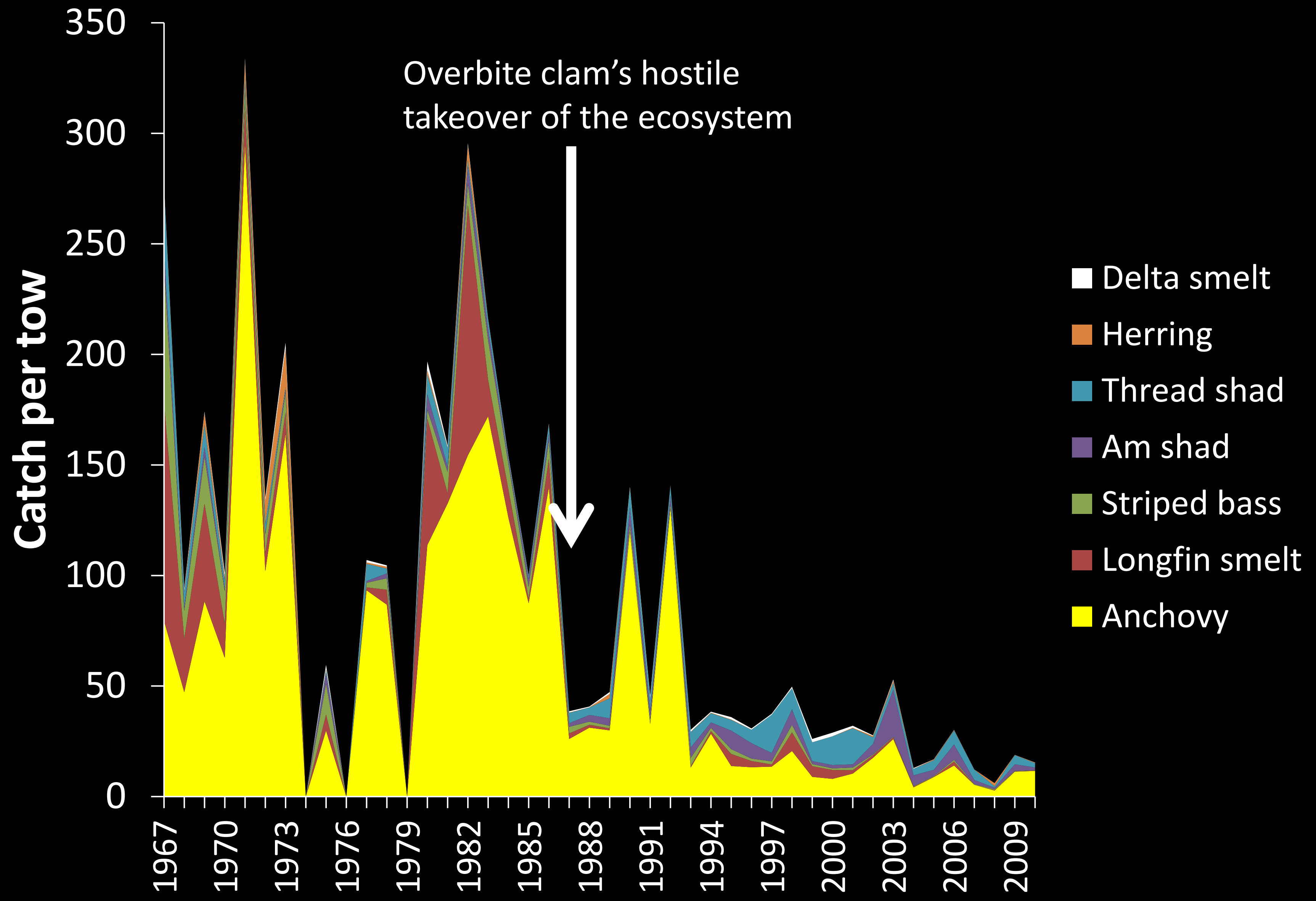
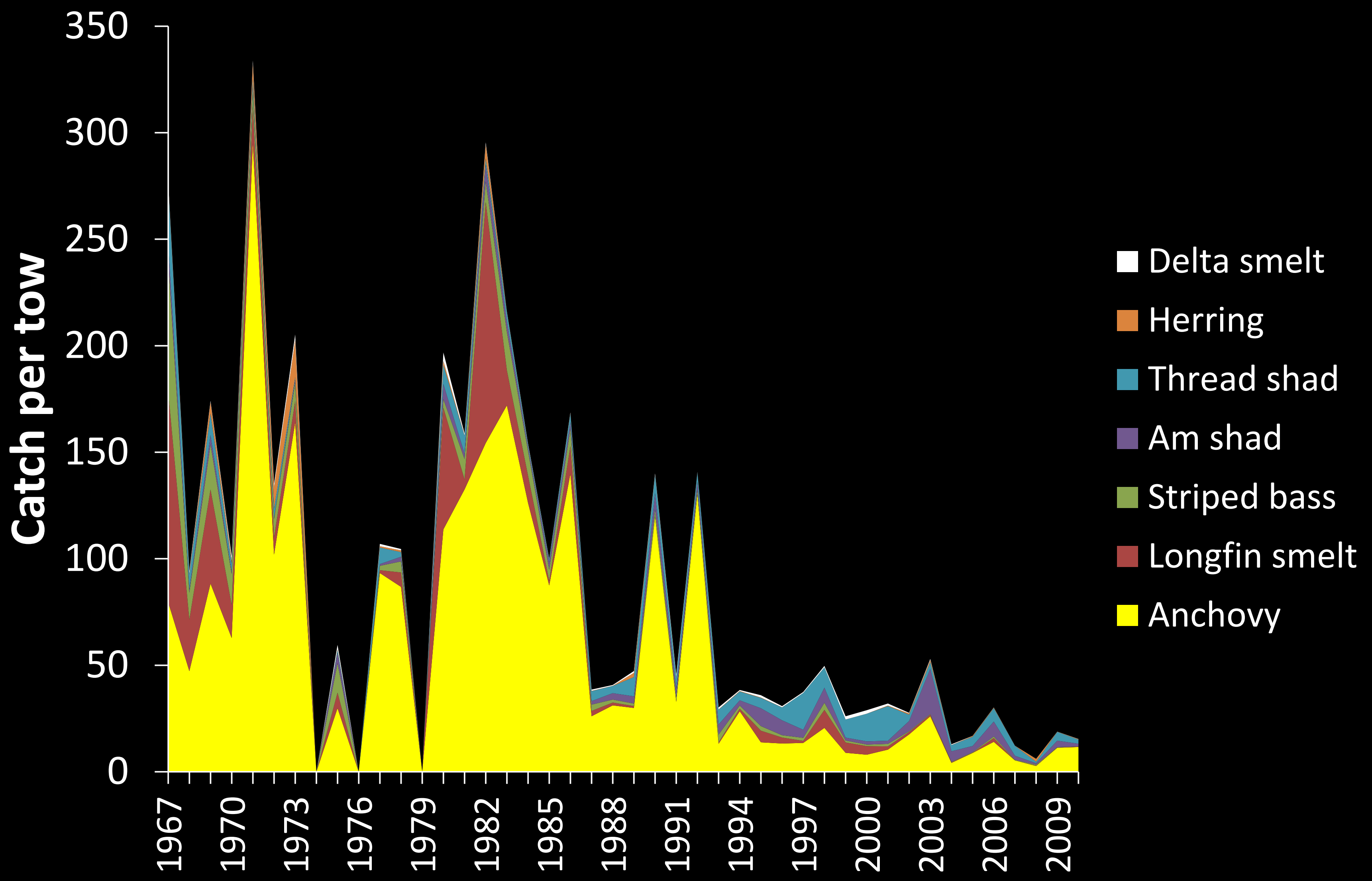


Figure credit: Cloern and Jassby (2012)

