San Francisco Bay Delta Ecosystem Changes & the Low Salinity Zone

California Department of Fish & Game

Workshop 1: Ecosystem Changes and the Low Salinity Zone

September 5, 2012

KEY POINTS

- Delta smelt and longfin smelt are at risk
- ↑ impairment of Delta outflow threatens longfin smelt viability
- ↓ size/quality of fall LSZ habitat threatens delta smelt viability
- LSZ and key species respond positively to Delta outflow
- Bay-Delta Plan insufficiently protective of smelt species
- 2011 exhibits the potential of improved Plan objectives

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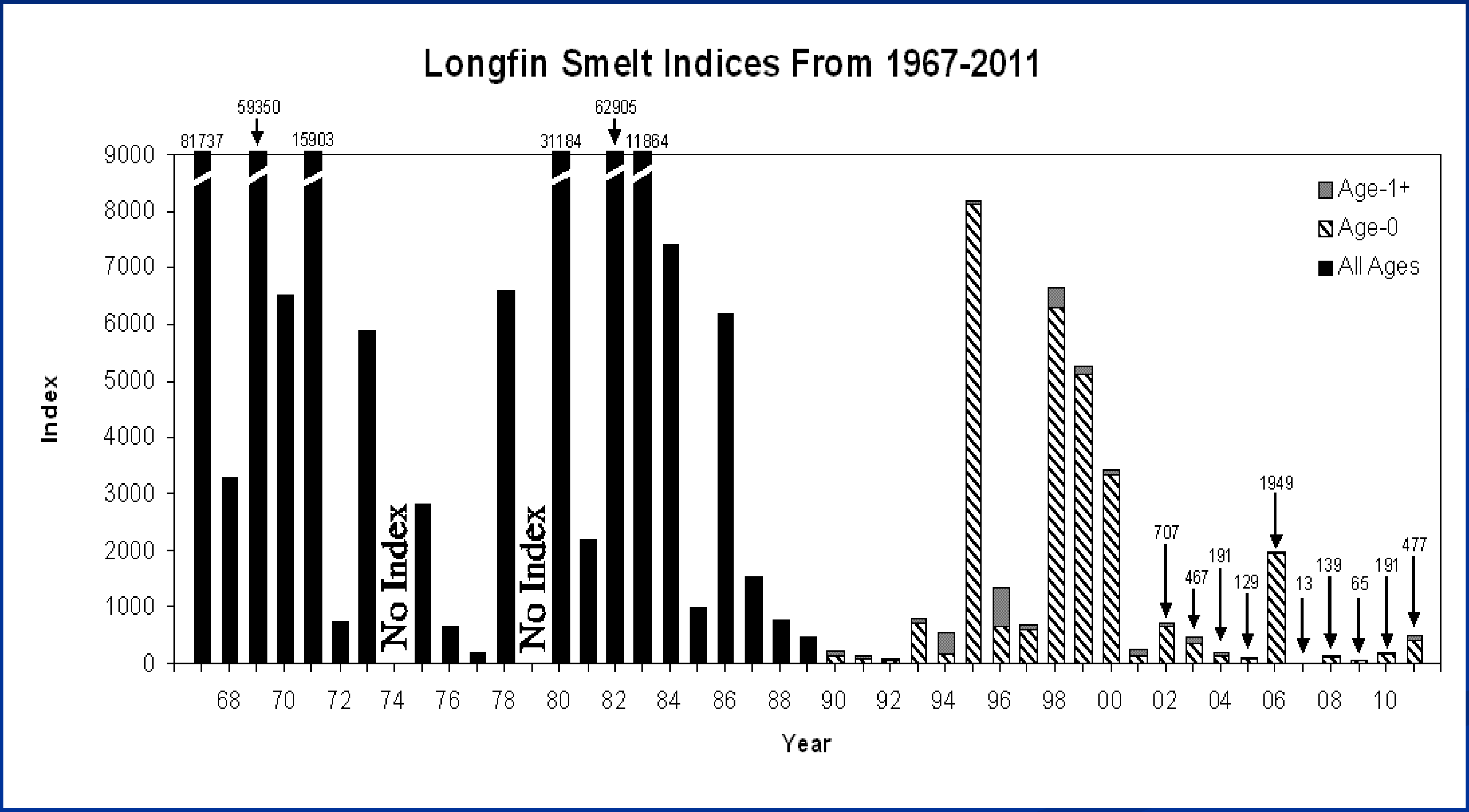
P. Coulston

SMELT SPECIES ARE AT RISK:
Listing Actions Since 2006

- Jan. 2010: Delta smelt threatened → endangered (CESA)
- Apr. 2010: Delta smelt warrant endangered status (ESA)
- Apr. 2010: Longfin smelt listed as threatened (CESA)
- Apr. 2012: Longfin smelt Bay-Delta DPS warrants listing (ESA)

SMELT SPECIES ARE AT RISK:

Longfin Smelt Status

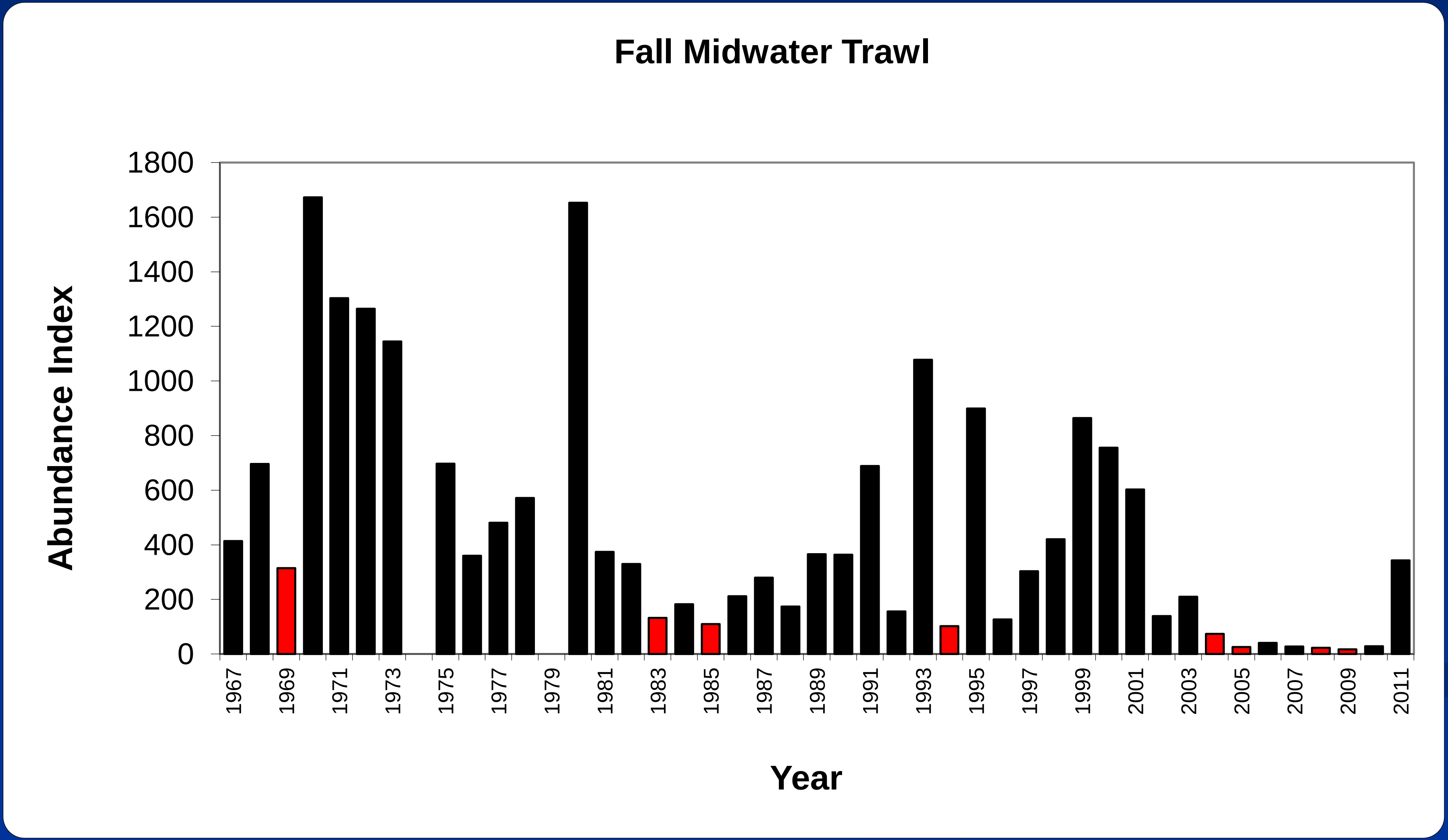


Current (2006) Bay-Delta Plan Insufficiently Protective of Longfin Smelt

- Longfin smelt respond strongly/positively to winter-spring outflow
- Spring outflow increasingly impaired
- Outflow impairment limits longfin smelt (and prey) production
- Bay-Delta Plan objectives allow for very high levels of outflow impairment
- Longfin smelt cohort-over-cohort increases are rare, thus population levels are fluctuating at very low levels
- Modest flow response in 2011

SMELT SPECIES ARE AT RISK:

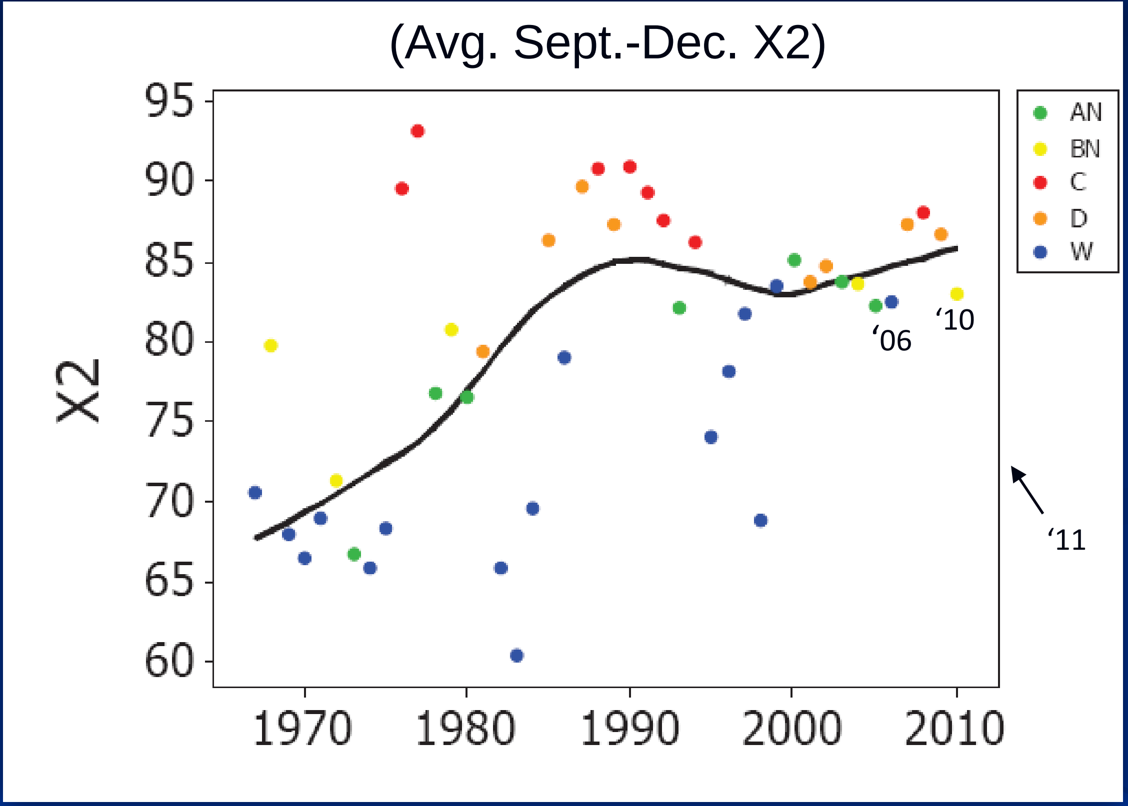
Delta Smelt Status



Good Fall Habitat Needed for Delta Smelt Viability

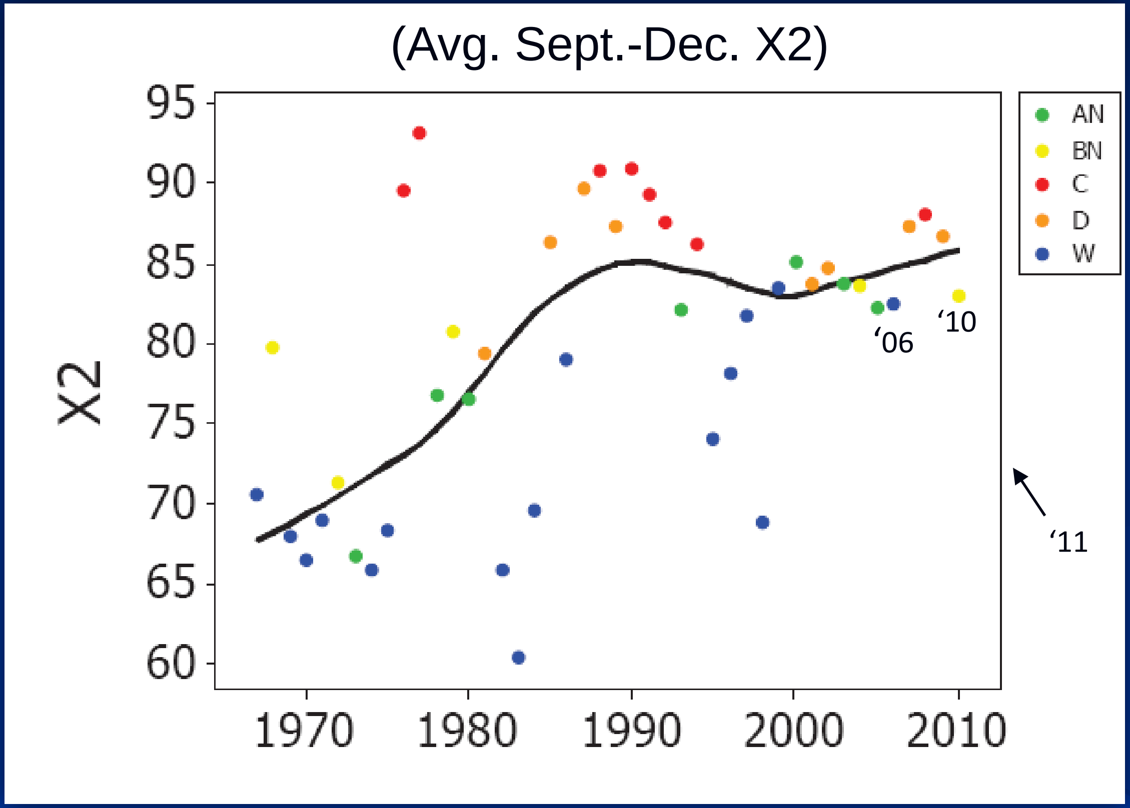
- Delta smelt live primarily within the LSZ
- Fall indices recently ≈10% of previous 30 years
- Increased frequency of record low indices
- Fall LSZ position influences cohort survival
- Striking detrimental trends are evident in fall X2 position, thus LSZ extent and condition.
- Bay-Delta Plan fall outflow objectives do not guard against high fall X2, irrespective of water year type
- Encouraging “bump” in fall 2011 abundance index

