State Water Resources Control Board
Comprehensive Review and Update of the Bay-Delta Plan

Invited Panel Introduction

Peter Goodwin

Delta Lead Scientist
Delta Stewardship Council

Workshop 1, September 5-6, 2012
Ecosystem Changes and the Low Salinity Zone

State Water Resources Control Board
Comprehensive Review and Update of the Bay-Delta Plan

What's new since 2010?

Invited Panel, 2012:

Larry Brown, Jim Cloern, Steve Culberson,
Cliff Dahm, Bill Fleenor, Bruce Herbold,
Wim Kimmerer, Anke Mueller-Solger,

Workshop 1, September 5-6, 2012
Ecosystem Changes and the Low Salinity Zone

Invited Panel, 2010

Five Key Points on Setting Delta Environmental Flows

Cliff Dahm on behalf of the Delta Environmental Flows Group

William Bennett, Jon Burau, **Cliff Dahm**, **Chris Enright**, Fred Feyrer, **William Fleenor**, **Bruce Herbold**, **Wim Kimmerer**, **Jay Lund**, Peter Moyle, Matthew Nobriga

March 22, 2010

State Water Resources Control Board

Informational Proceeding on Delta Flow Criteria

Invited Panel, 2010

Five Key Points

1. Environmental flows are more than just volumes of inflows and outflows
2. Recent flow regimes both harm native species and encourage non-native species
3. Flow is a major determinant of habitat and transport
4. Recent Delta environmental flows are insufficient to support native Delta fishes for today's habitats
5. A strong science program and a flexible management regime are essential to improving flow criteria




State Water Resources Control Board
Comprehensive Review and Update of the Bay-Delta Plan

Today's Invited Panel Presentations:

1. Bill Fleenor: Hydrologic Changes
2. Wim Kimmerer: Ecosystem and Low Salinity Zone Changes
3. Jim Cloern: Managing the Estuary for an Uncertain Future
4. Anke Mueller-Solger & Larry Brown: Changing Science
5. Cliff Dahm: Conclusions and Recommendations

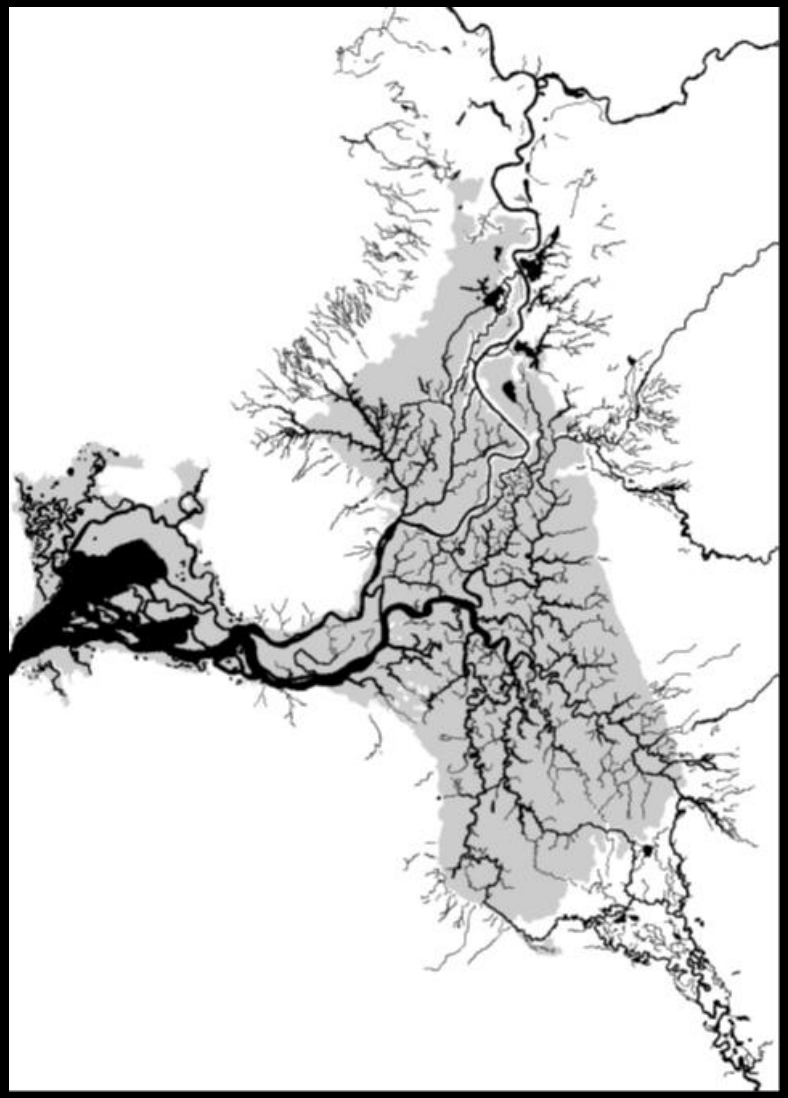
Workshop 1, September 5-6, 2012
Ecosystem Changes and the Low Salinity Zone