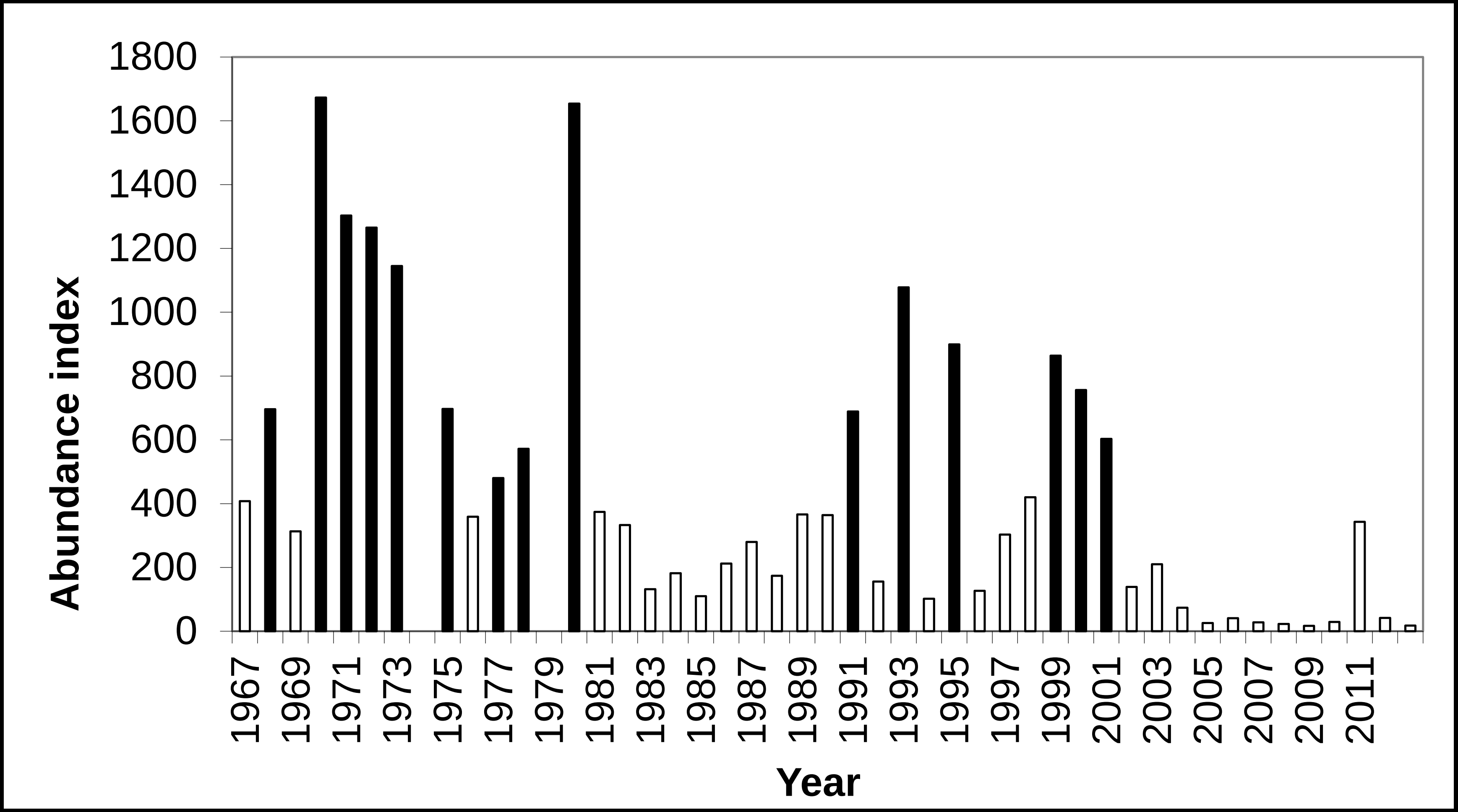
What about fish? Yep, them too



But delta smelt is a “needle in a haystack”



…and the needle may not do exactly what the haystack does



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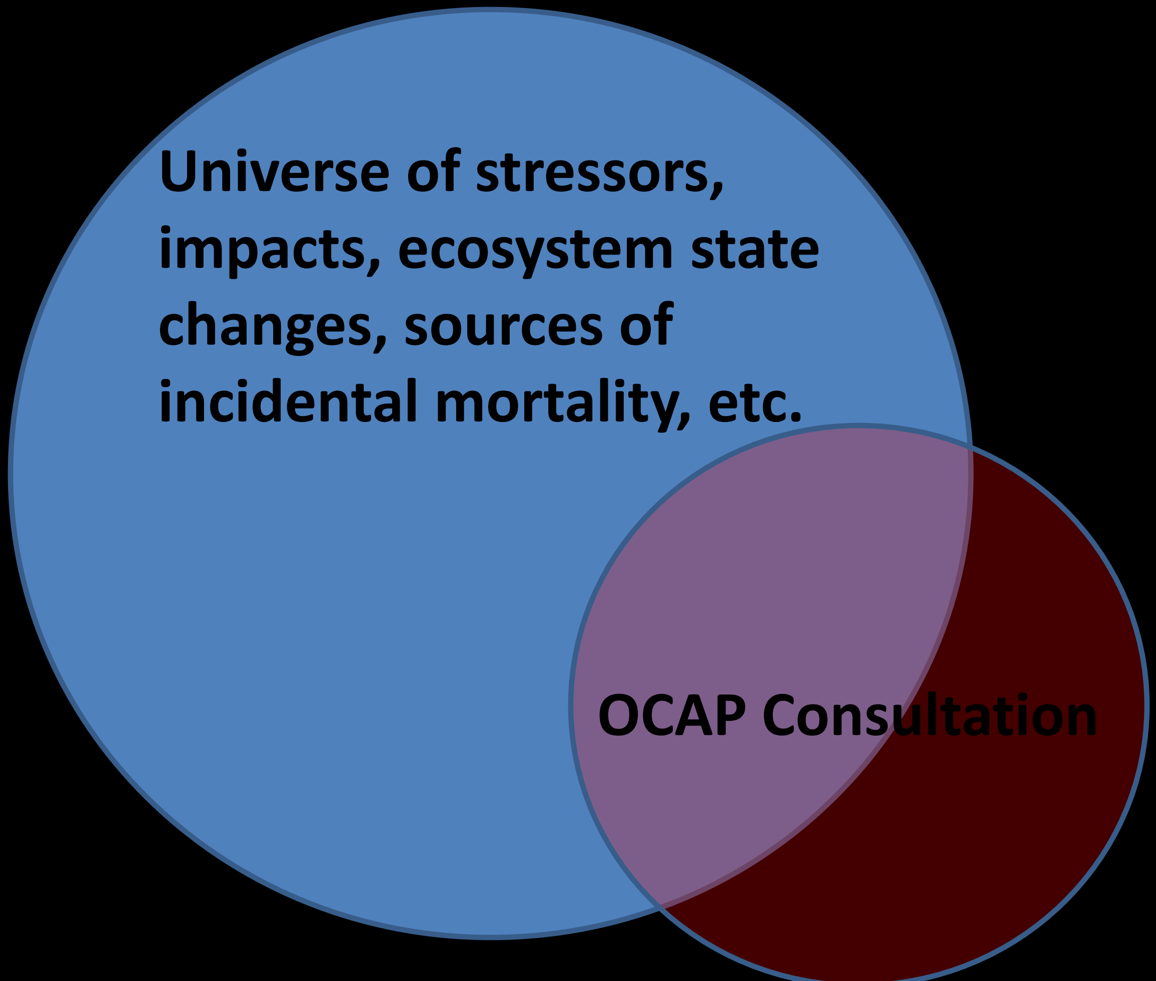


There have been many changes to the central and southern Delta

- Deepening of shipping channels
- Rip-rapped levees
- Flooded islands
- Non-Project flow allocations in the San Joaquin and Mokelumne basins
- Nutrient and water quality changes
- SAV proliferation and its 'lake fish' assemblage

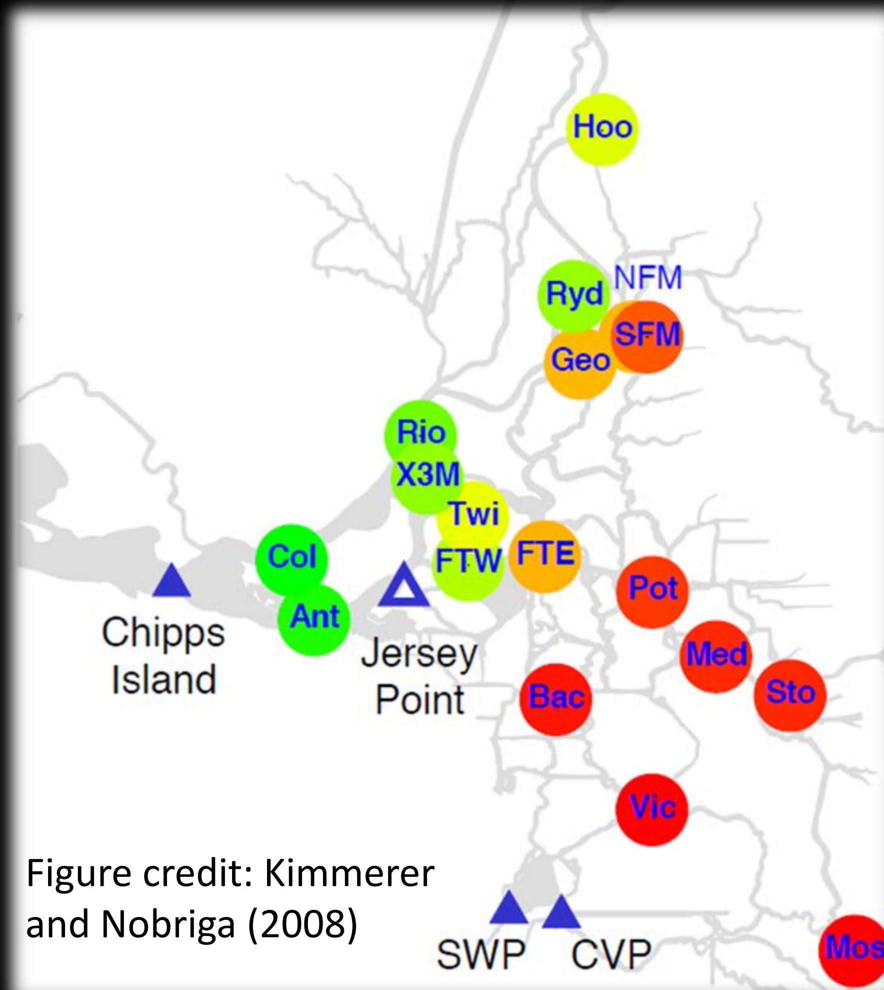


Figure credit: Kimmerer and Nobriga (2008)

The intersection

(Why do we care about Project Ops in a degraded habitat?)