Recent History of Fall X2



Adapted from F. Feyrer 9/7/11 testimony during litigation of 2008 BO RPA

Delta Smelt Recruitment in Relation to Fall X2



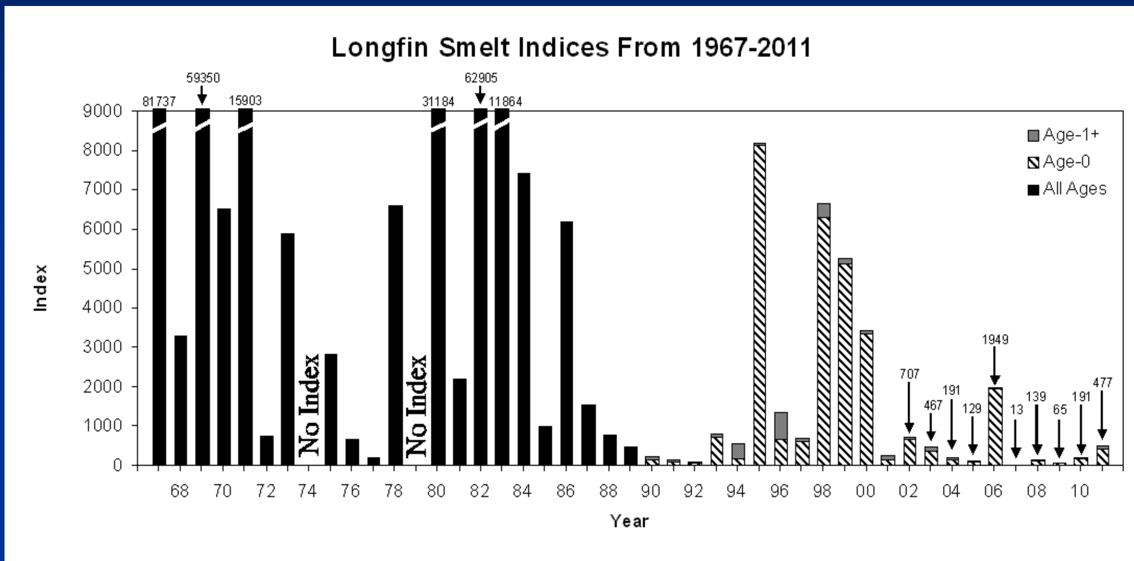
Recruitment Progression (FMWT → 20mm → FMWT)

2009-2011: 17 → 3.8 → 29

29 → 8.0 → 343

2005-2006: 26 → 9.9 → 41

2011 Smelt Flow Response

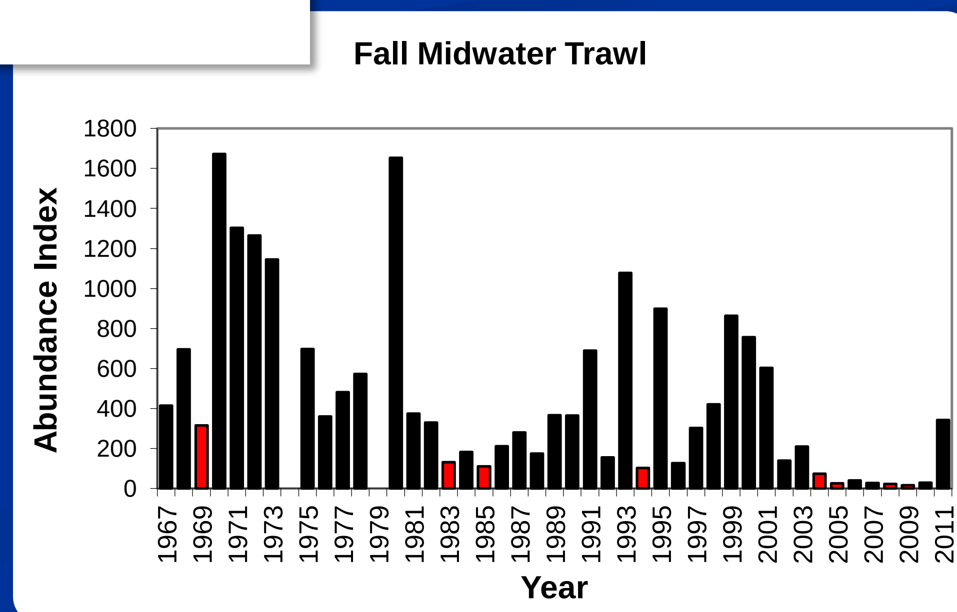


Longfin Smelt Recruitment Ratios
(FMWT/FMWT-2yrs)

2006	2010	2011
10.2	1.3	7.3

Delta Smelt
Recruitment Ratios
(FMWT/20mm)

2006	2010	2011
4.1	7.6	42.9



Sources of "Additional" Information

Available

- 2010-2012 ESA/CESA Listing Documents
- 2011 and early 2012 IEP indices and survey data
- USBR fall outflow Adaptive Management Plan, and independent science review
- Various other independent science reviews

Pending

- FLaSH Study Results
- BDCP Effects Analysis, Conservation Measures

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- LSZ and key species respond positively to Delta outflow
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WHAT'S NEXT

Adaptive Management

- Why (complex adaptive system)
- Adaptive Management model is well vetted
- Where we are (conceptually) in this process
- What we need out of WQCP

Climate Change

- Stages of response

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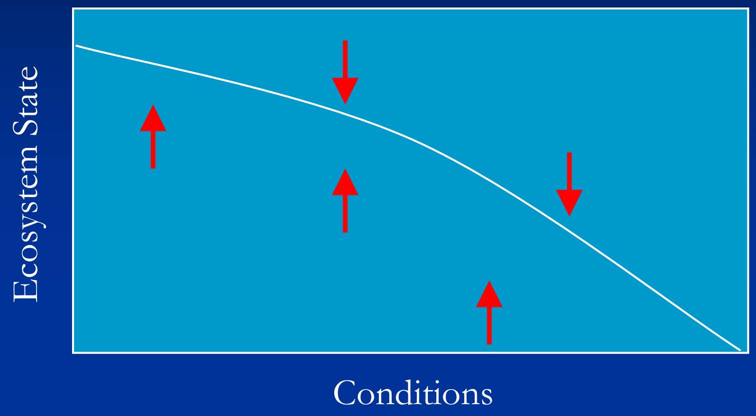
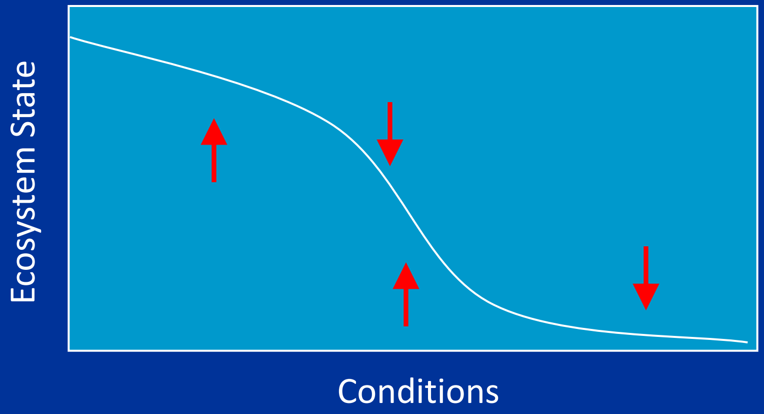
John Shelton

Complex Systems



Ecological Systems tend to be Non-linear

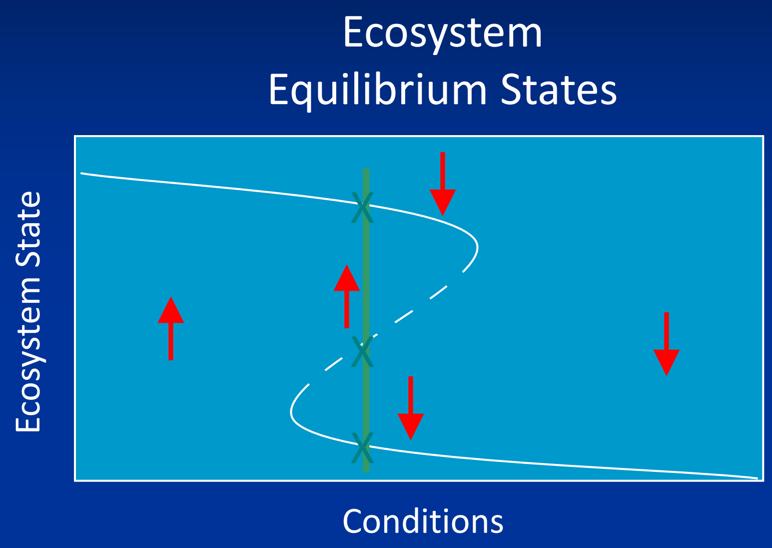


This Non-linearity can be pronounced

The arrows indicate the direction of change when the system is out of equilibrium.

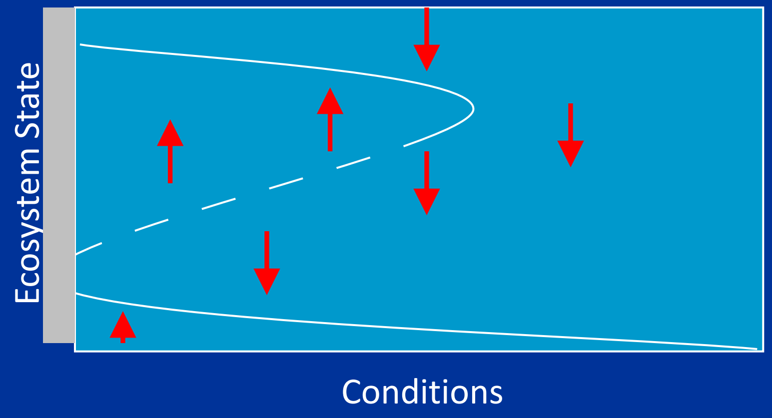
Modified from: Scheffer, M., Brock, W. & Westley, F. 2000. Socioeconomic mechanisms preventing optimum use of ecosystem services: an interdisciplinary theoretical analysis. Ecosystems 3, 451-471

Critical Transitions - Hysterisis



Hysteresis occurs when there is a fold of the “equilibrium line” that results in:

- Different “paths” of change
- Tipping point characteristics



Further folding of the equilibrium line can lead to irreversible system dynamics

Modified from: Scheffer, M., Brock, W. & Westley, F. 2000. Socioeconomic mechanisms preventing optimum use of ecosystem services: an interdisciplinary theoretical analysis. Ecosystems 3, 451-471

Complex Adaptive Systems

Nonlinear Interactions

- Multiple individual parts undergoing simultaneous nonlinear interactions
- Emergent behavior is more than the sum of the parts

Aggregate Behavior

- Impact of the system is its aggregate behavior
- Aggregate behavior feeds back to the parts and modifies their behavior

Change

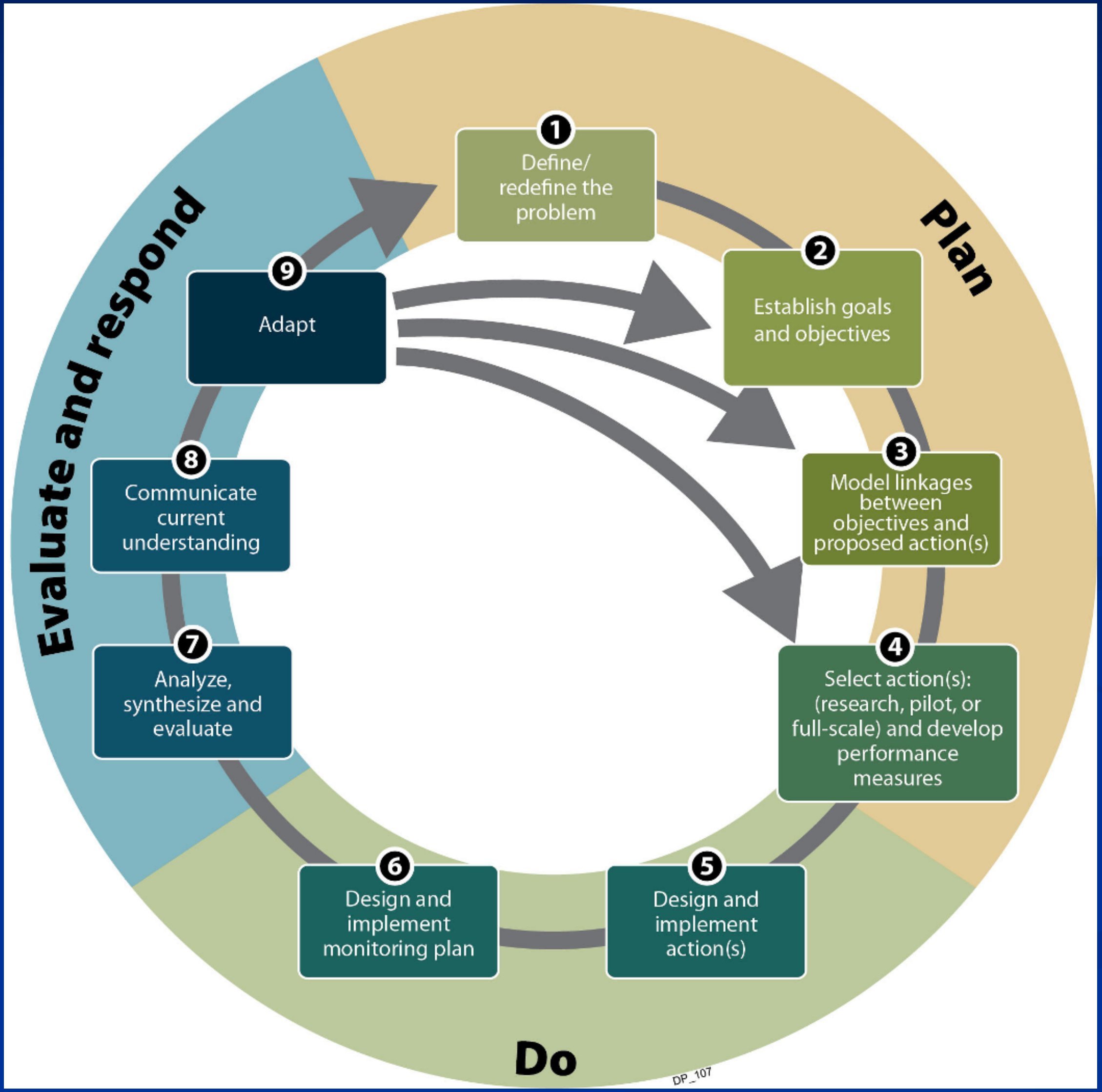
- Interaction of the parts evolves over time
- Parts may face perpetual novelty
- Typically operate far from optimum and far from equilibrium