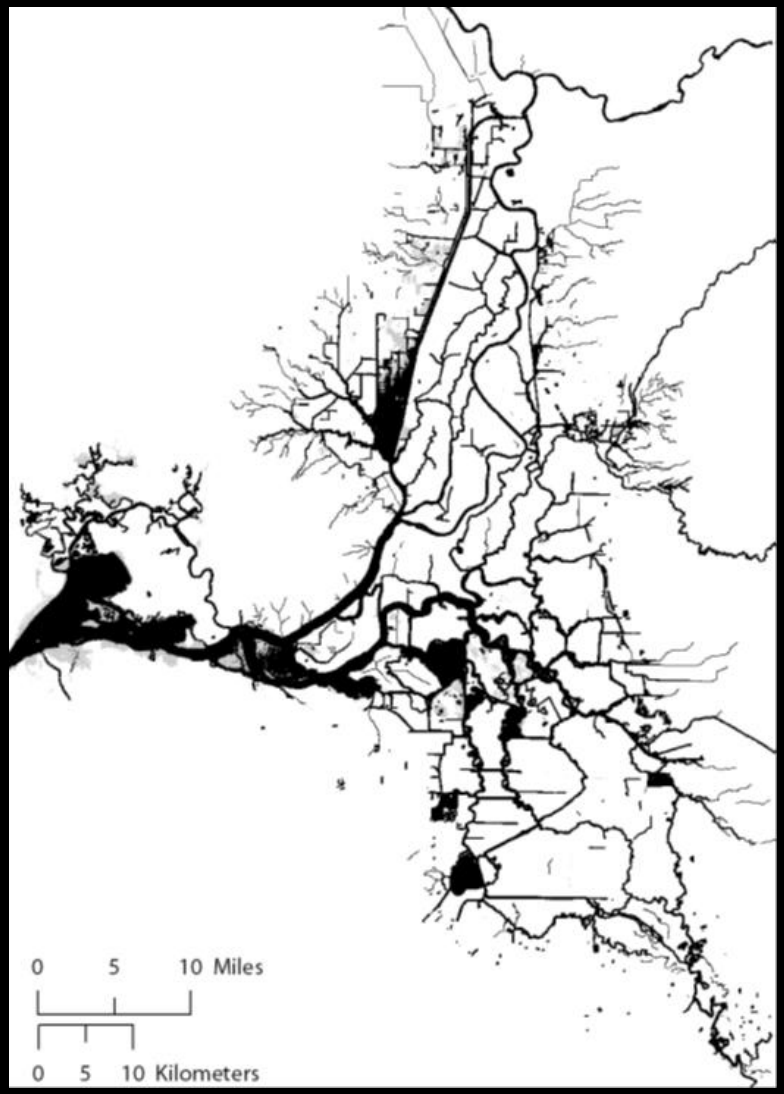
Hydrologic Changes to the Delta

Hydrologic Changes to the Delta

- *Physical /Habitat changes*
- *Consumptive use increases*
- *Inflow decreases*
- *Outflow decreases*
- *Water quality degradation*