- Fish entrainment → OMR flow

OMR is part of the "salvage equation"

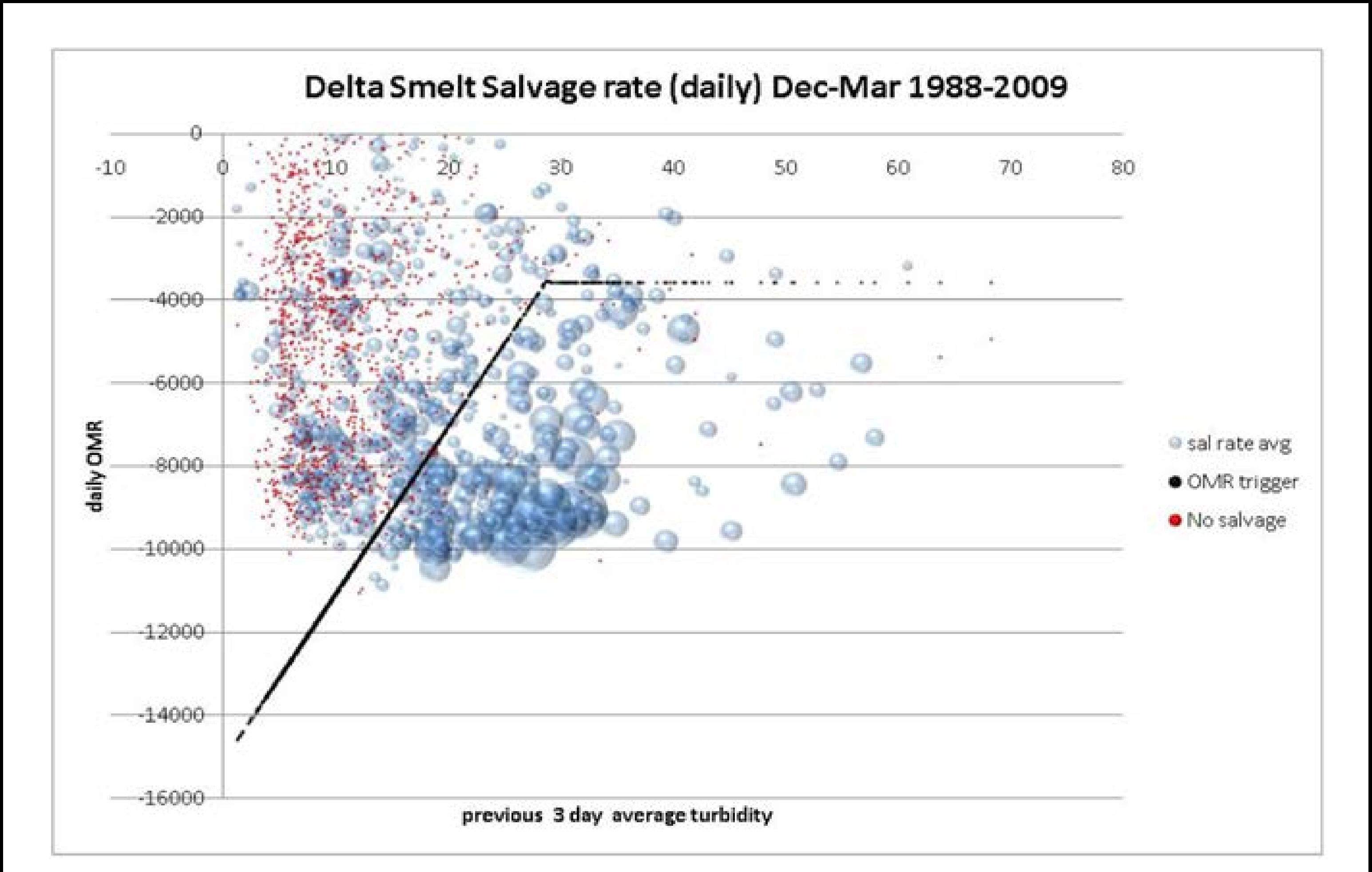
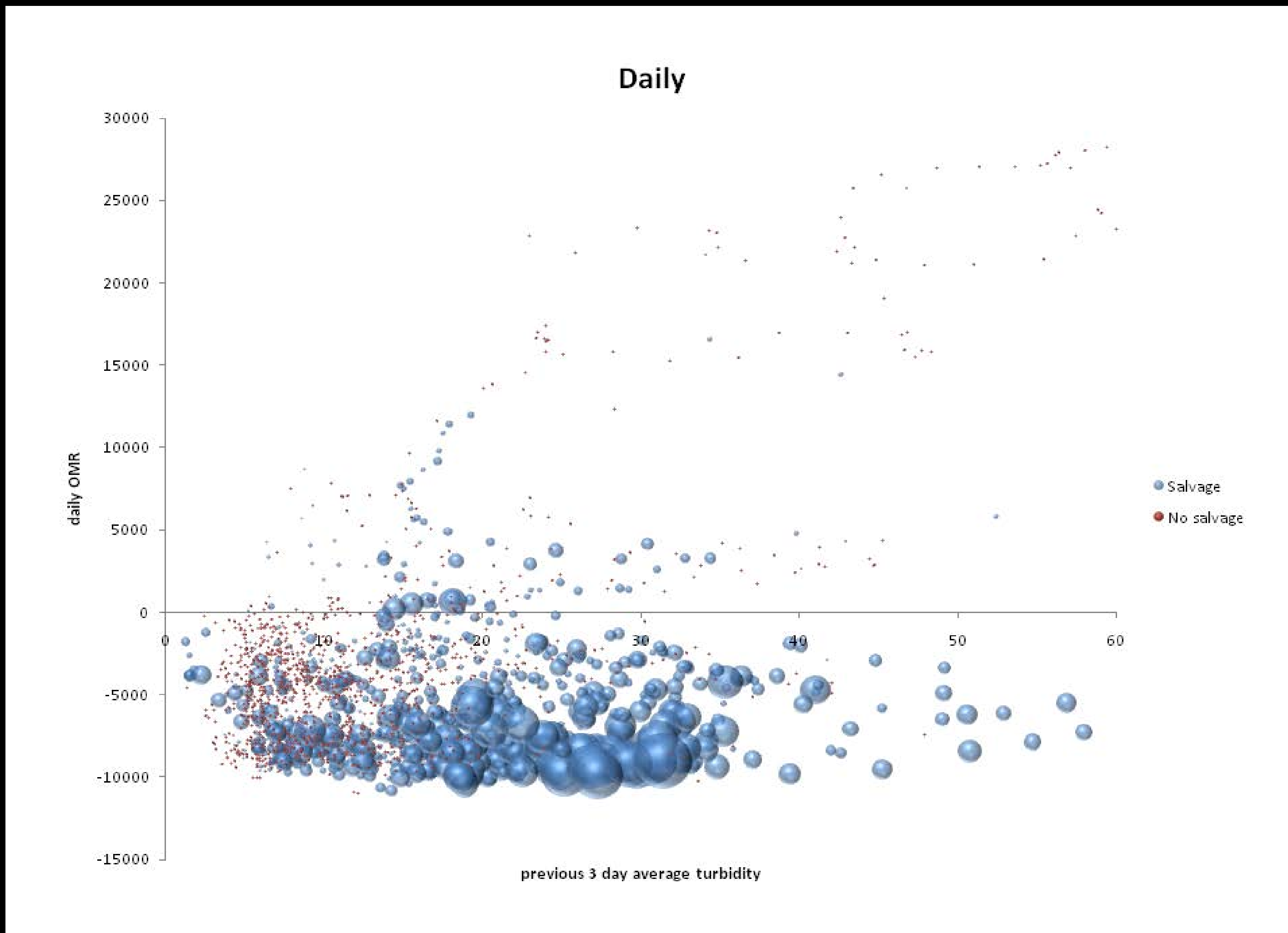