Anticipation

- Individual parts anticipate the consequences of their responses
- Aggregate anticipation affects the system's behavior
- Is the least understood property of such systems

Modified from: Holland, J. H. 1975. *Adaptation in Natural and Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence*, USA: MIT Press

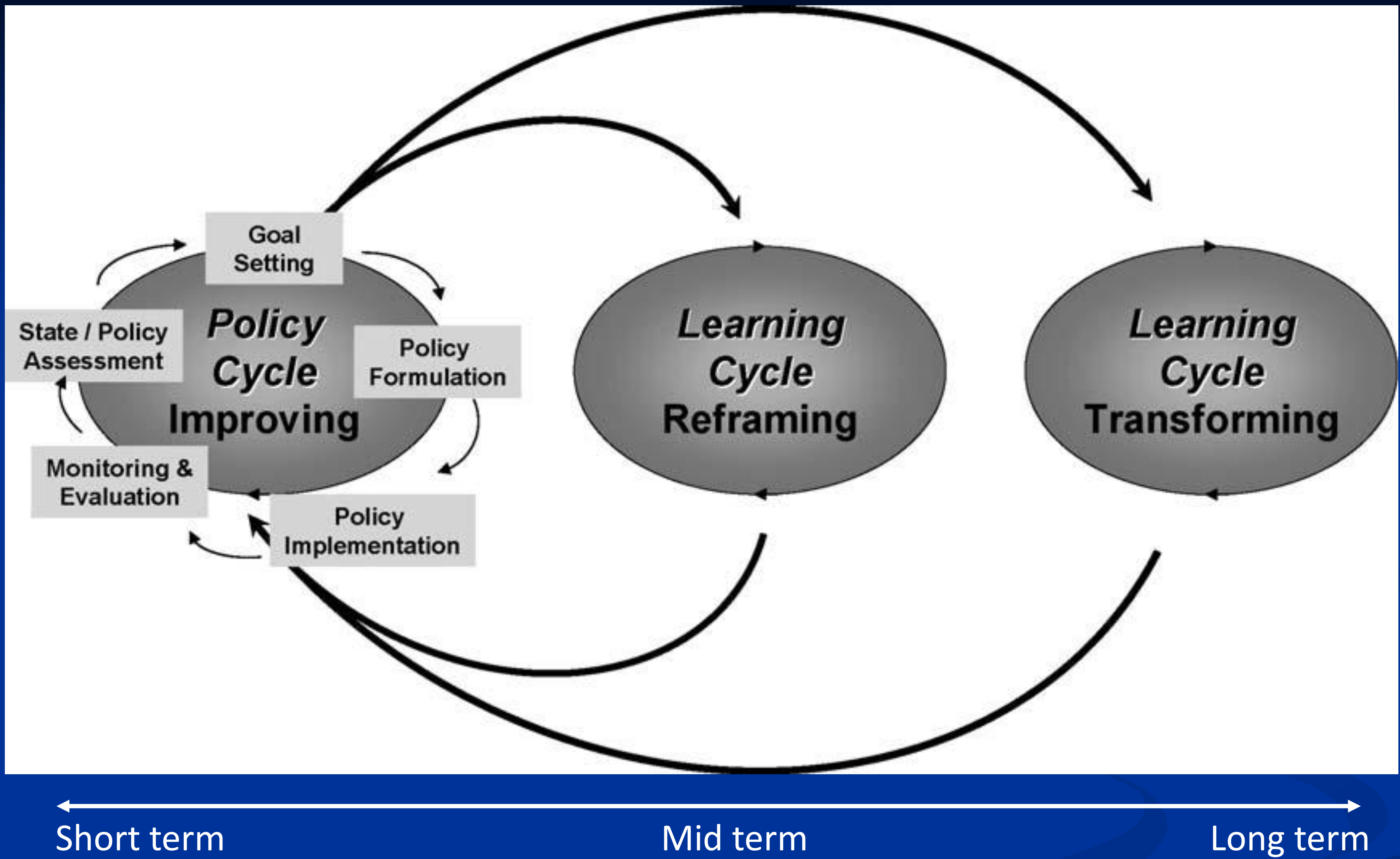
Adaptive Management



The Delta Independent Science Board noted that the Delta Plan provides:

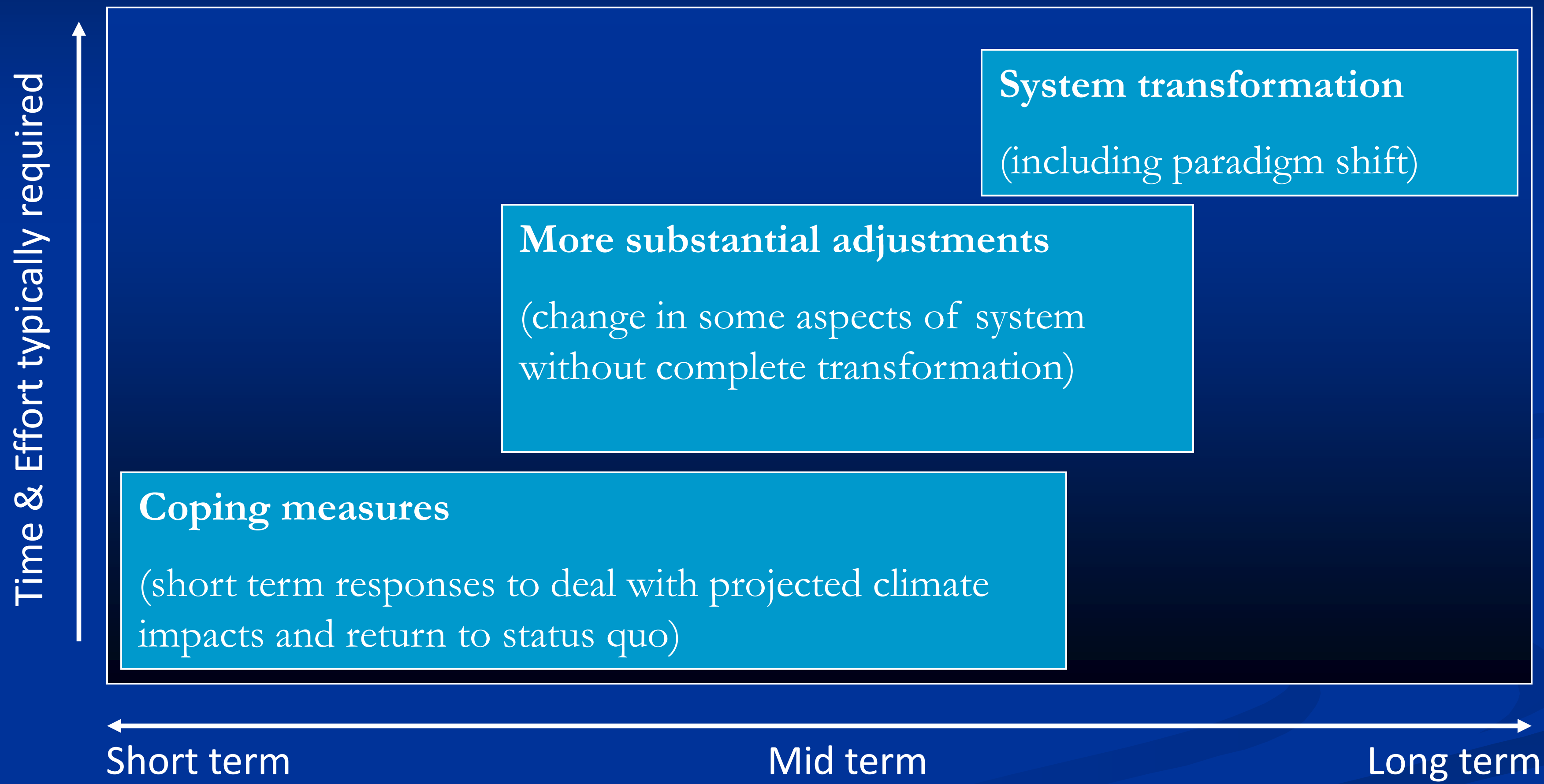
- ✓an excellent description of adaptive management
- ✓Represents an effective synthesis of the existing literature
- ✓Is presented in a manner that is instructive

From: Delta Stewardship Council. 2012. Final Staff Draft of the Delta Plan. Available online: http://deltacouncil.ca.gov/delta-plan. Accessed 8/10/12.



From: Pahl-Wostl C. 2009. A conceptual framework for analyzing adaptive capacity and multi-level learning processes in resource governance regimes. Glob Environ Change 19:354–365.

Scope and Scale of Adaptation to Climate Change



Modified from: Moser SC, Ekstrom JA. 2010. A framework to diagnose barriers to climate change adaptation. Proc Natl Acad Sci USA 107:22026–22031.

Summary

- Adaptive Management
  - Delta is a Complex Adaptive System
  - Requires Adaptive Management
  - Adaptive Management Model is well accepted
  - Delta Ecosystem Management
    - “Transformed” by Delta Reform Act & Co-Equal Goals
    - Current Processes need to “Re-Frame”
    - Need clear objectives to have effective “Policy Cycle”
- Climate Change
  - Response related to Time Horizon

SWRCB San Francisco Estuary low-salinity zone workshop

U.S. Fish and Wildlife Service

September 5, 2012

Key points

1. Please see April 2012 key points

2. We suggest the Board model a range of flow objectives that could be incorporated into the WQCP

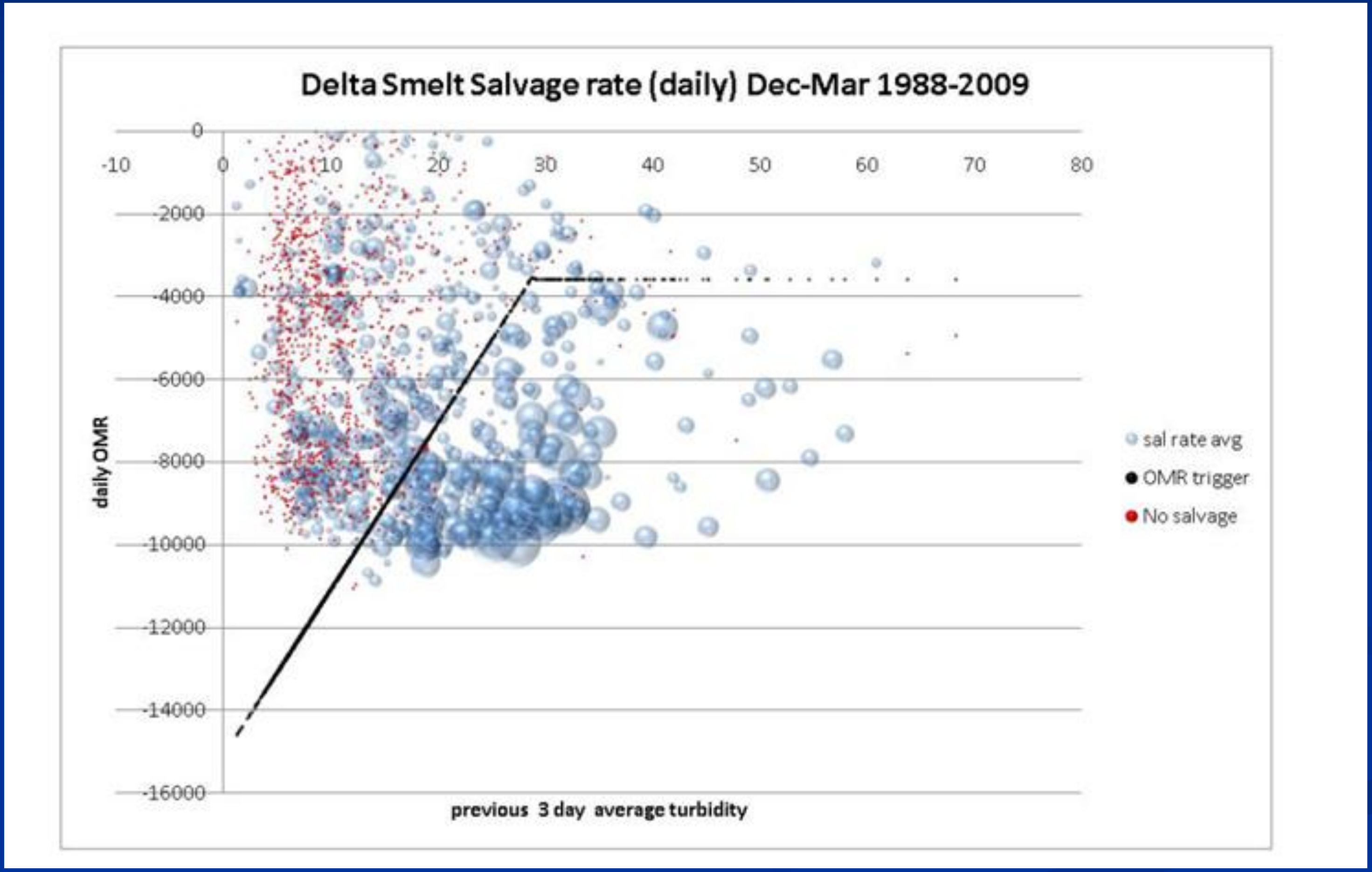
3. OMR flows contribute to the entrainment risk of adult delta smelt

4. OMR flows drive entrainment of larval delta smelt

5. Multiple factors have contributed to the long-term degredation of the LSZ. However, Delta outflow is still an extremely important aspect of habitat suitability for delta smelt

NEW SCIENCE REGARDING ADULT DELTA SMELT ENTRAINMENT

High adult delta smelt salvage usually happens when OMR flows are negative and turbidity is high