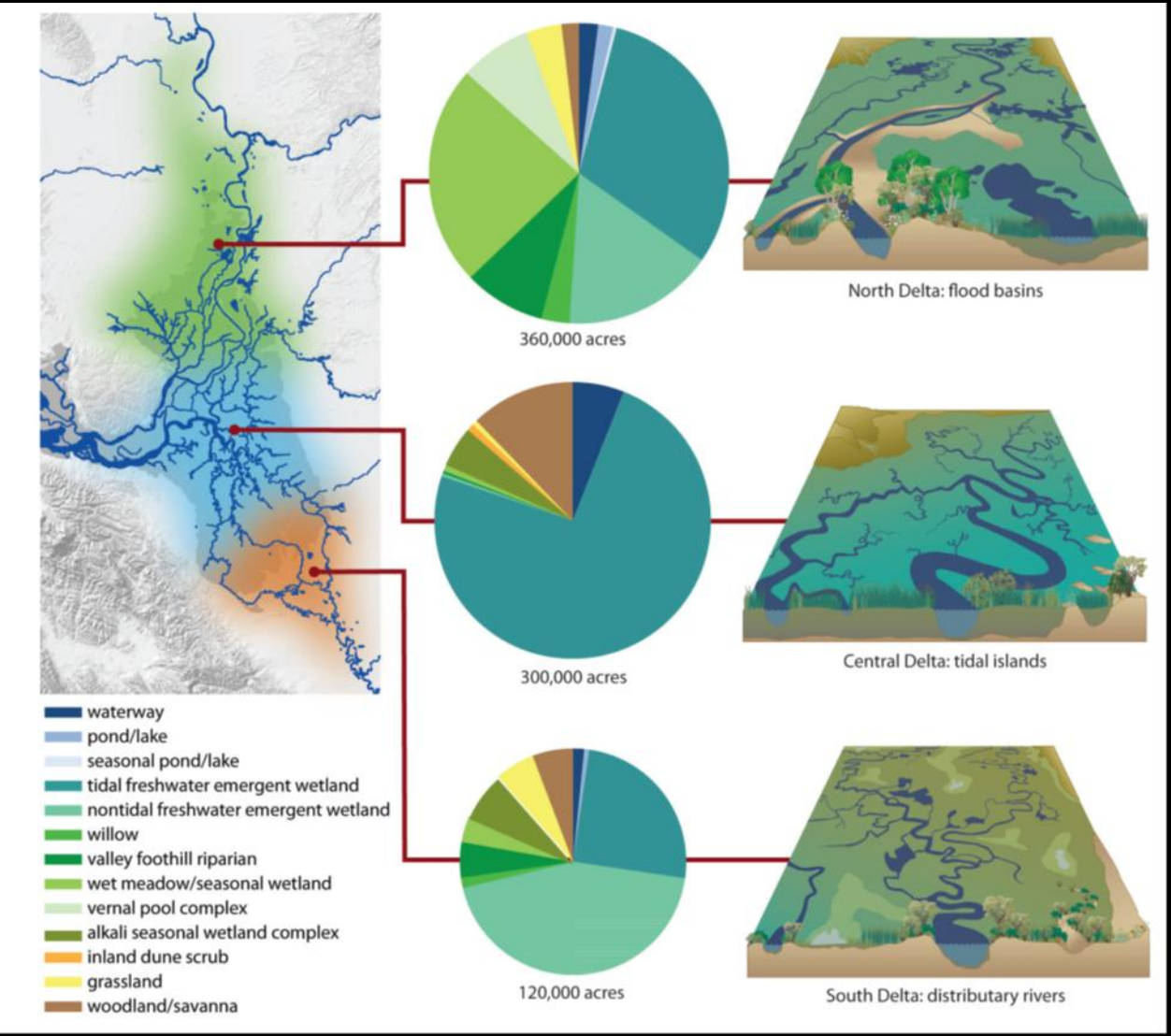
Physical modification of Delta