Figure credit: Rick Deriso (unpublished)

OMR is part of the "salvage equation"

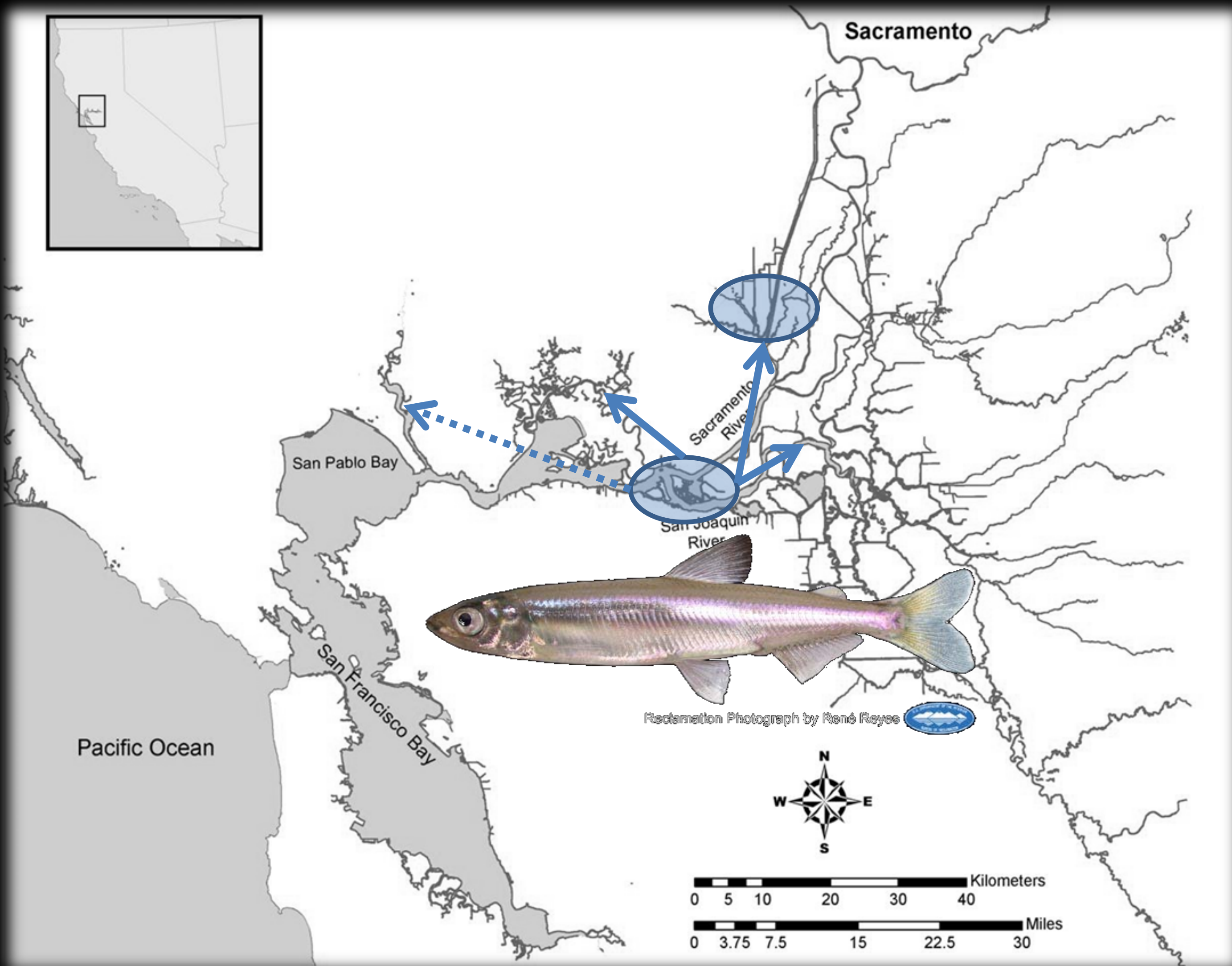


The intersection

(Why do we care about Project Ops in a degraded habitat?)

- Fish entrainment → OMR flow
- Habitat suitability → Delta outflow and tidal marsh restoration…but also OMR

The simplest CM of delta smelt pre-spawning movements



What is OMR flow?