Source: Declaration of Dr. Richard Deriso

Time scale affects OMR-salvage linkage: a direction for adaptive management

Time step (days)	Starting OMR (cfs)		Turbidity threshold (NTU)		Alternative OMR
1	-3000	Until	13	Then	-1900
7	-5200	Until	23	Then	-1900
14	-3300	Until	25	Then	-2500
24	-4600	Until	29	Then	-3600
28-31	-4200	Until	No threshold	Then	-4200

Source: USFWS unpublished data analysis

NEW SCIENCE REGARDING LARVAL DELTA SMELT ENTRAINMENT

Modeling and data agree on driver of larval delta smelt entrainment

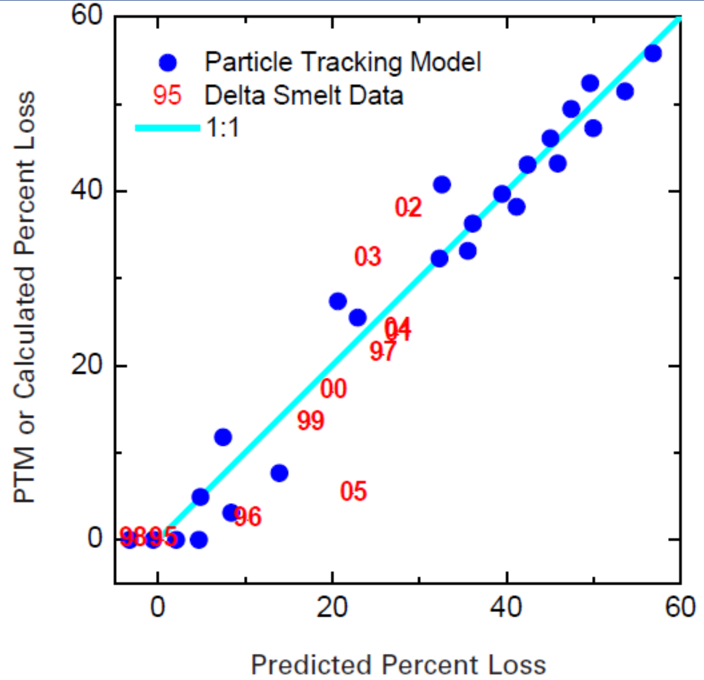
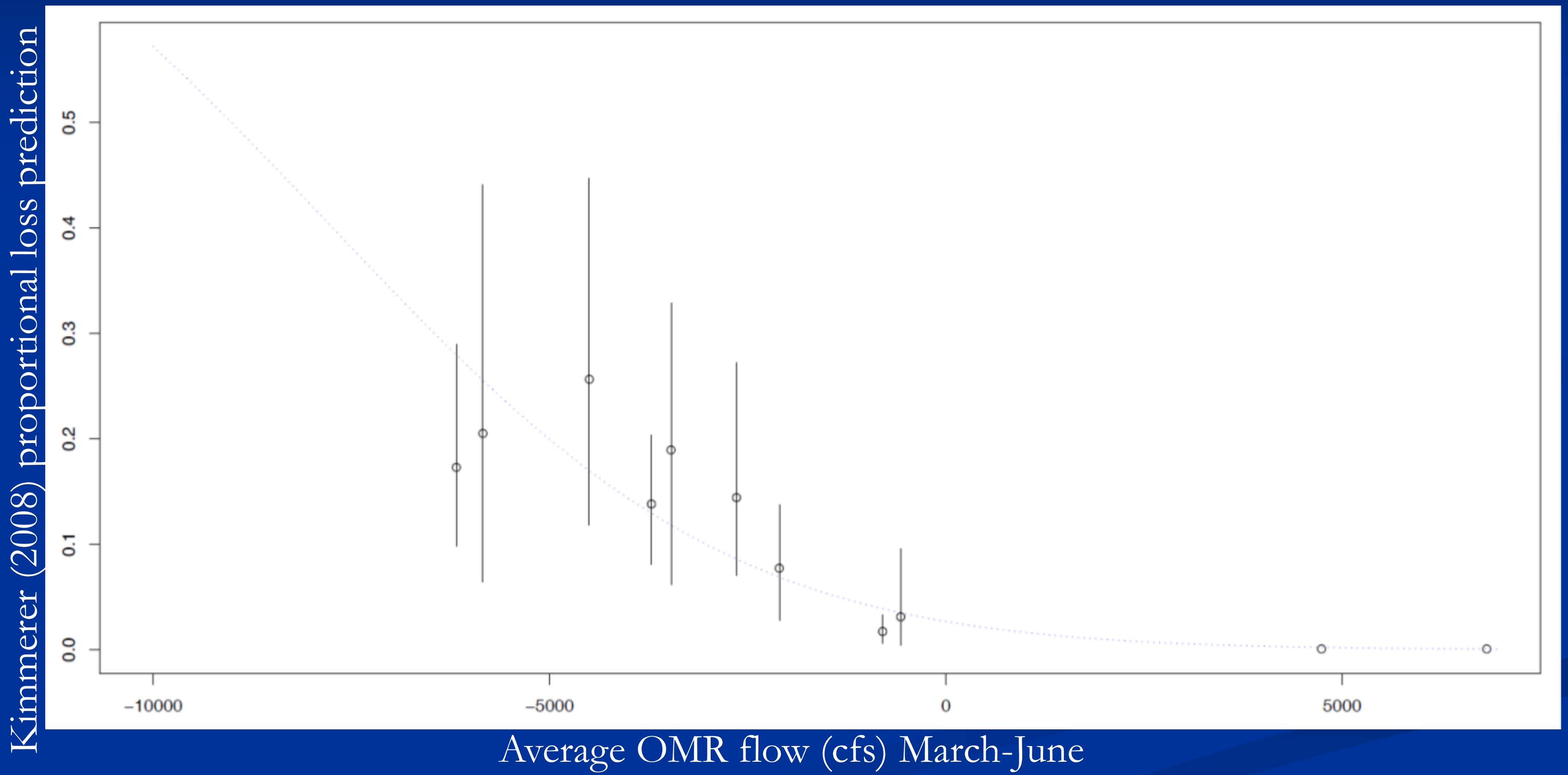


Figure 16. Larval/juvenile delta smelt. Predicted percent loss to the population by regression using log of Delta inflow and log of export flow as predictors (with interaction), and particle-tracking model results as the dependent variable (circles), with the line indicating a 1:1 relationship. The regression is:

Source: Kimmerer (2008) San Francisco Estuary and Watershed Science

OMR flow drives larval delta smelt entrainment



Source: USFWS unpublished data analysis

Entrainment can contribute to delta smelt decline

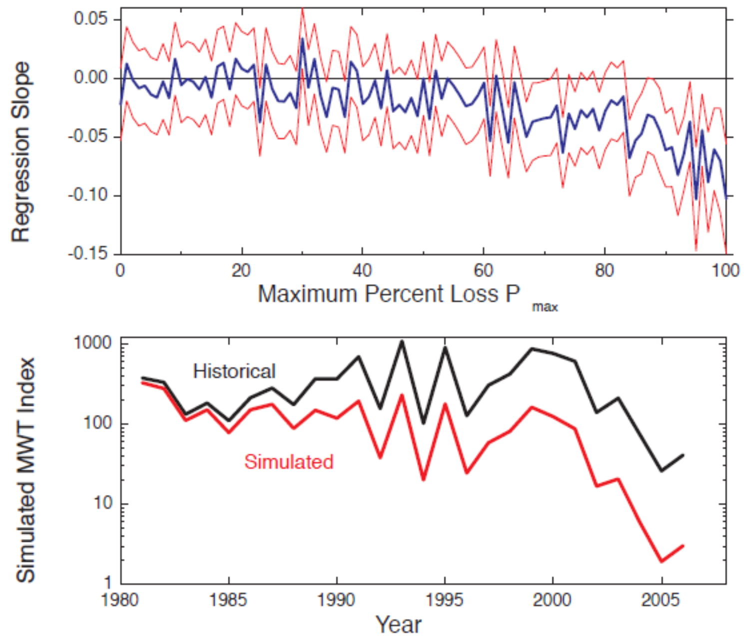
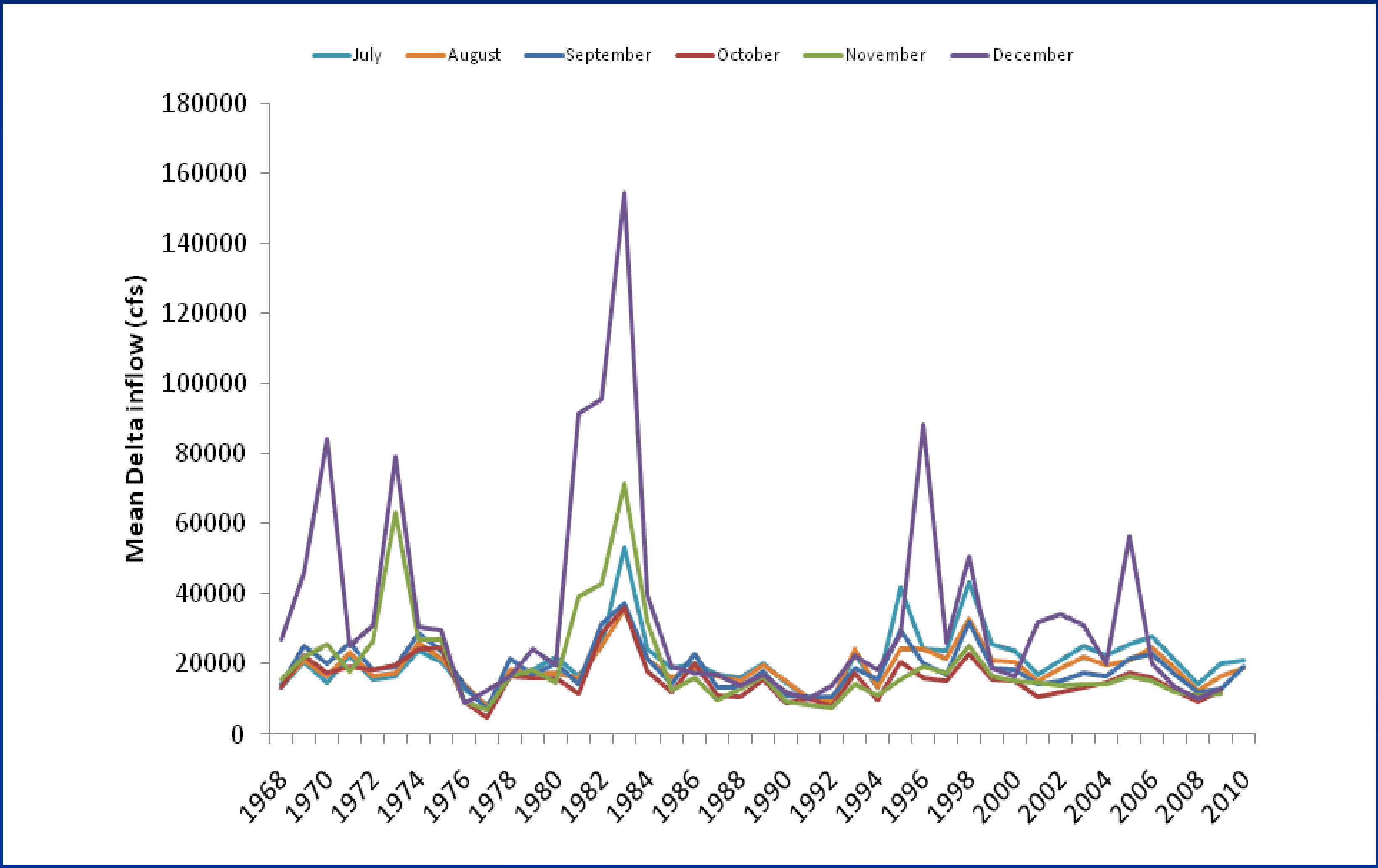


Figure 3 Results of simulation of ability to detect export loss through regression analysis. Upper panel: individual simulation results giving the slope (thick blue line) and 95% confidence limits (thin red lines) for regressions of the stock-recruit index on southward OMR flow. Lower panel: trajectory of the fall midwater trawl index (upper line) and the same index with a 20% P_{max} value imposed for the entire time series (mean P_L ~10%). This is for illustration only (see text), and does not imply anything about the cause of the decline in delta smelt.

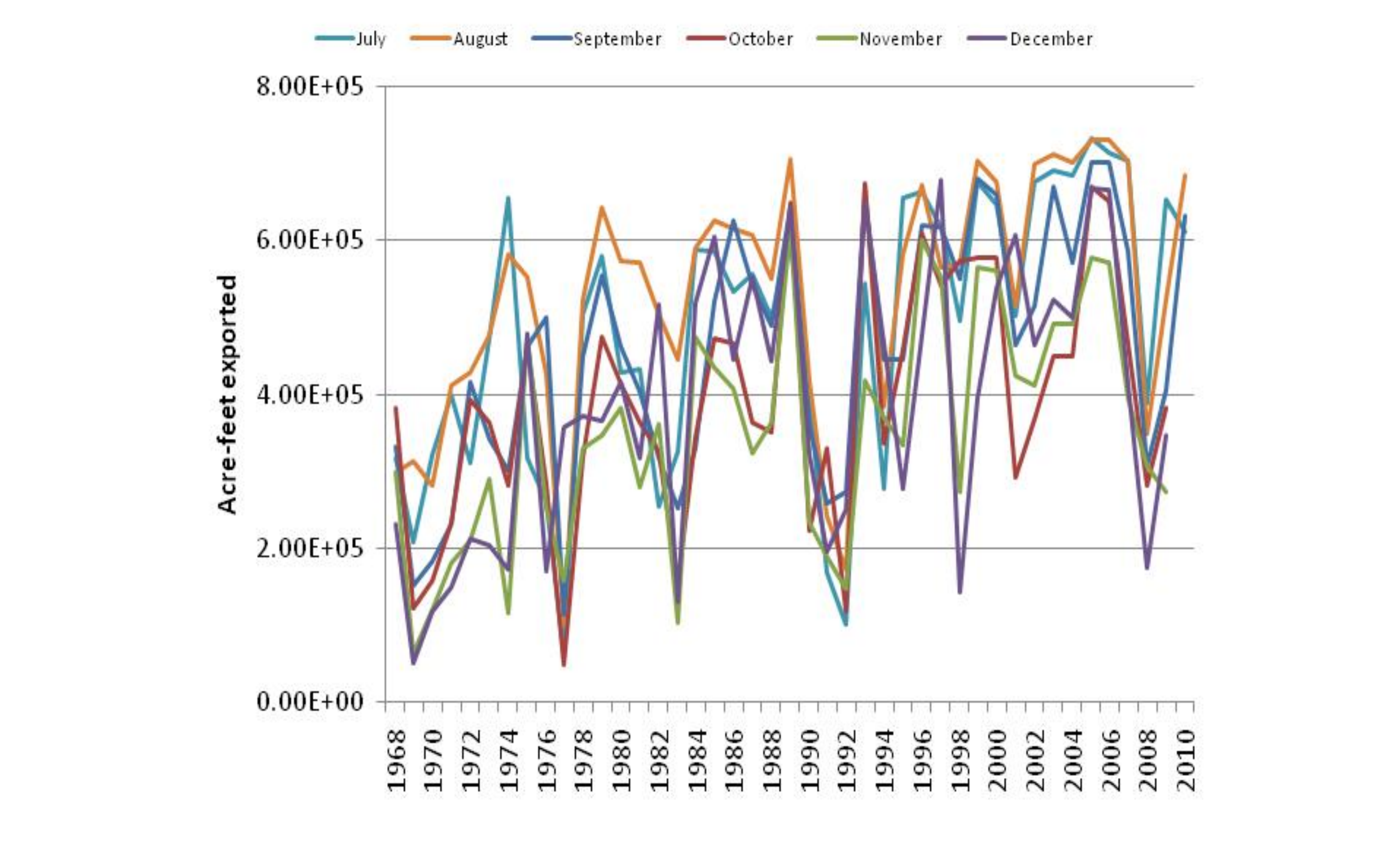
Source: Kimmerer (2011) San Francisco Estuary and Watershed Science