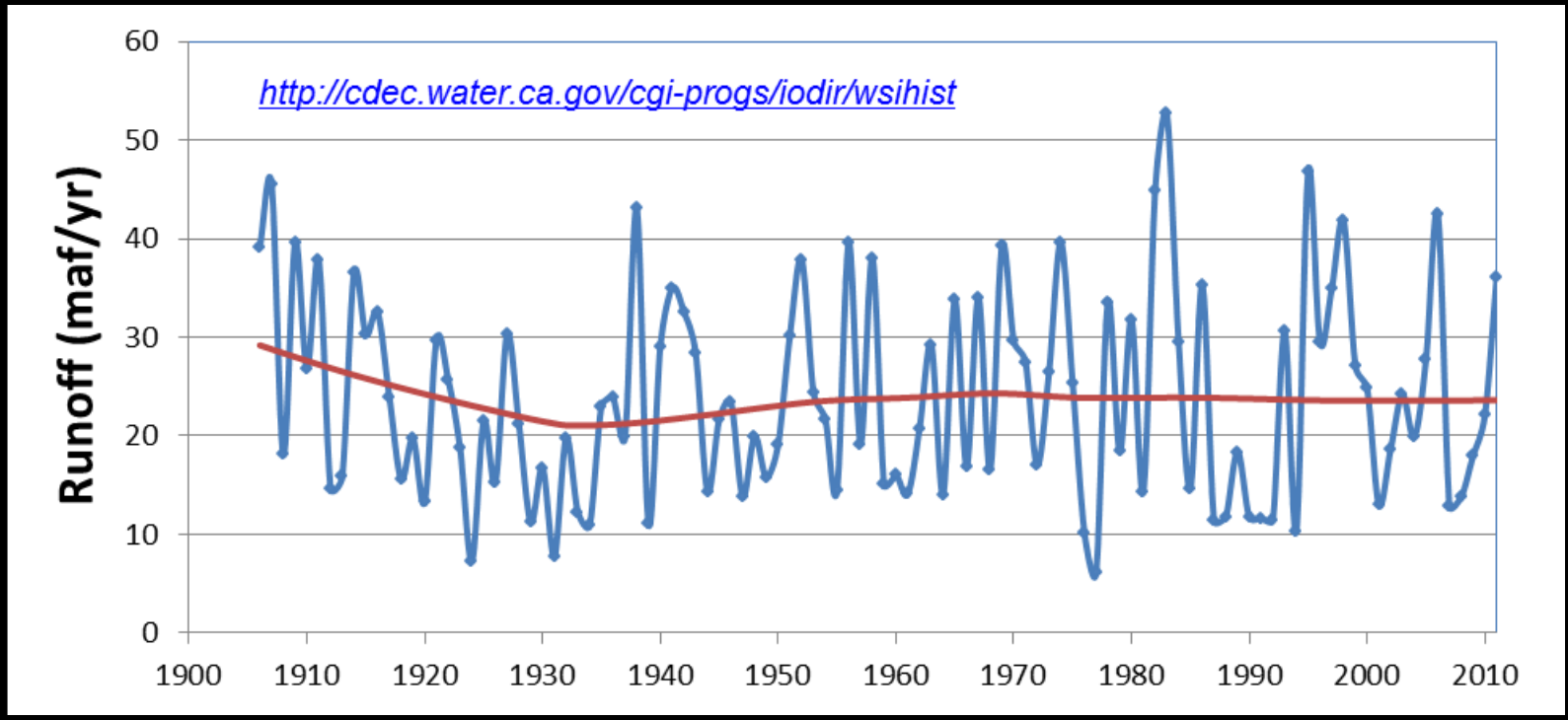
Whipple et al. 2012

Historical habitat lost