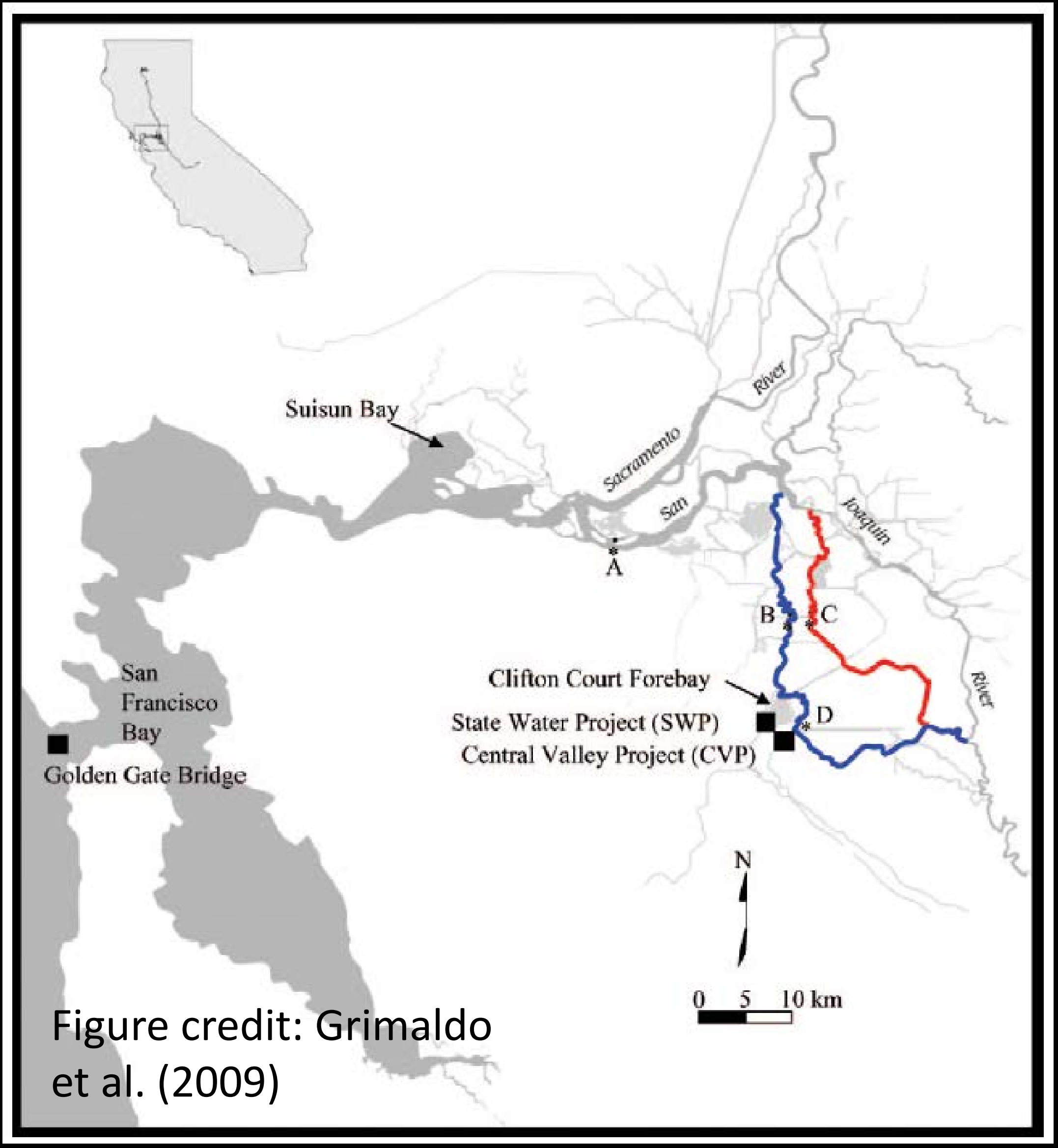
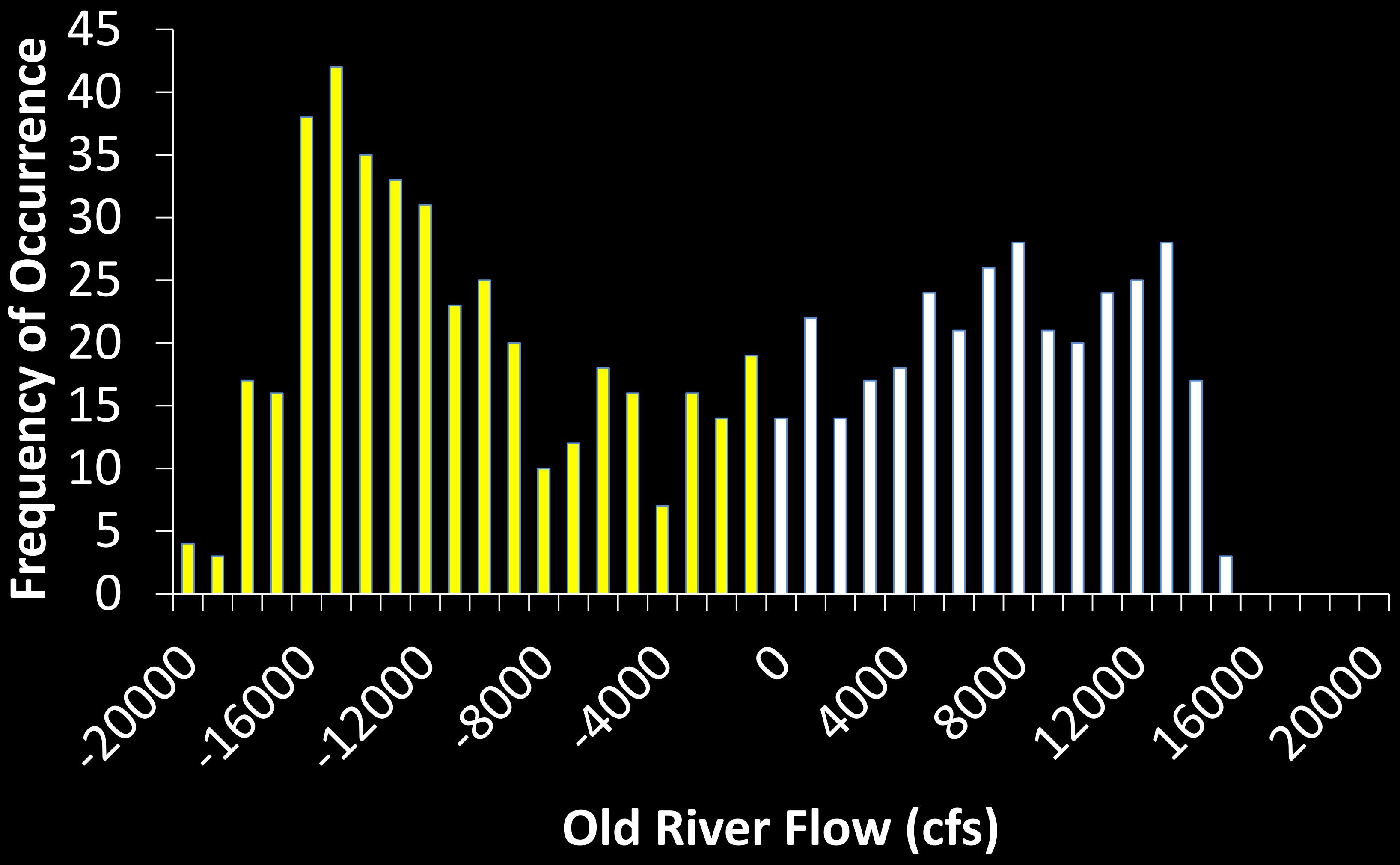
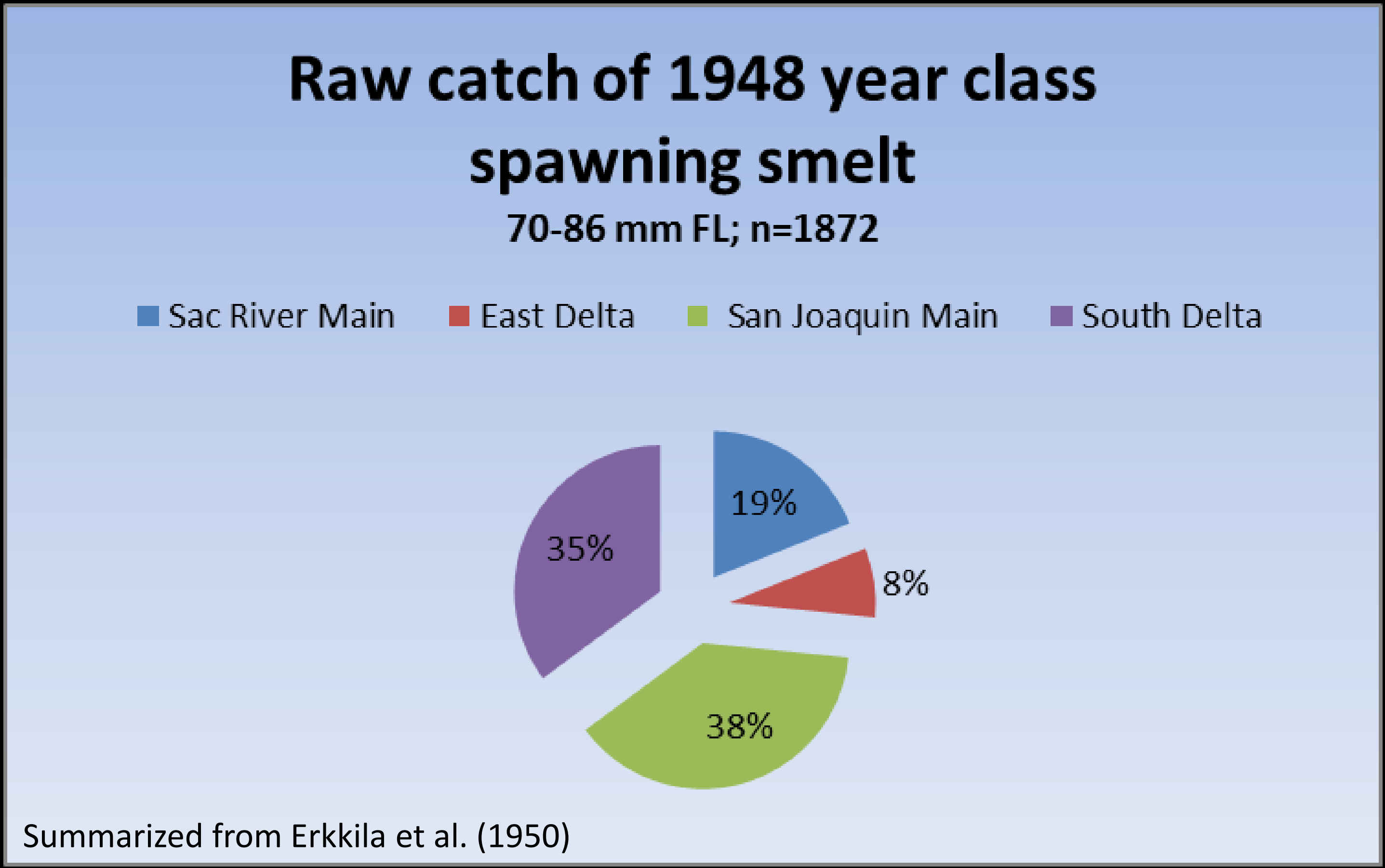


Figure credit: Grimaldo et al. (2009)