NEW SCIENCE REGARDING DELTA SMELT REARING HABITAT

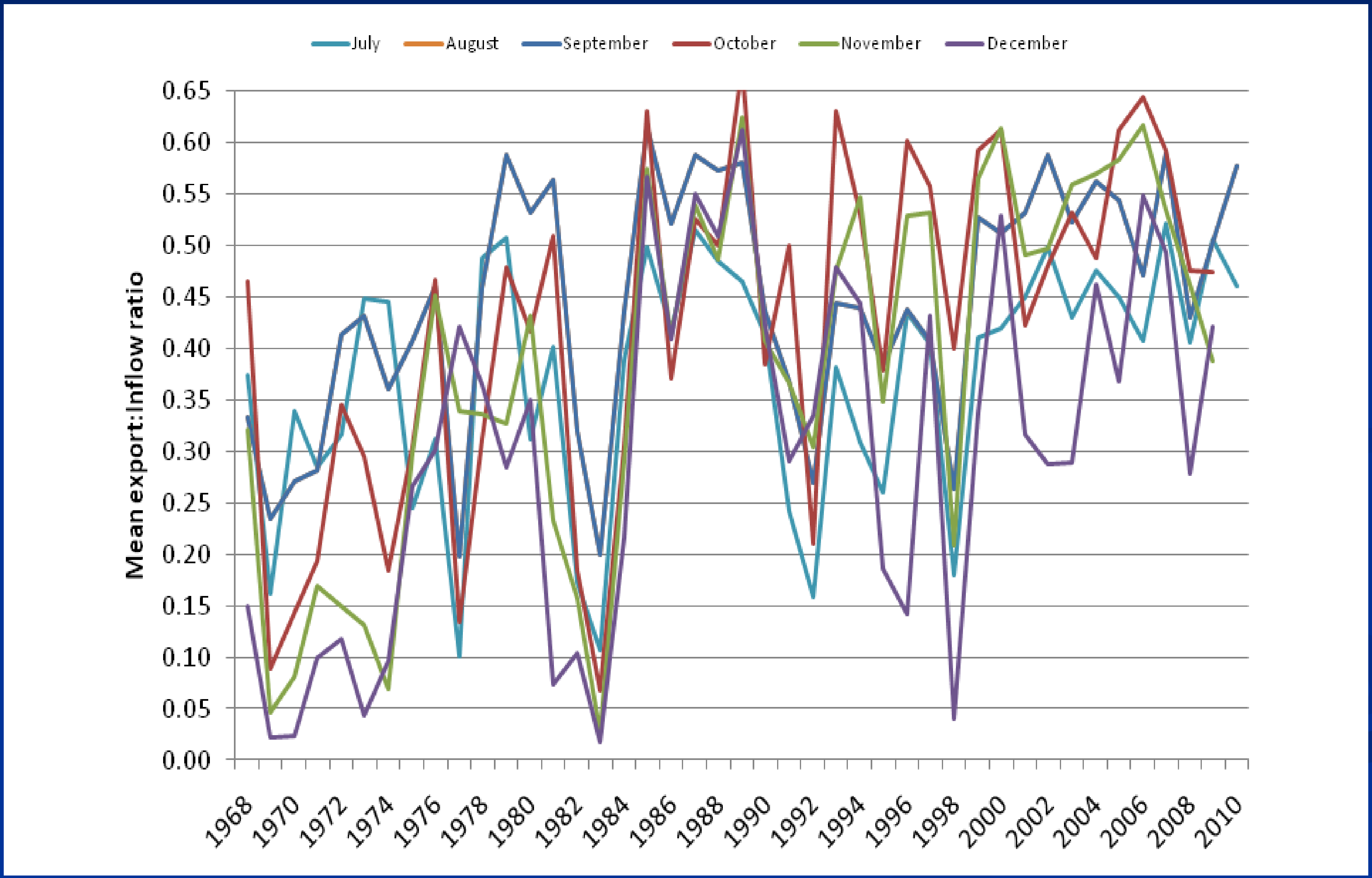
Time series of summer-fall Delta inflow



Time series of summer-fall exports



Time series of summer-fall E:I ratios



Feyrer et al. (2011)

- Fall habitat suitability has declined
- Fall habitat suitability is closely, but nonlinearly related to X2
- Fall habitat suitability correlated with abundance

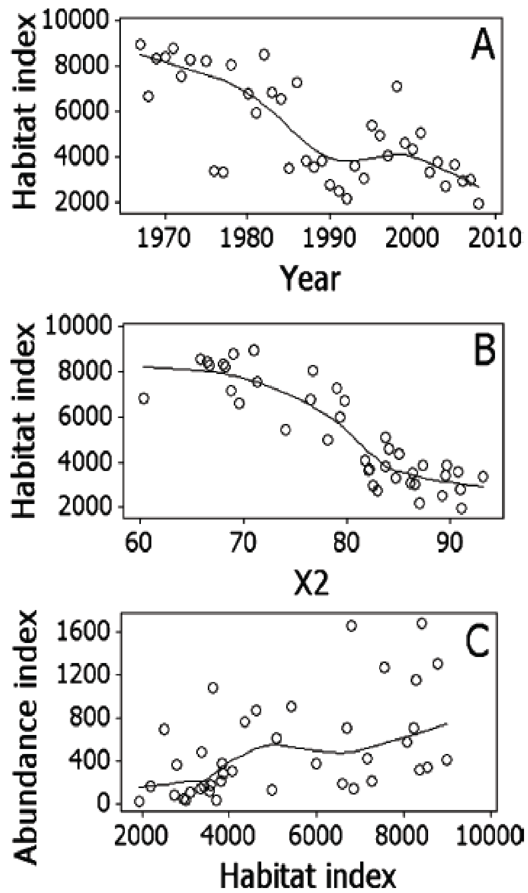


Fig. 2 Plots of the habitat index time series (**a**), relationship between *X2* (km) and the habitat index (**b**), and relationship between the habitat index and delta smelt abundance measured as the fall midwater trawl index. Curves are LOESS smooths

Key points

1. Please see April 2012 key points
2. We suggest the Board model a range of flow objectives that could be incorporated into the WQCP
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SWRCB San Francisco Estuary low-salinity zone workshop

U.S. Environmental Protection Agency

September 5, 2012

Outline

- Clean Water Act
- New information
- Bay-Delta Basin Plan

Clean Water Act

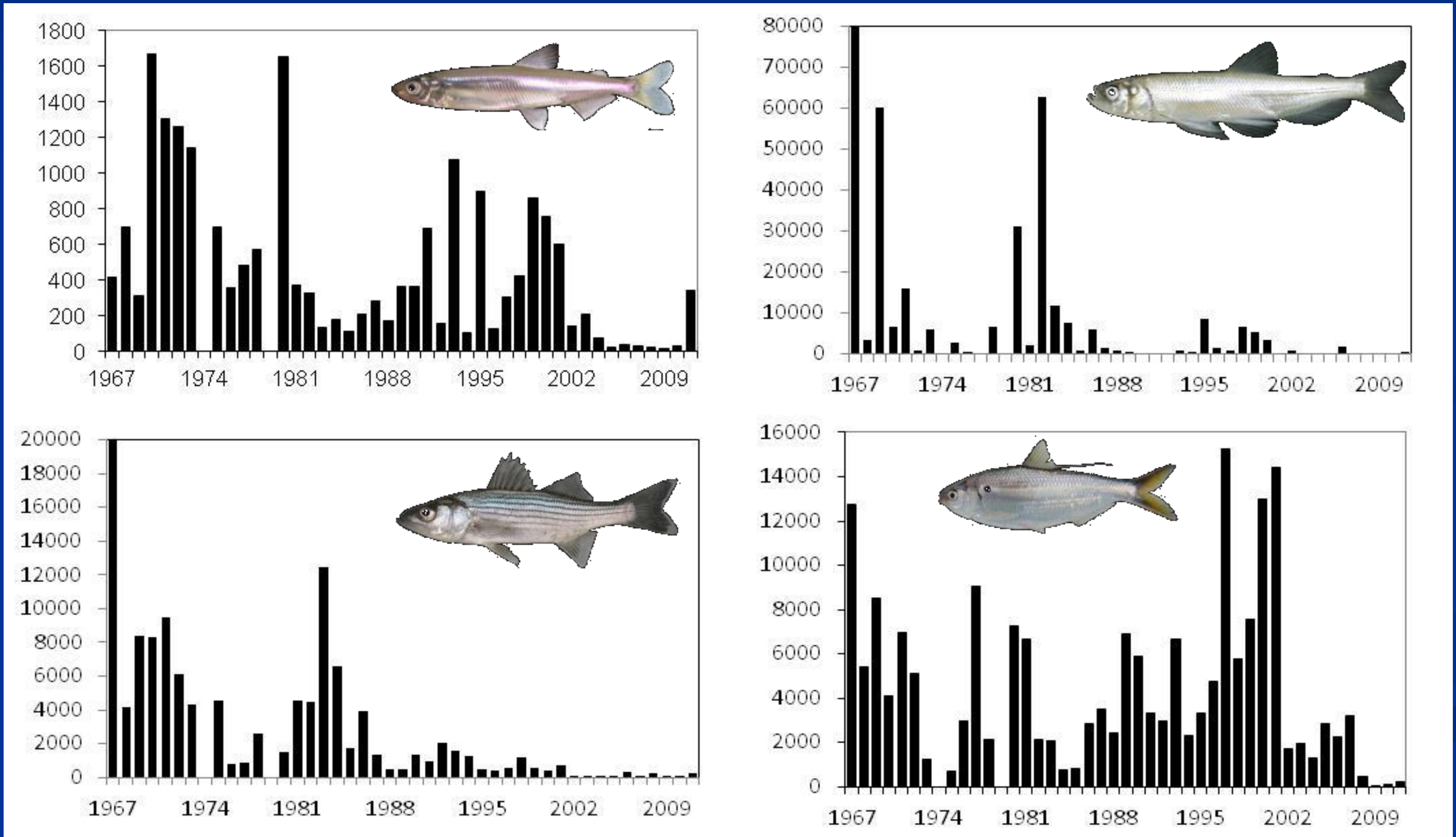
Water Quality Standards

New Information

EPA SF Bay Delta Action Plan

www.epa.gov/sfbaydelta/actionplan

Aquatic life beneficial uses are not adequately protected



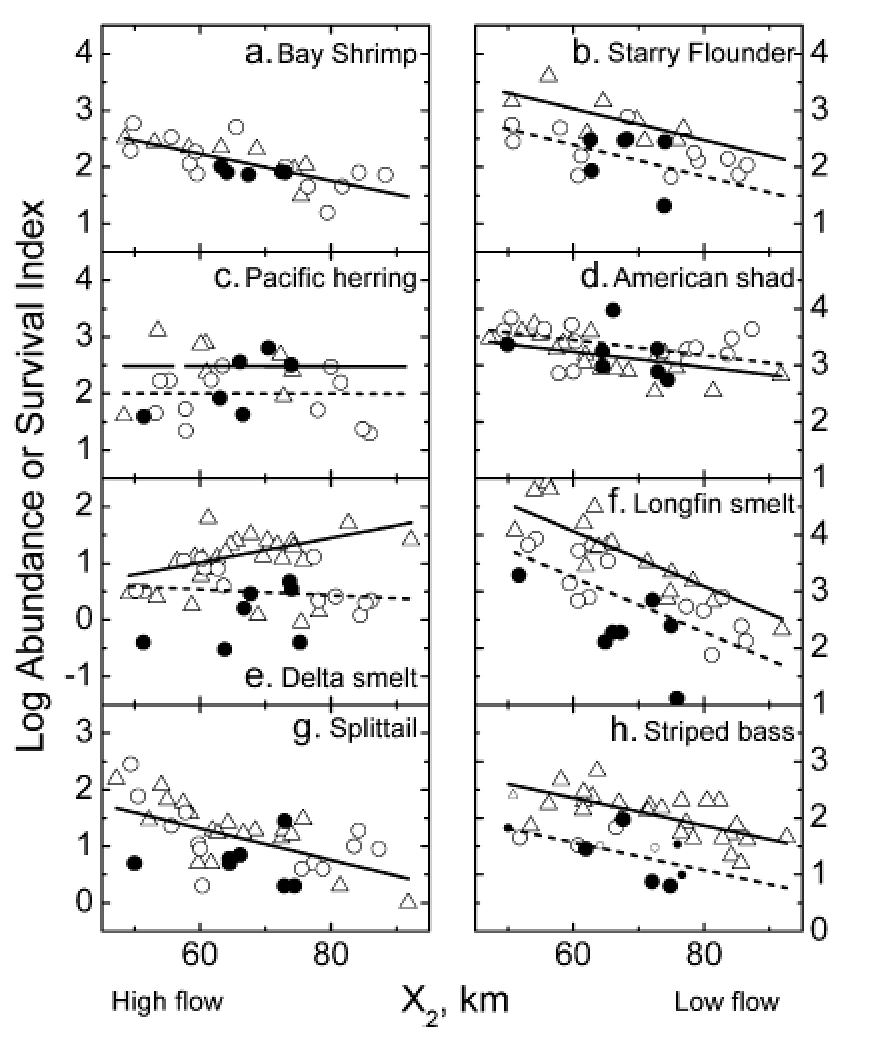
Source DFG 2008 Fall MW Trawl -- No sampling 1974 and 1979