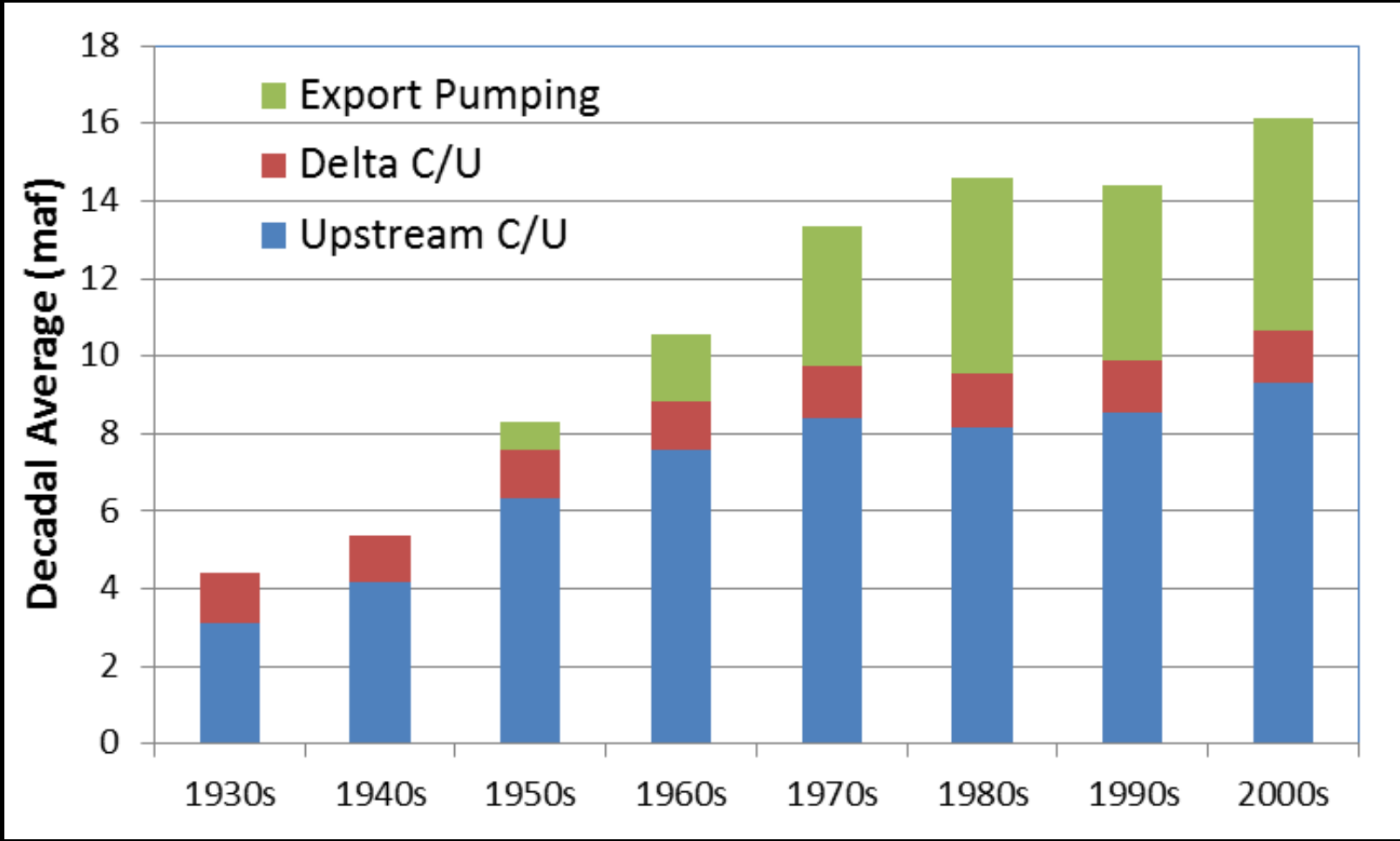
Whipple et al. 2012

Long-term 'runoff' change