OMR is an index for more than net flow



This is about where delta smelt seem to have spawned in 1949



This is about where delta smelt seem to have spawned in 1964

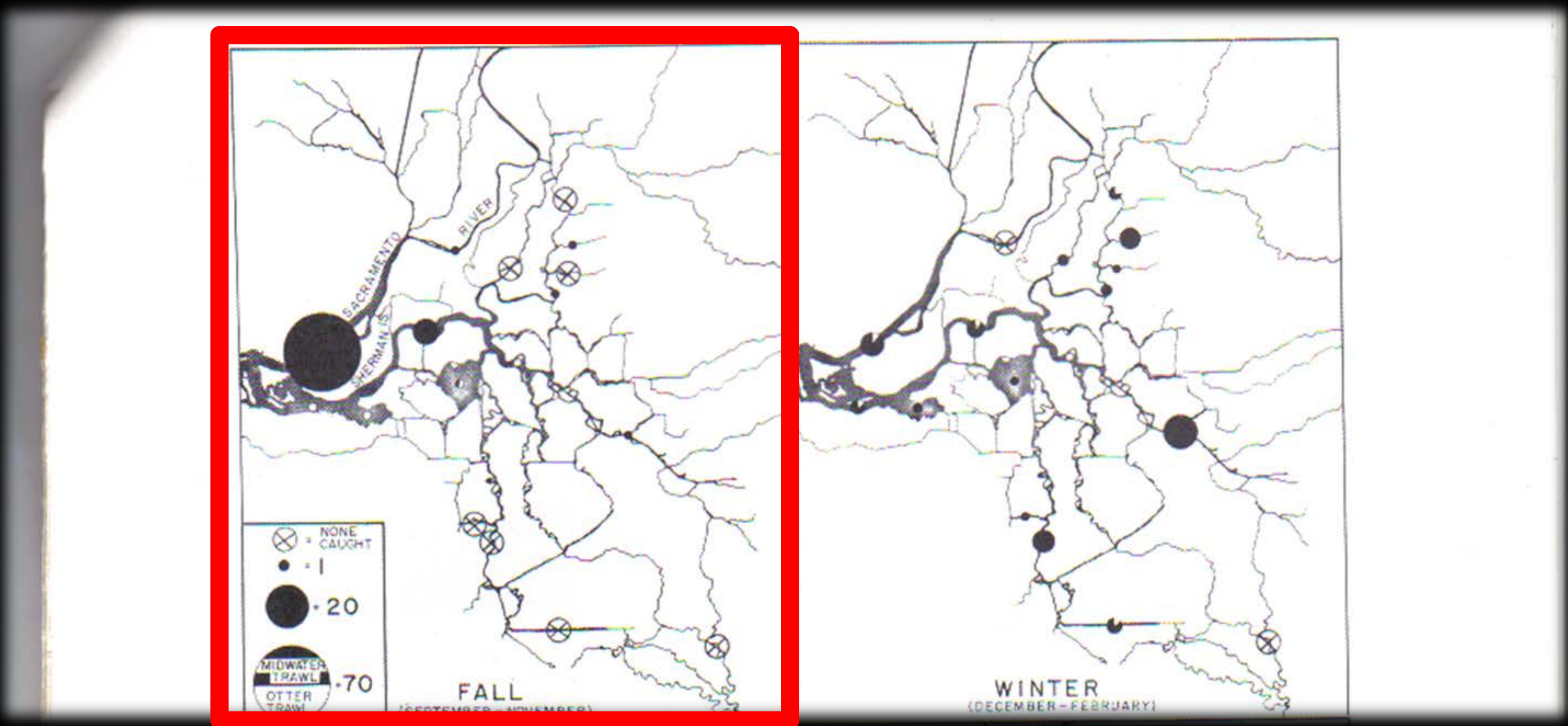


Figure credit: Turner and Kelley (1966)

This is about where delta smelt seem to have spawned in 1964

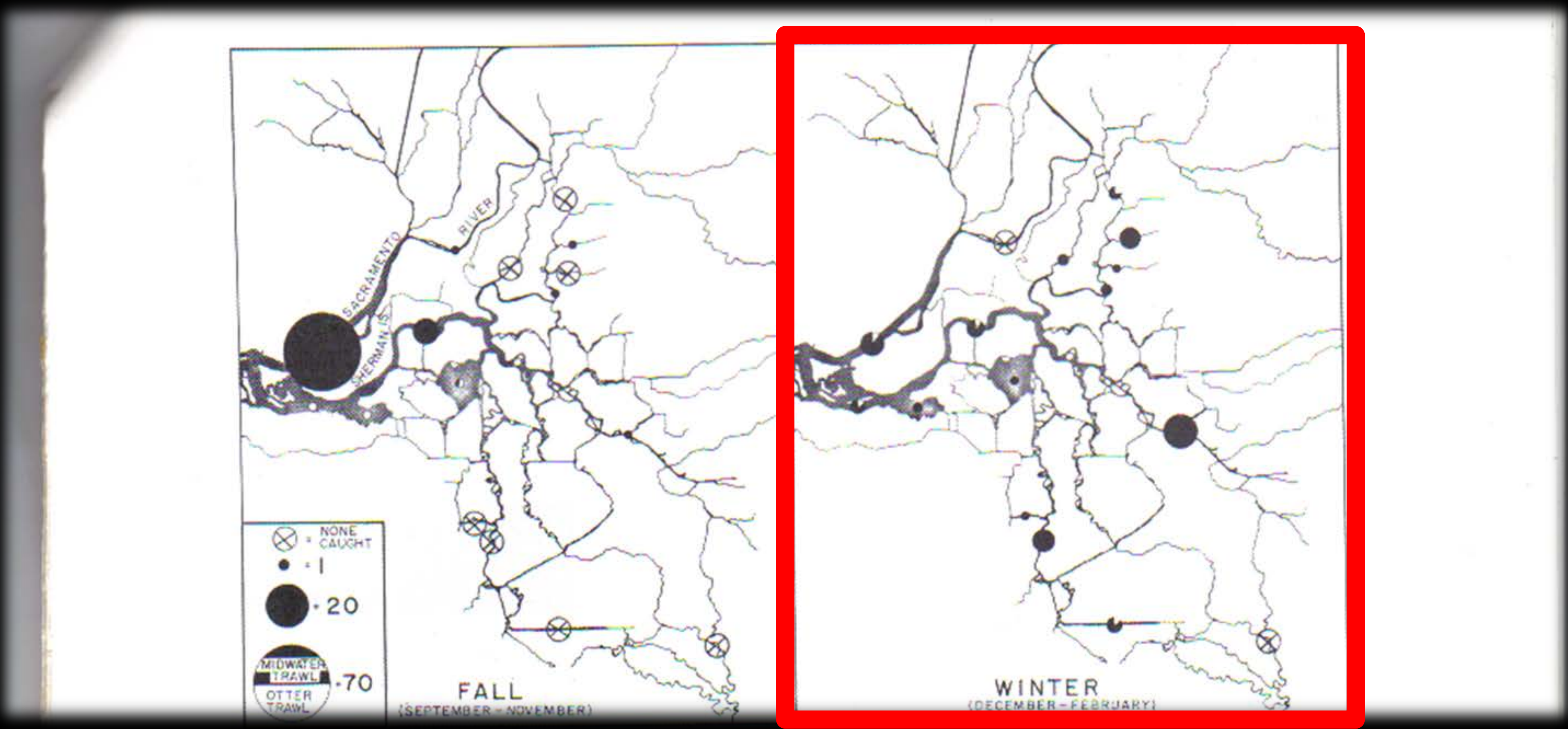
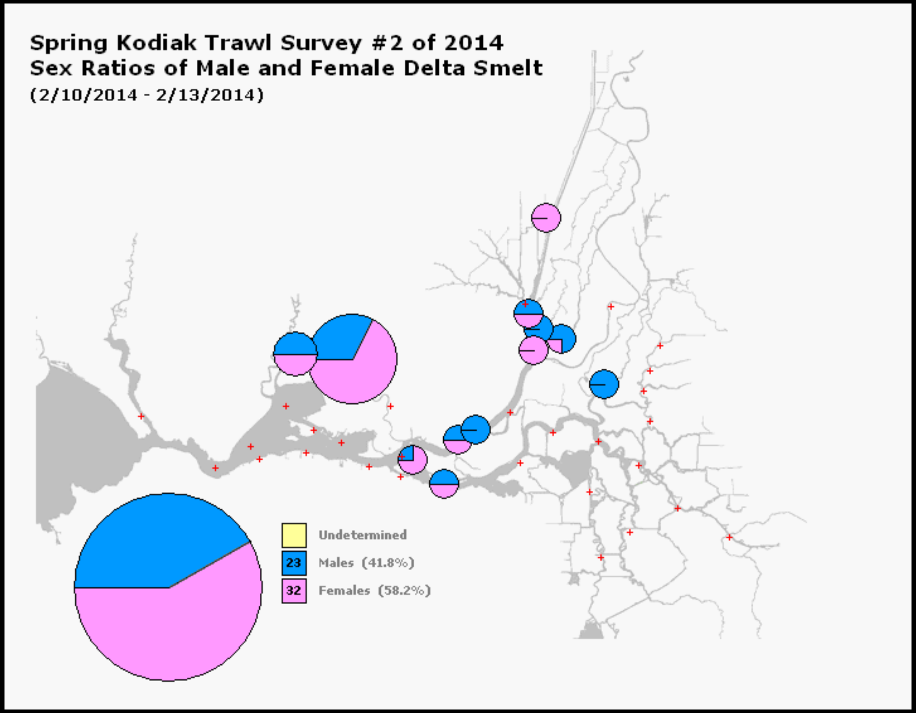
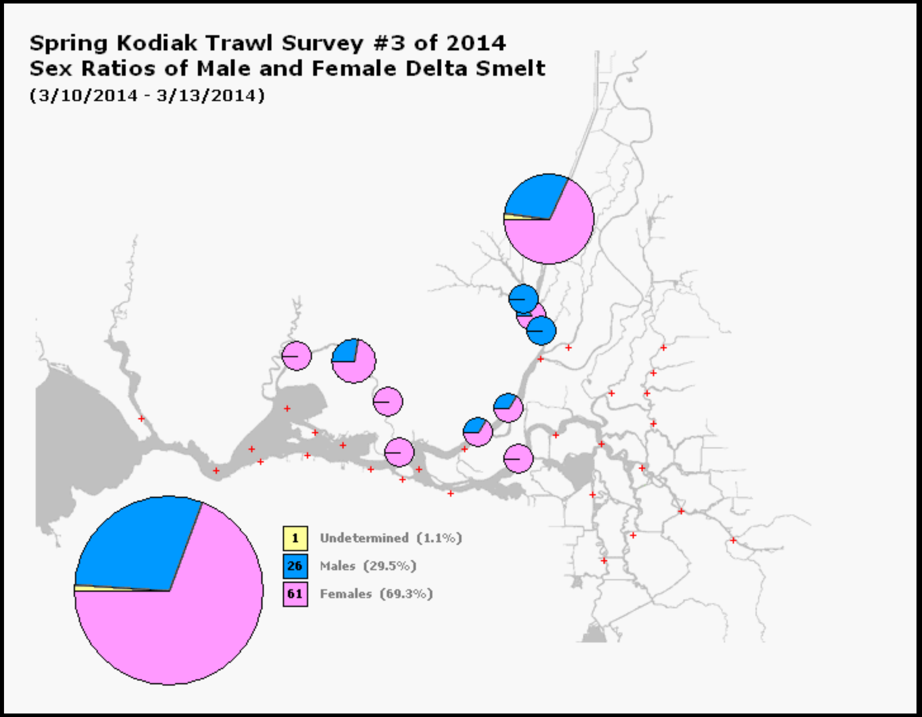