EPA SF Bay Delta Action Plan

- First Priority: Update flow standards
- Other priorities: Delta RMP, TMDL, Selenium objectives, pesticide pollution prevention, MeHg, & BDCP
- Flow standards are essential for success of other efforts

New Information

Evaluation & Support for X2



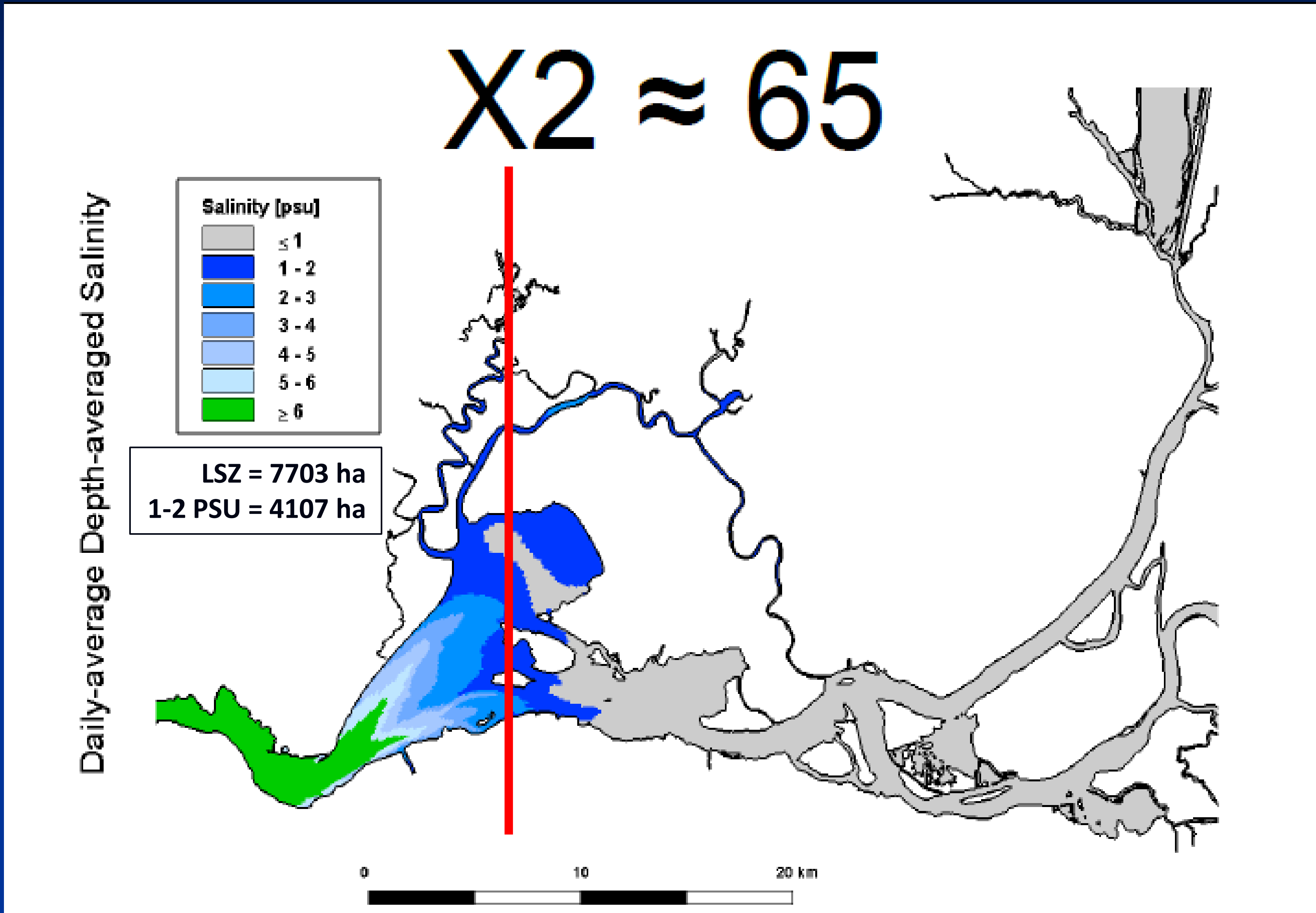
Kimmerer 2002MEPS

National Research Council (2012)

- SF Bay and Delta estuarine species are more abundant when the LSZ is further downstream.
- X2 continues to be a valid foundation for WQS in the SF Bay Delta estuary.

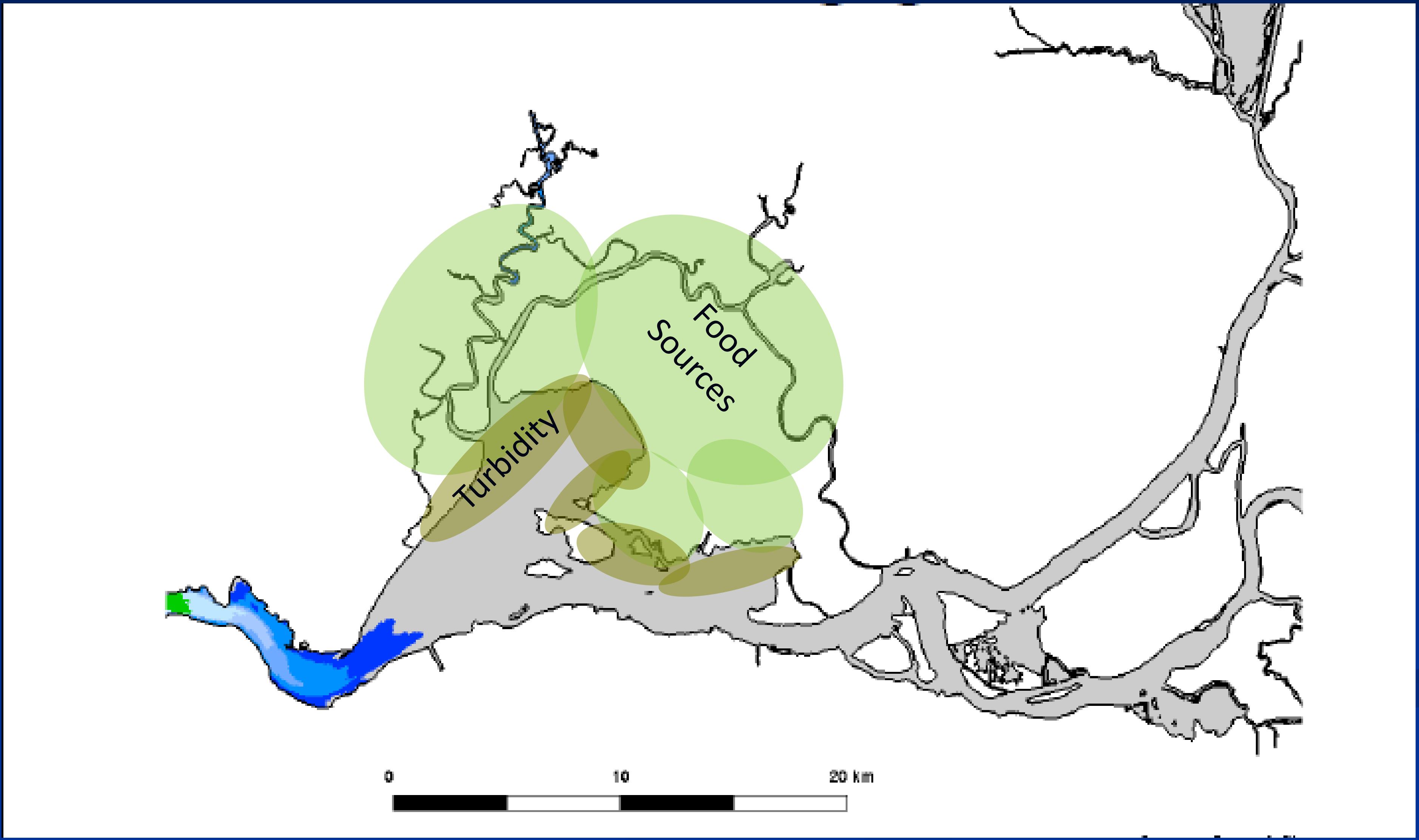
New Information

3D LSZ Modeling & X2



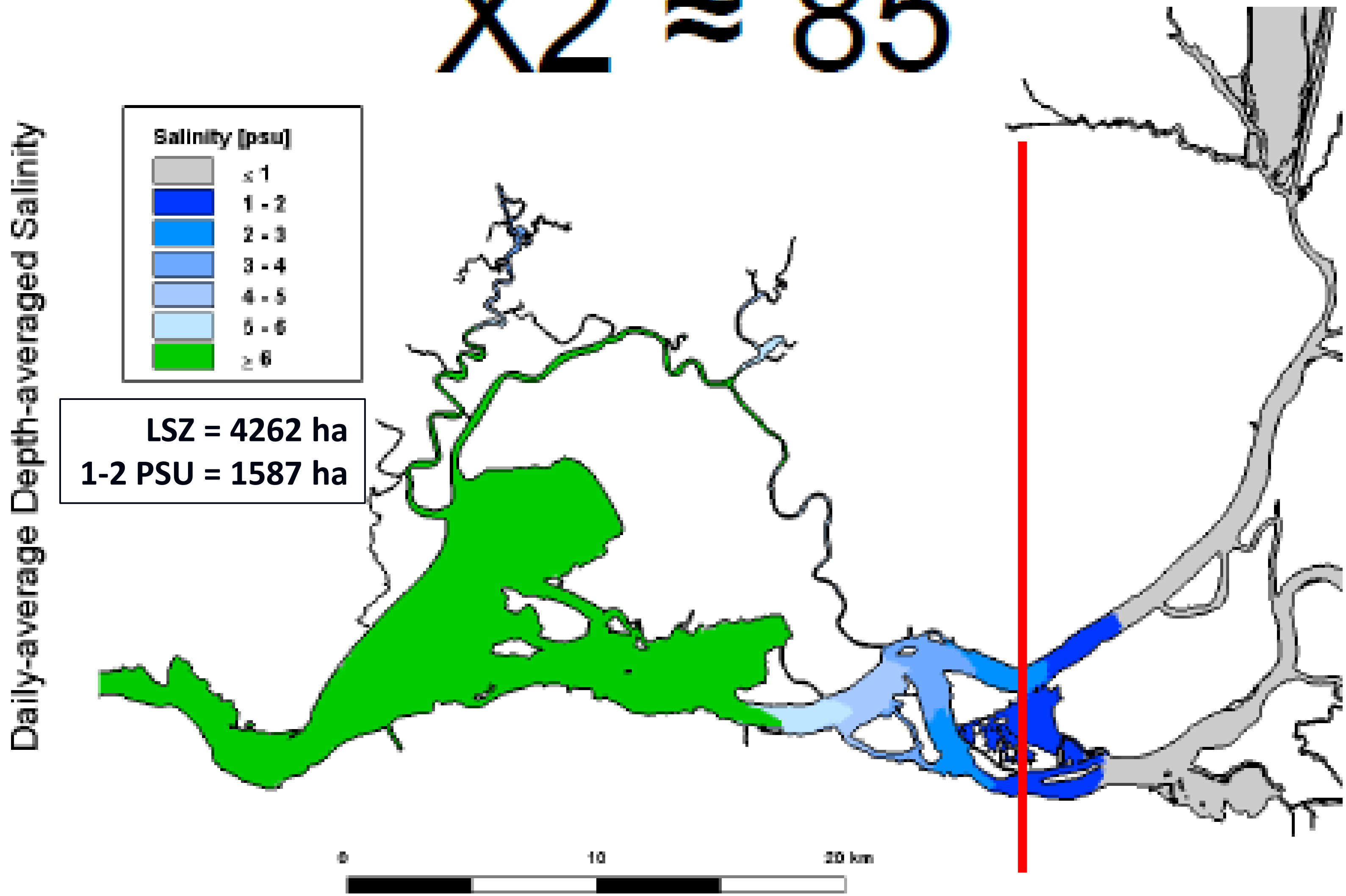
Source Delta Modeling Associates Low Salinity Flip Book. June 15, 2012. Version 0.9.

Location of LSZ



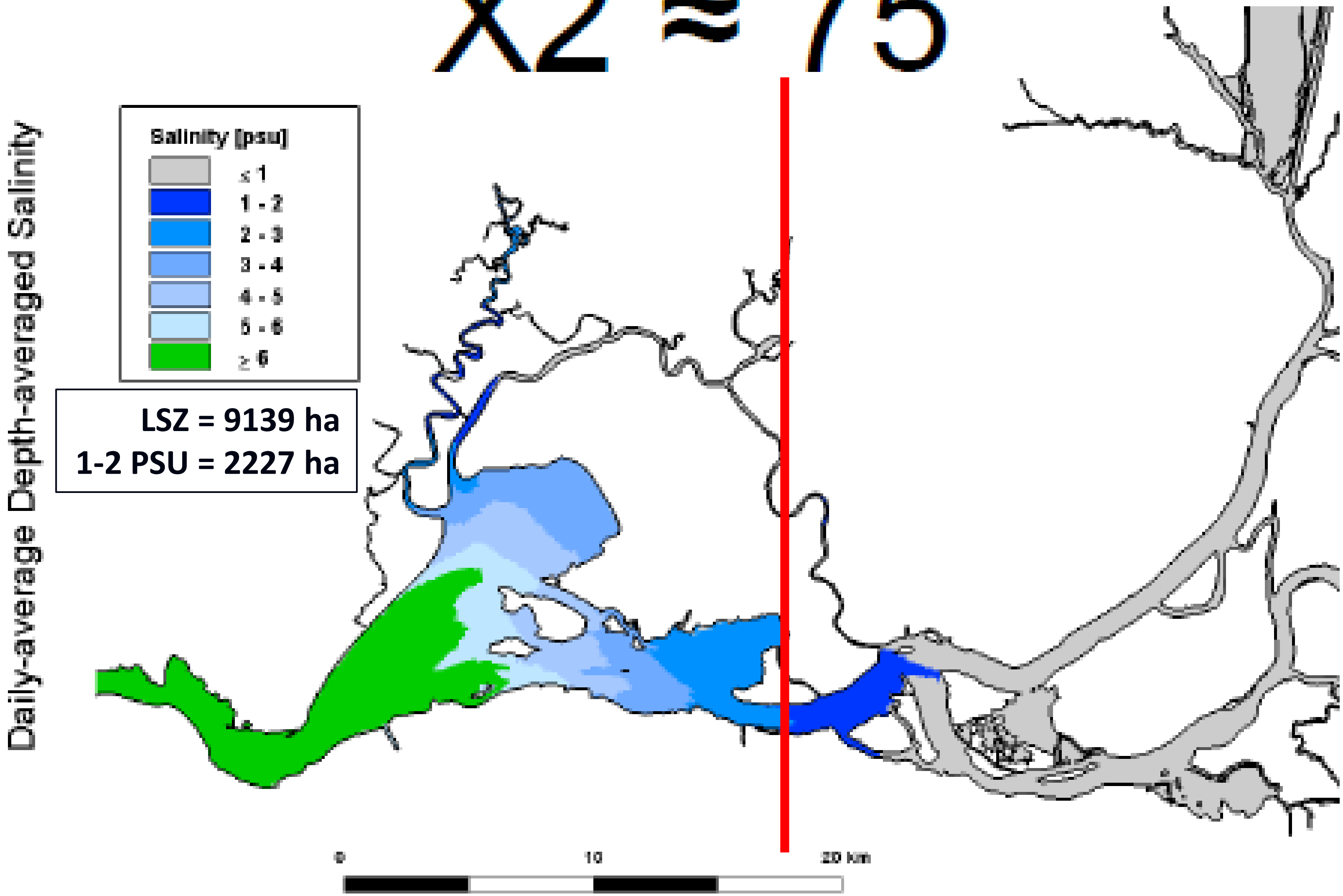
Base Source Map Delta Modeling Associates Low Salinity Flip Book. June 15, 2012. Version 0.9. Green & brown circles added by EPA

X2 ≈ 85



Source Delta Modeling Associates Low Salinity Flip Book. June 15, 2012. Version 0.9.