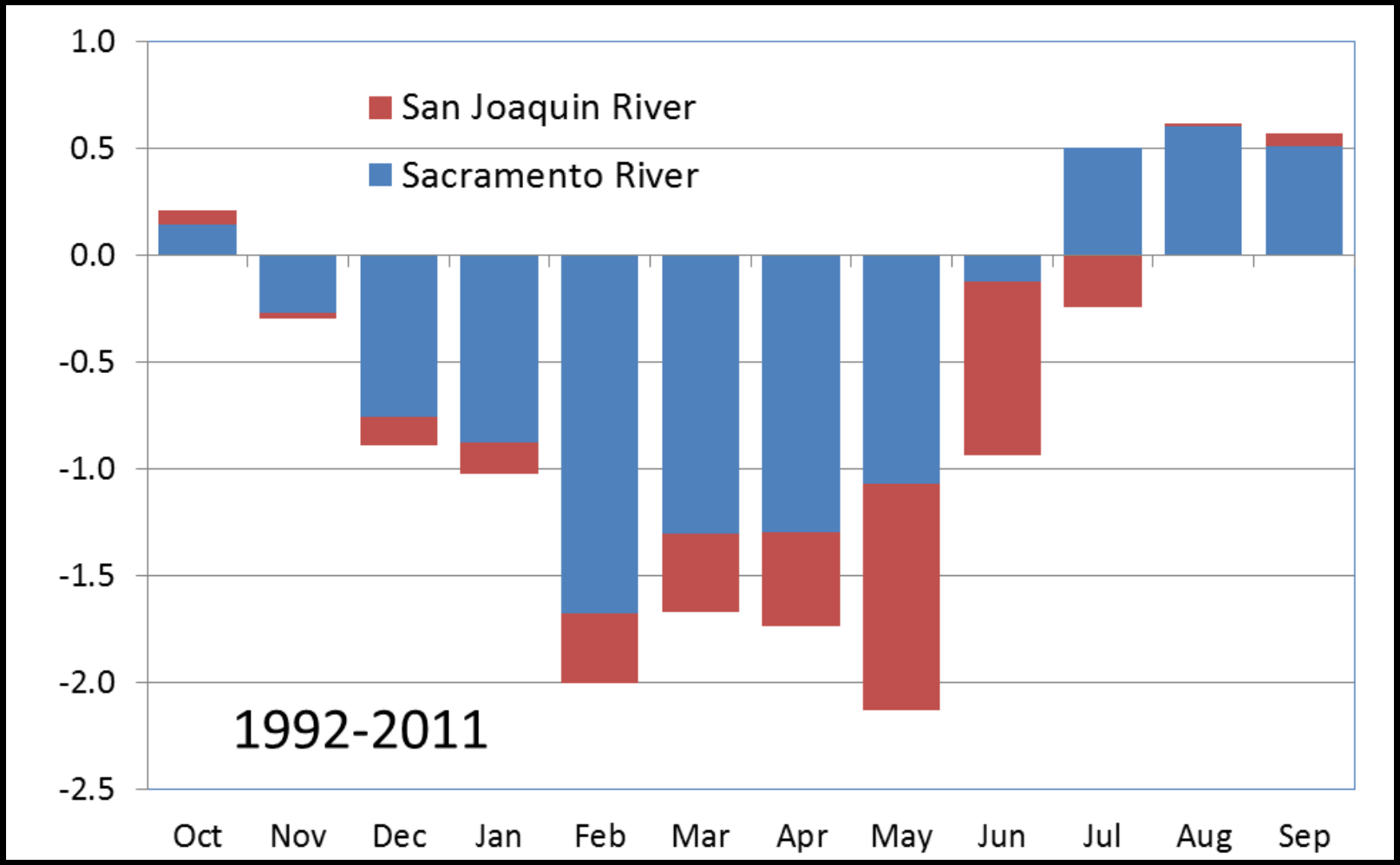
after Cloern & Jassby 2012

Increases in consumptive use