Figure credit: Turner and Kelley (1966)

This year was similar to most recent dry years





http://www.dfg.ca.gov/delta/data/skt/DisplayMaps.asp

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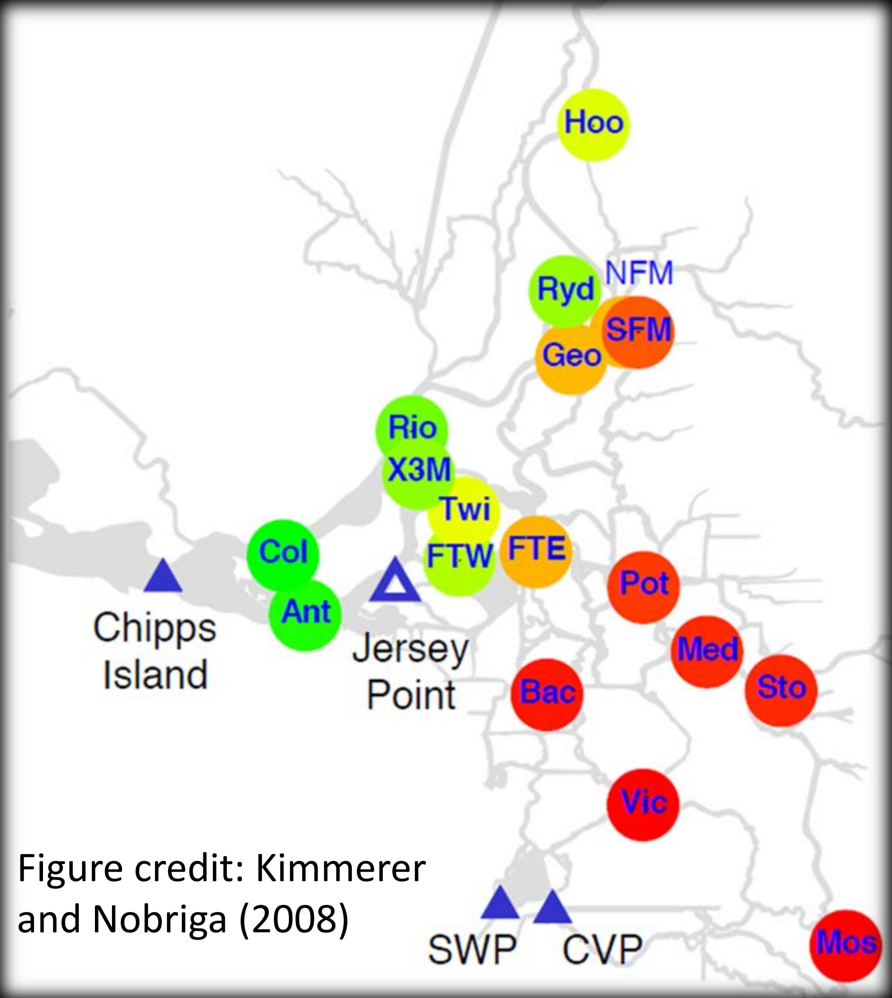

Figure credit: Kimmerer and Nobriga (2008)

ADULT ENTRAINMENT CONCEPTUAL MODEL FRAMEWORK

NORTH DELTA RESIDENTS

1. Ƒ(Q_{tide})
2. Ƒ(turbidity)
3. Ƒ(Q_{tide} + turbidity)
4. Ƒ(Q_{tide} + turbidity + ?)

P(E) ≈ 0

LEGEND

Q_{tide} = tidal flow
Q_{out} = Delta outflow
Q_{OMR} = OMR flow
P(E) = probability of entrainment

FISH AT THE CONFLUENCE CAN MOVE SEAWARD

Ƒ(Q_{out} > ?)

P(E) ≈ 0

FISH AT CONFLUENCE CAN MOVE INTO EITHER THE SACRAMENTO OR SAN JOAQUIN RIVERS

1. Ƒ(Q_{tide})
2. Ƒ(turbidity)
3. Ƒ(Q_{tide} + turbidity)
4. Ƒ(Q_{tide} + turbidity + ?)

P(E) > 0

FISH THAT MOVE INTO THE SJR CAN MOVE INTO OLD/MIDDLE RIVER

1. Ƒ(Q_{tide})
2. Ƒ(Q_{OMR})
3. Ƒ(turbidity)
4. Ƒ(Q_{tide} + turbidity)
5. Ƒ(Q_{OMR} + turbidity + ?)
6. Ƒ(Q_{tide} + turbidity + ?)
7. Ƒ(Q_{OMR} + turbidity + ?)

1. P(E) >> 0
2. P(E) ≈ 1

ADULT ENTRAINMENT CONCEPTUAL MODEL FRAMEWORK

NORTH DELTA RESIDENTS

1. $F(Q_{tide})$
2. $F(\text{turbidity})$
3. $F(Q_{tide} + \text{turbidity})$
4. $F(Q_{tide} + \text{turbidity} + ?)$

$P(E) \approx 0$

LEGEND

Q_{tide} = tidal flow
Q_{out} = Delta outflow
Q_{OMR} = OMR flow
$P(E)$ = probability of entrainment

FISH AT THE CONFLUENCE CAN MOVE SEAWARD

$F(Q_{out} > ?)$

$P(E) \approx 0$

FISH AT CONFLUENCE CAN MOVE INTO EITHER THE SACRAMENTO OR SAN JOAQUIN RIVERS

1. $F(Q_{tide})$
2. $F(\text{turbidity})$
3. $F(Q_{tide} + \text{turbidity})$
4. $F(Q_{tide} + \text{turbidity} + ?)$