X2 ≈ 75



Source Delta Modeling Associates Low Salinity Flip Book. June 15, 2012. Version 0.9.

Low Salinity Zone

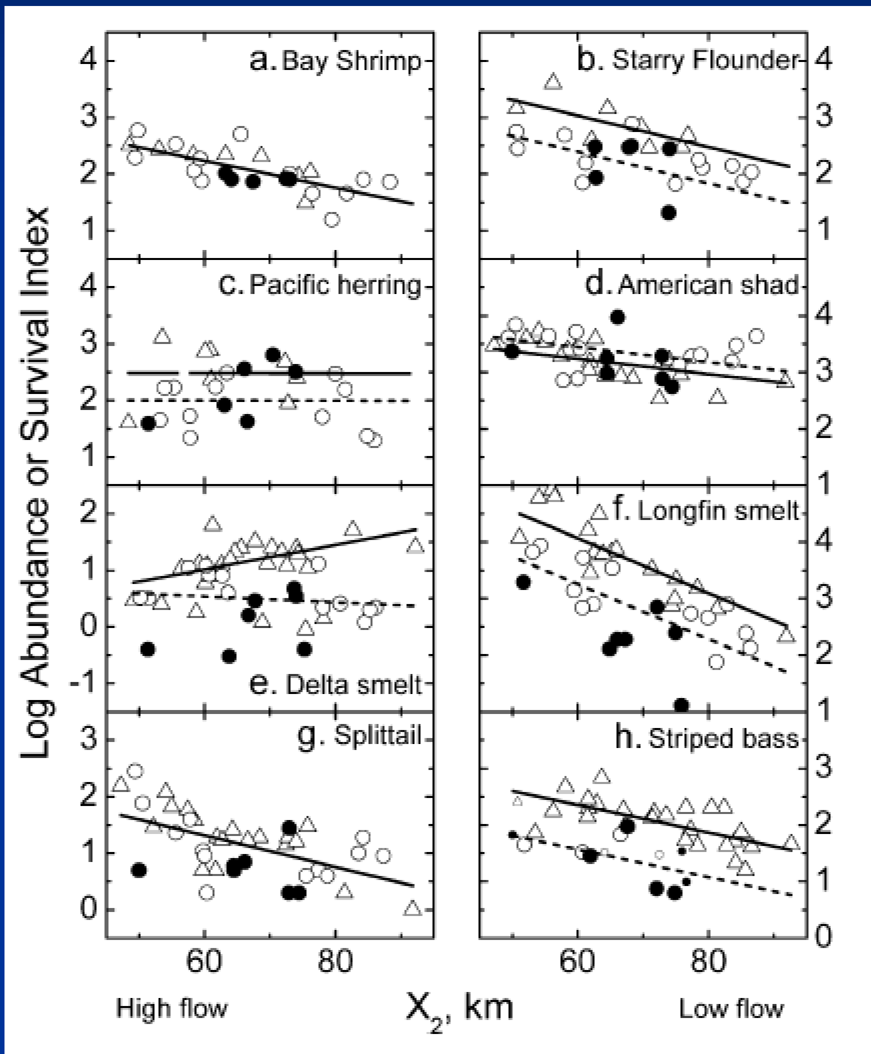
- $65 \text{ km} \leq X2 \leq 74 \text{ km}$
  - Access to food and turbidity are maximized
  - Surface area is maximized

- $X2 > 85 \text{ km}$
  - Access to food and turbidity are limited
  - Surface area is minimized

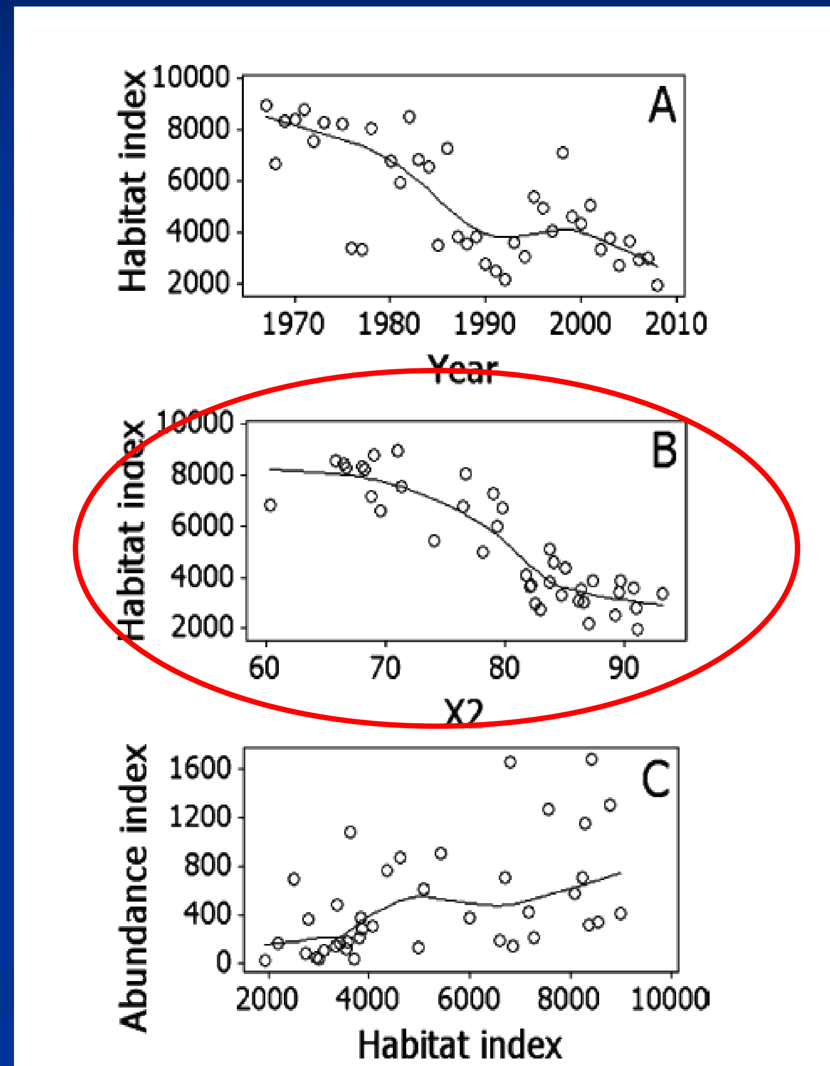
New Information

LSZ is important year-round

Spring



Fall

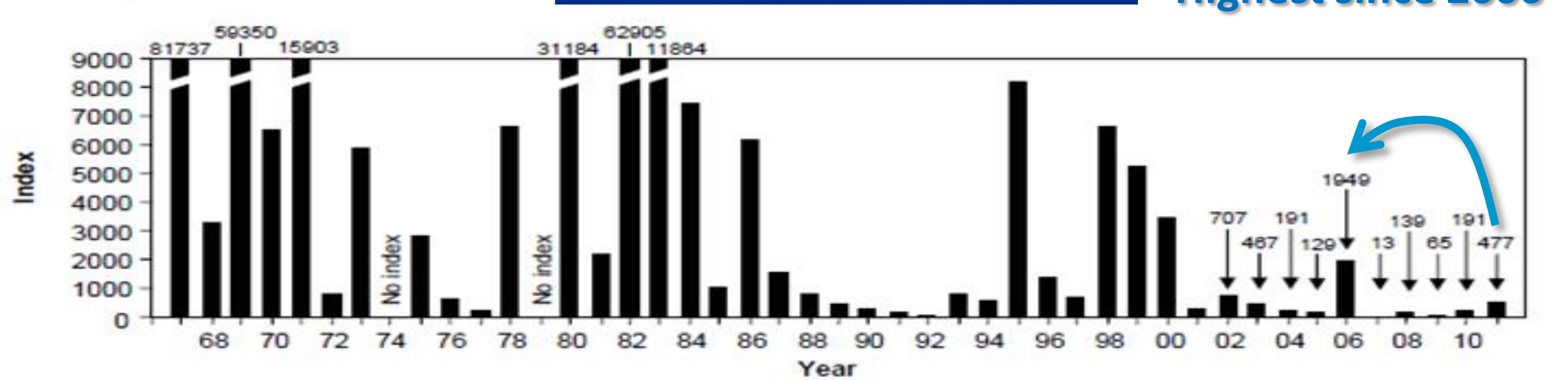


Kimmerer 2002MEPS

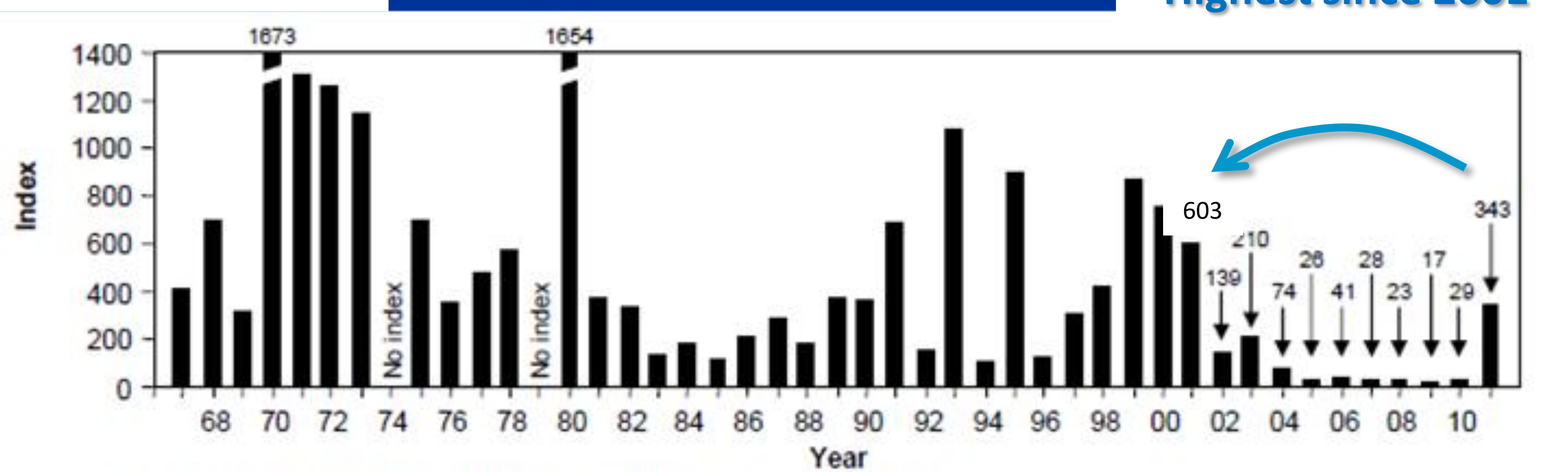
Feyrer et al (2011)