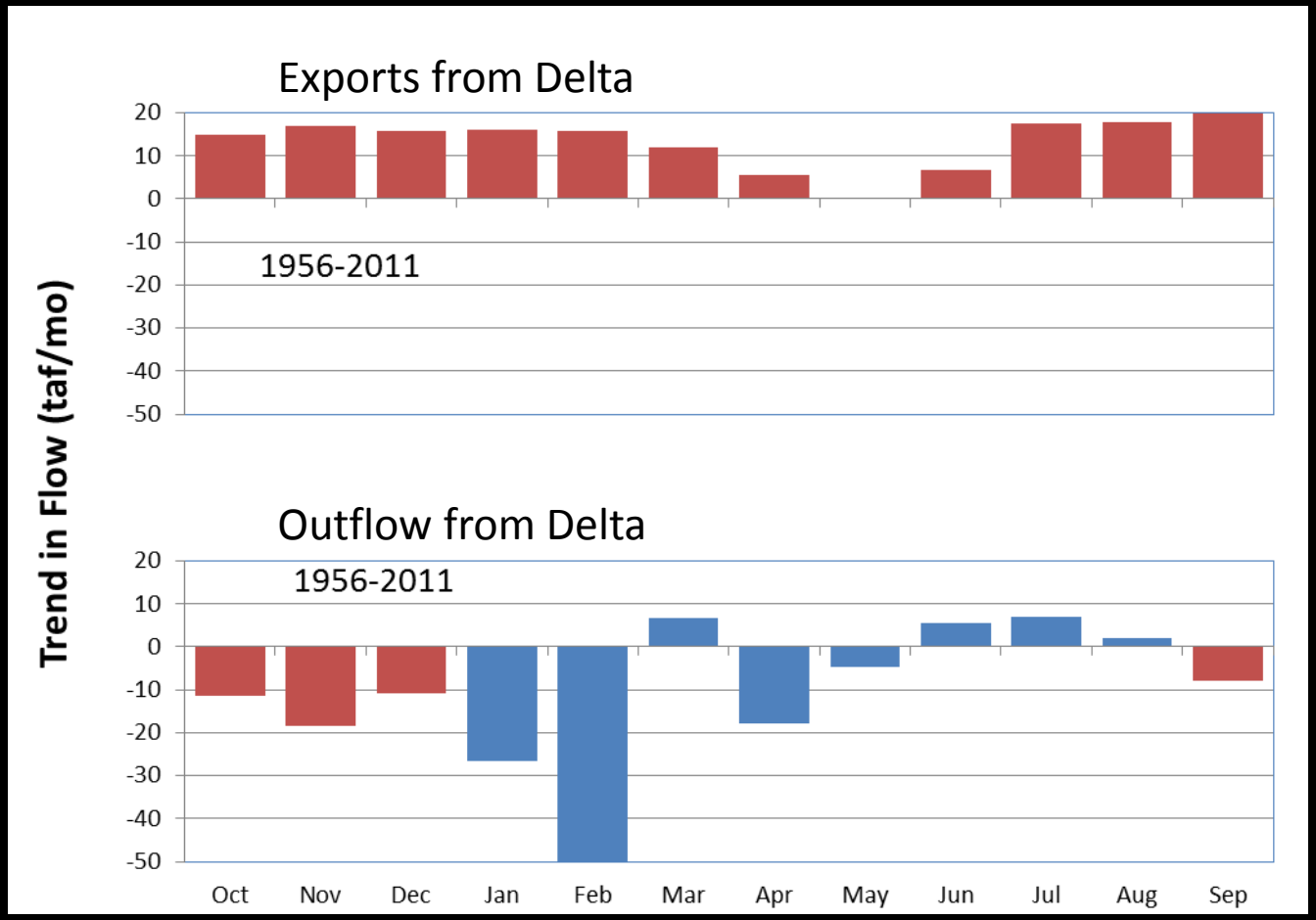
Dayflow data

Inflow Changes to Delta (maf)