$P(E) > 0$

FISH THAT MOVE INTO THE SJR CAN MOVE INTO OLD/MIDDLE RIVER

1. $F(Q_{tide})$
2. $F(Q_{OMR})$
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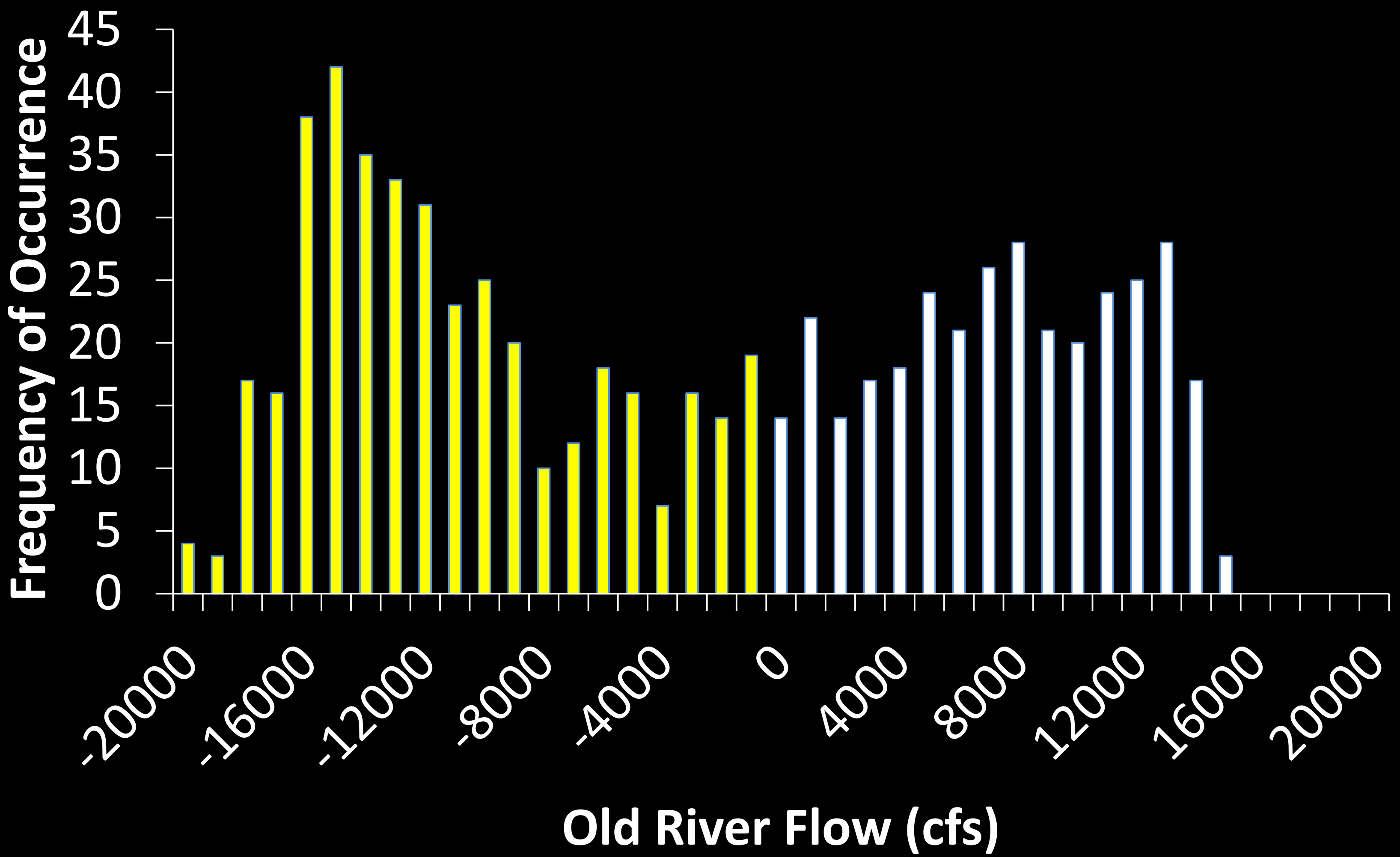
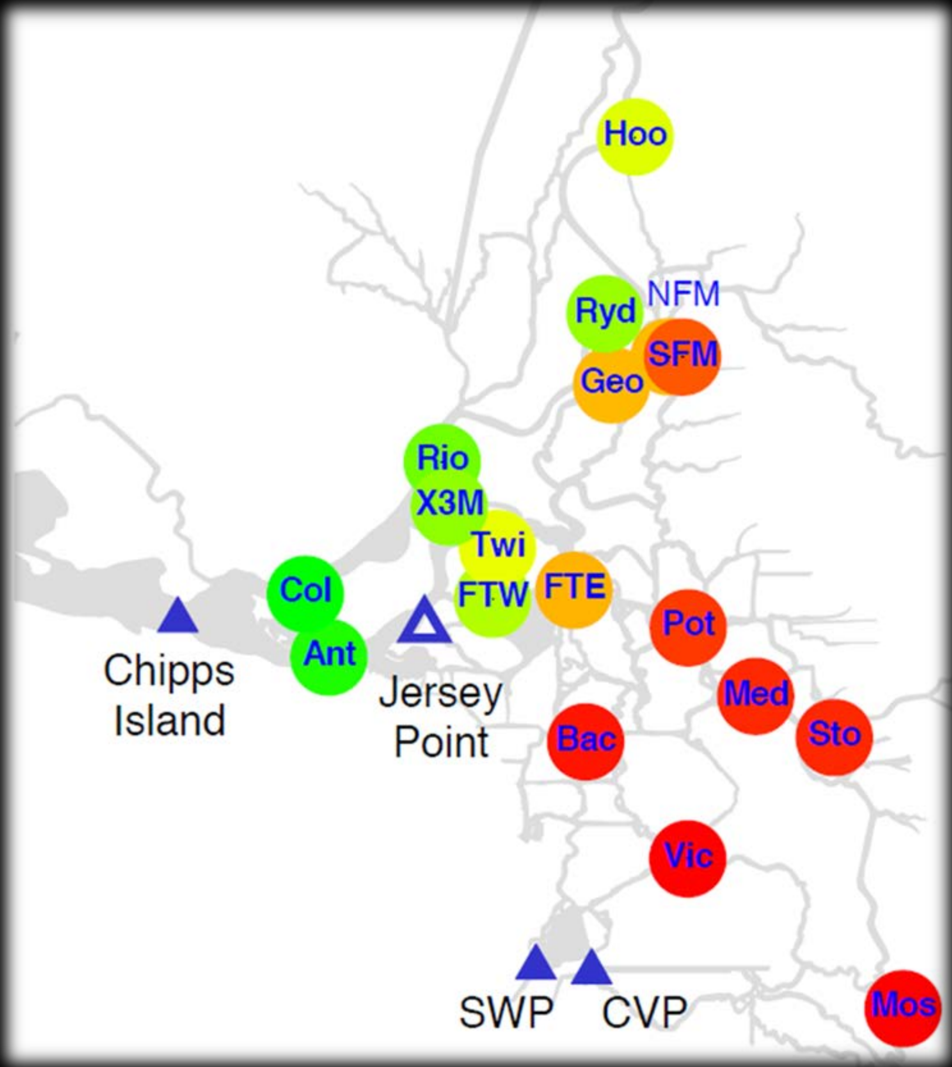
4. $F(Q_{tide} + \text{turbidity})$
5. $F(Q_{OMR} + \text{turbidity} + ?)$
6. $F(Q_{tide} + \text{turbidity} + ?)$
7. $F(Q_{OMR} + \text{turbidity} + ?)$

1. $P(E) >> 0$
2. $P(E) \approx 1$

OMR is an index for more than net flow



A neutrally buoyant particle is extremely unlikely to be entrained from Chipps Island, but a tide-surfing particle can be



Why not QWEST or E:I Ratio?

OMR FLOW IS THE BEST AVAILABLE HYDRODYNAMIC INDICATOR OF ENTRAINMENT RISK FOR DELTA SMELT

Take home points

- It’s a clam’s estuary
- The OCAP BiOp RPA focuses on OMR and Delta outflow because Project Operations were the scope of the consultation
- OMR is the best available flow metric to characterize/conceptualize entrainment risk for delta smelt

Relevant literature

Kimmerer, Wim J., and Matthew L. Nobriga. "Investigating particle transport and fate in the Sacramento-San Joaquin Delta using a particle tracking model." *San Francisco Estuary and Watershed Science* 6.1 (2008).

Kimmerer, Wim J. "Losses of Sacramento River Chinook salmon and delta smelt to entrainment in water diversions in the Sacramento-San Joaquin Delta."*San Francisco Estuary and Watershed Science* 6.2 (2008).

Miller, William J. "Revisiting assumptions that underlie estimates of proportional entrainment of delta smelt by state and federal water diversions from the Sacramento-San Joaquin Delta." *San Francisco Estuary and Watershed Science* 9.1 (2011).

Kimmerer, Wim J. "Modeling Delta Smelt losses at the south Delta export facilities." *San Francisco Estuary and Watershed Science* 9.1 (2011).

Grimaldo, Lenny F., et al. "Factors affecting fish entrainment into massive water diversions in a tidal freshwater estuary: can fish losses be managed?." *North American Journal of Fisheries Management* 29.5 (2009): 1253-1270.

Relevant literature

Mac Nally, Ralph, et al. "Analysis of pelagic species decline in the upper San Francisco Estuary using multivariate autoregressive modeling (MAR)."*Ecological Applications* 20.5 (2010): 1417-1430.

Thomson, James R., et al. "Bayesian change point analysis of abundance trends for pelagic fishes in the upper San Francisco Estuary." *Ecological Applications* 20.5 (2010): 1431-1448.

Miller, William J., et al. "An investigation of factors affecting the decline of delta smelt (Hypomesus transpacificus) in the Sacramento-San Joaquin Estuary."*Reviews in Fisheries Science* 20.1 (2012): 1-19.

Maunder, Mark N., and Richard B. Deriso. "A state–space multistage life cycle model to evaluate population impacts in the presence of density dependence: illustrated with application to delta smelt (Hyposmesus transpacificus)."*Canadian Journal of Fisheries and Aquatic Sciences* 68.7 (2011): 1285-1306.

Rose, Kenneth A., et al. "Individual-based modeling of Delta Smelt population dynamics in the upper San Francisco Estuary: I. Model description and baseline results." *Transactions of the American Fisheries Society* 142.5 (2013): 1238-1259.

Rose, Kenneth A., et al. "Individual-based modeling of Delta Smelt population dynamics in the upper San Francisco Estuary: II. Alternative baselines and good versus bad years." *Transactions of the American Fisheries Society* 142.5 (2013): 1260-1272.