LSZ is important year-round

Longfin Smelt



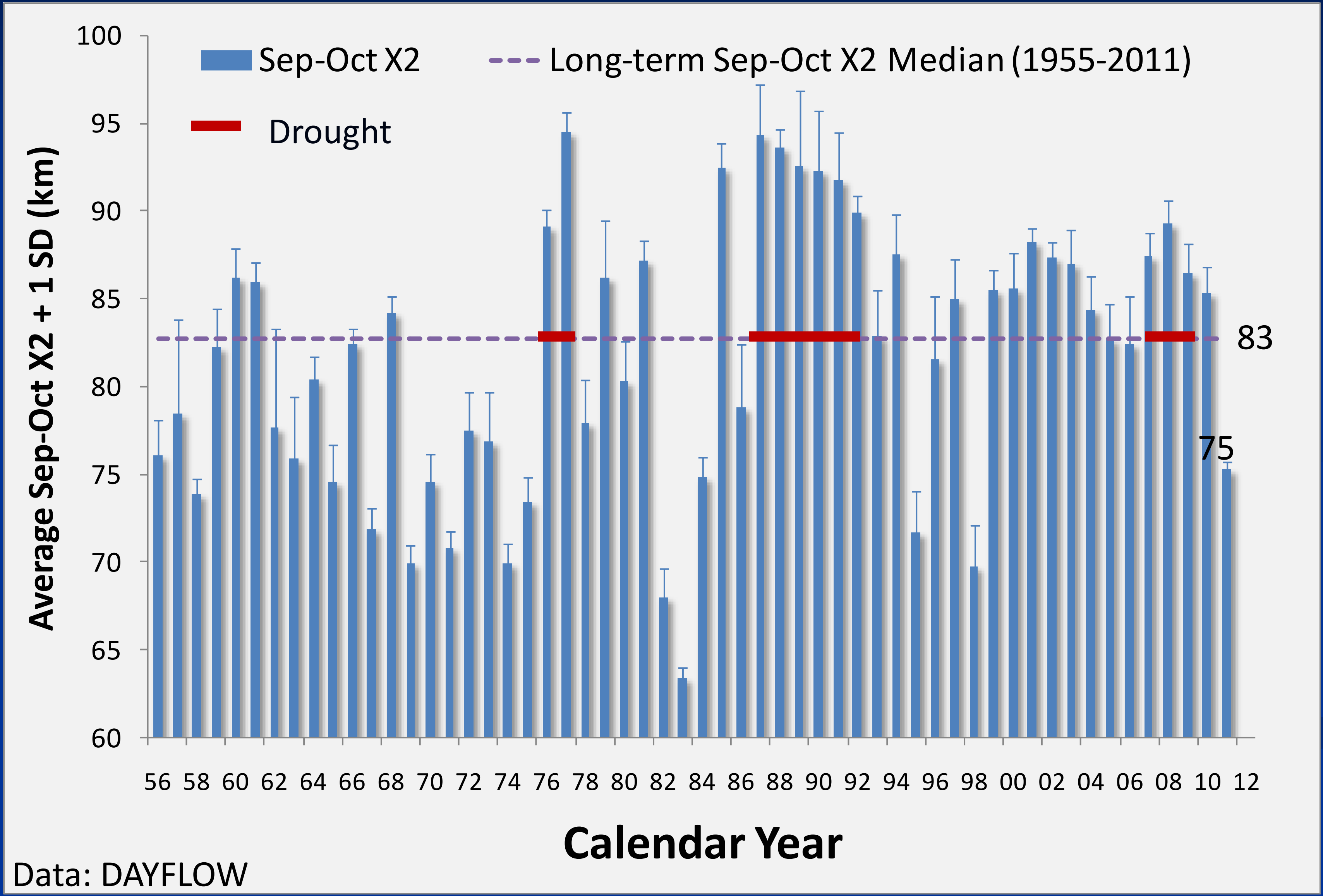
Delta Smelt



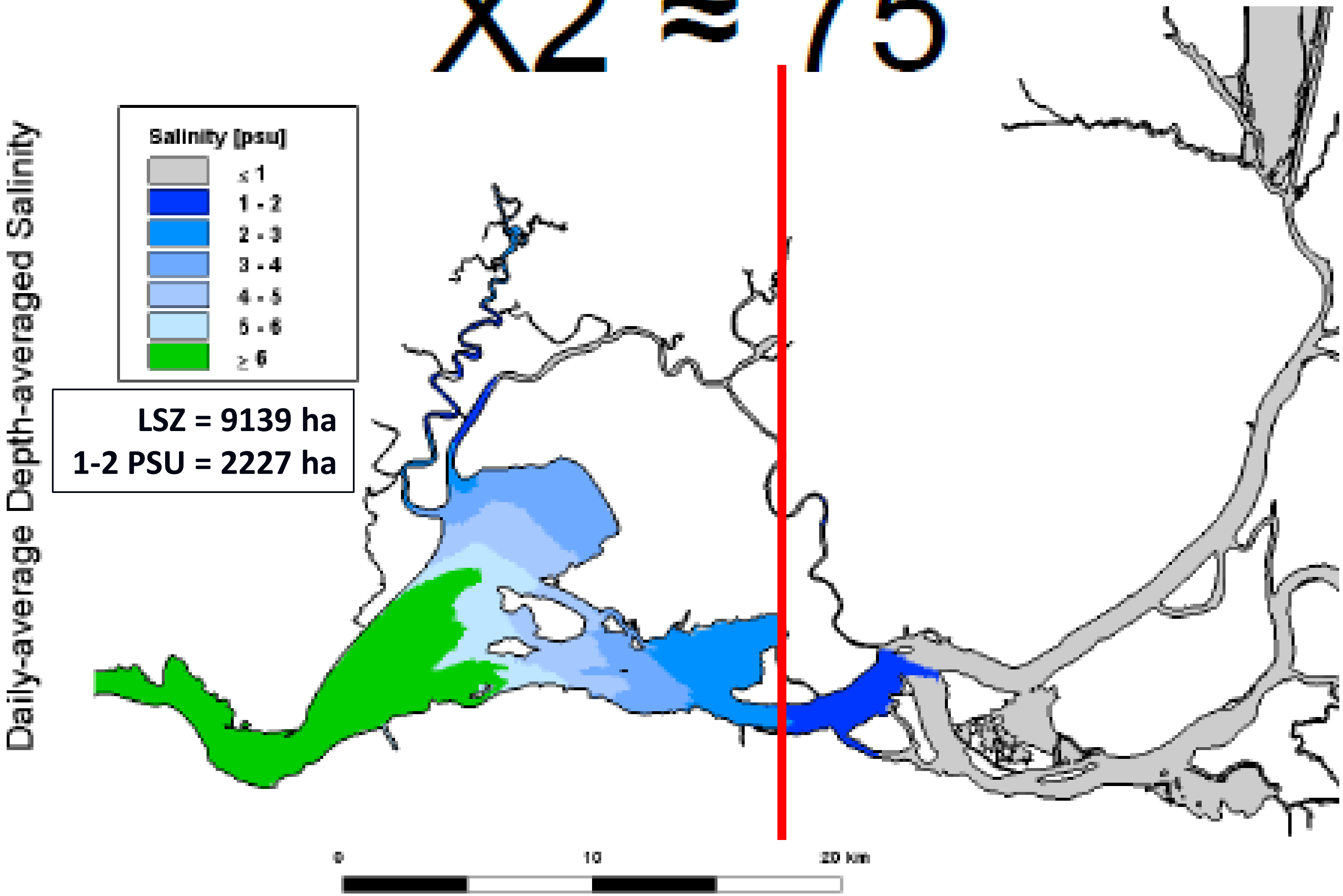
Source DFG 2008 Fall MW Trawl -- No sampling 1974 and 1979

Low Salinity Zone in the Fall.

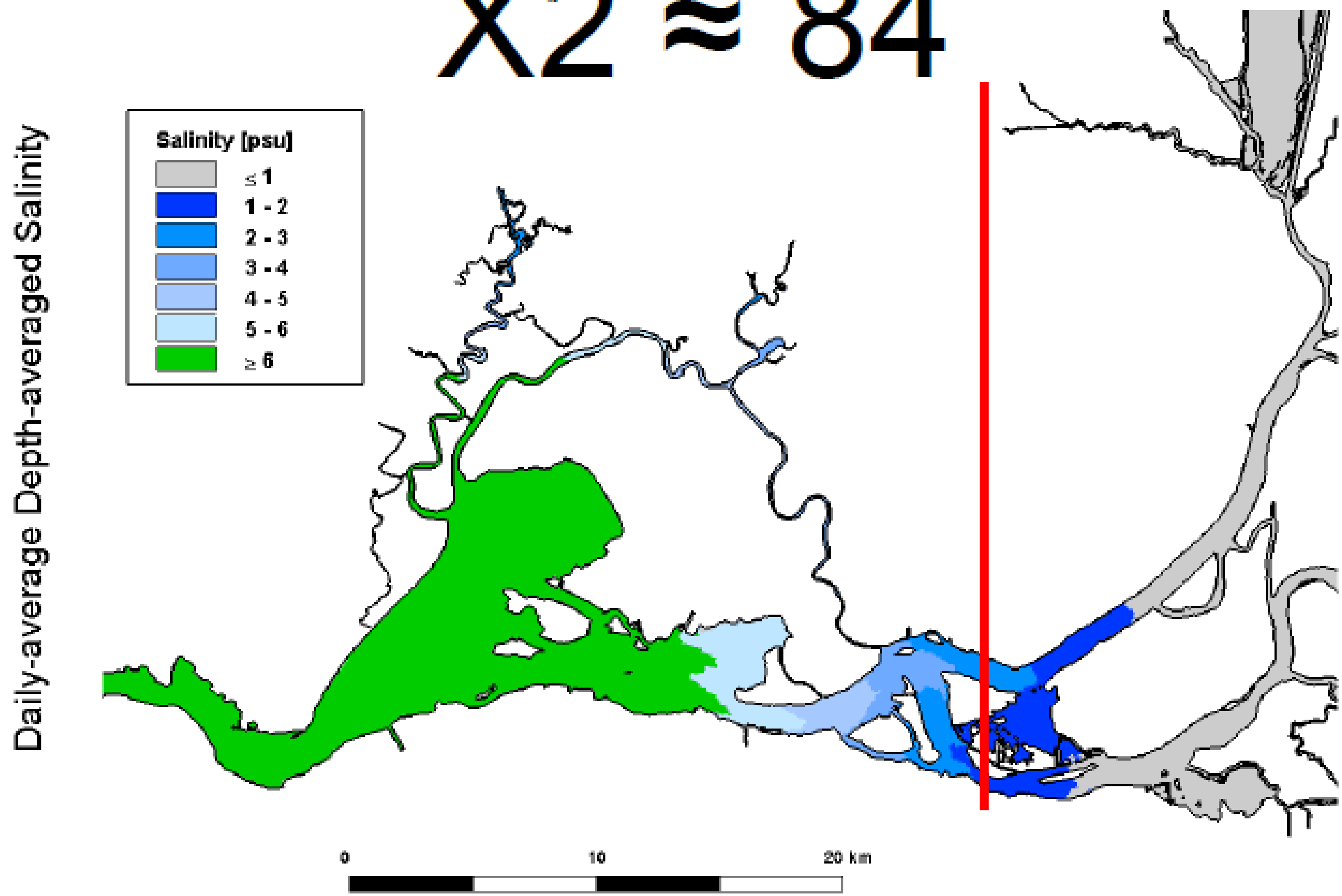
(September-October)



X2 ≈ 75


Daily-average Depth-averaged Salinity
Salinity [psu]
≤ 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
≥ 6
LSZ = 9139 ha
1-2 PSU = 2227 ha
0
10
20 km

X2 ≈ 84



Daily-average Depth-averaged Salinity
Salinity [psu]
≤ 1
1 - 2
2 - 3
3 - 4
4 - 5
5 - 6
≥ 6
0
10
20 km

Changes to Bay-Delta Plan

Start with existing recommendations

Table 20. Delta Outflow Summary Criteria

Delta Outflows

Category A

O	N	D	J	F	M	A	M	J	J	A	S	Criteria
			■	■	■	■	■	■				1) Net Delta Outflows: 75% of 14-day average unimpaired flow

Category B

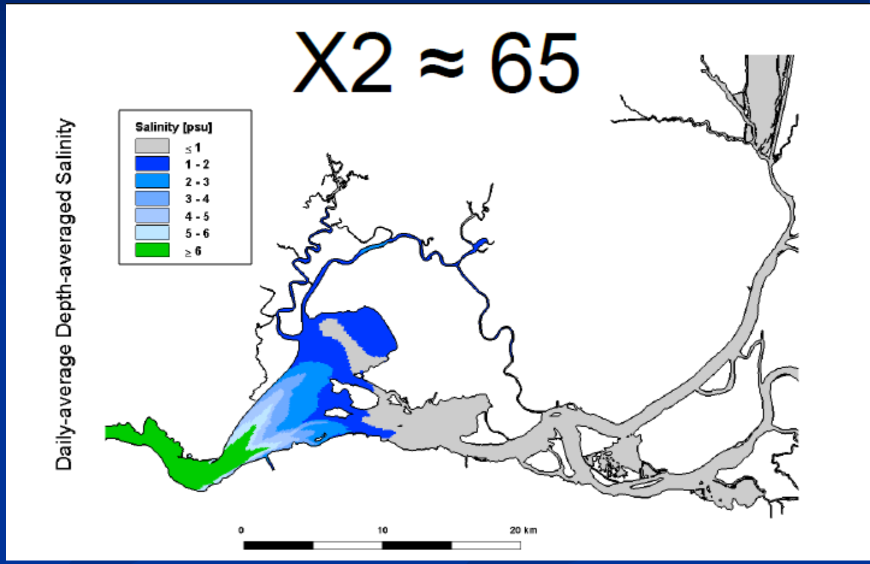
O	N	D	J	F	M	A	M	J	J	A	S	Criteria
■	■										■	2) Fall X2 a. Wet years: X2 less than 74 km (greater than approximately 12,400 cfs) b. Above normal years: X2 less than 81 km (greater than approximately 7,100 cfs)
■	■								■	■	■	3) Net Delta Outflows: 2006 Bay-Delta Plan Delta Outflow Objectives - applies during critical, dry, and below normal years

Basis for Criteria and Explanation

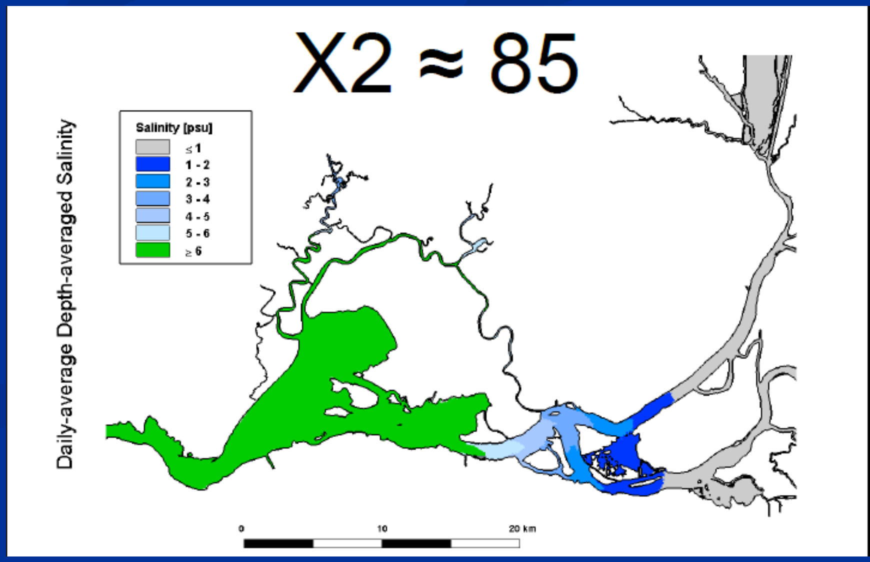
1) Promote increased abundance and improved productivity (positive population growth) for longfin smelt and other desirable estuarine species
2) Increase quantity and quality of habitat for delta smelt; fall X2 requirement limited to above normal and wet years to reduce potential conflicts with cold water pool storage, while promoting variability with respect to fall flows and habitat conditions in above normal and wet water year types; expected to result in improved conditions for delta smelt, however, the statistical relationship between fall X2 and abundance is not strong; note 2) above regarding need for improved understanding concerning the fall X2 action also applies
3) Fish and wildlife beneficial use protection

Connect Flow to Essential Habitat Elements

Net Delta Outflow at
65 % Unimpaired flow



Net Delta Outflow at
35 % Unimpaired flow



EPA Summary

- Aquatic life beneficial uses are not adequately protected.
- X2-abundance relationships have overwhelming scientific support.
- Resident LSZ species require year-round habitat.
- Connect percent unimpaired flows to habitat elements.
- The Bay-Delta Plan update needs to provide better protection for aquatic habitat.