Dayflow and Unimpaired data, DWR

DeltaTrends (maf)

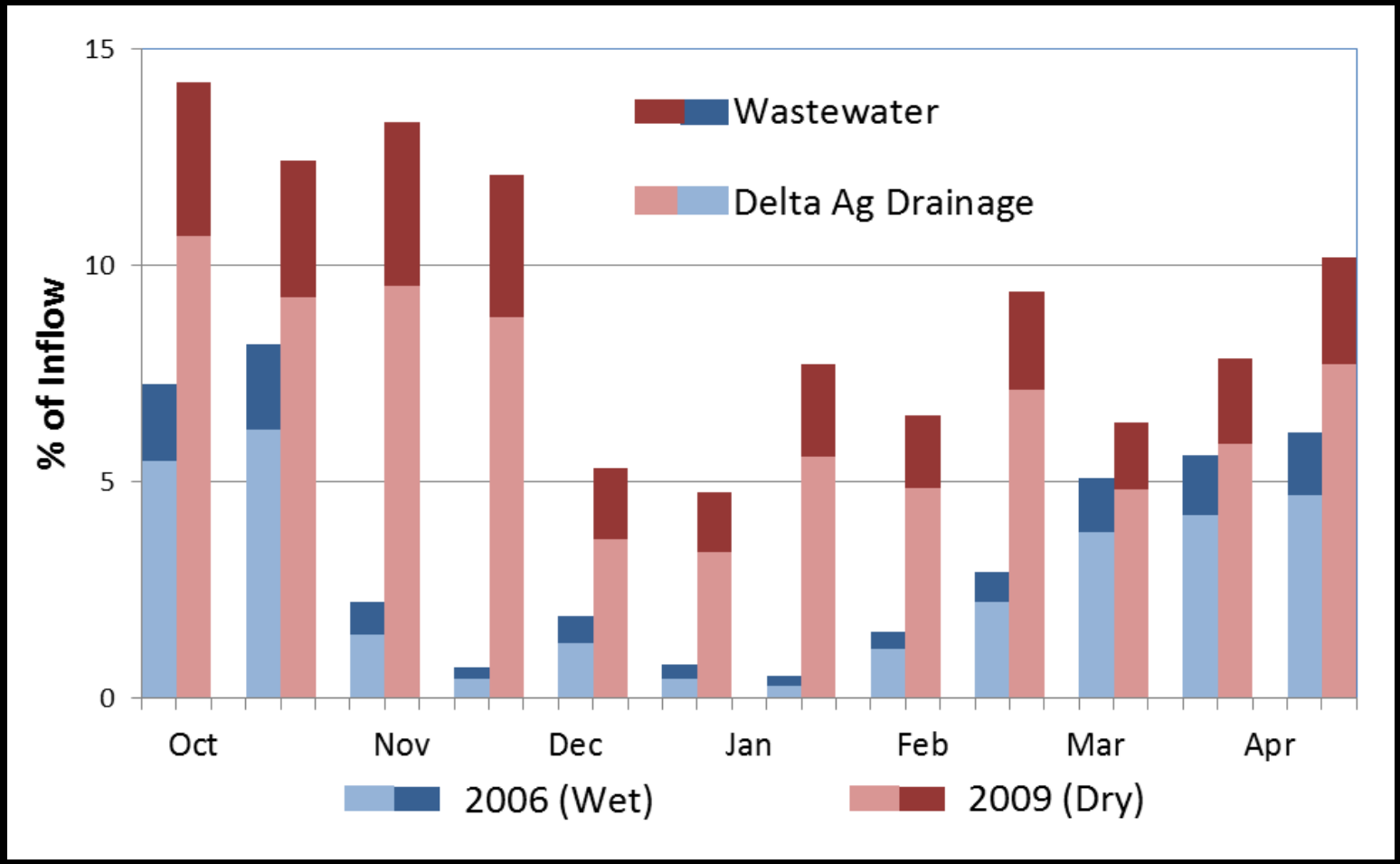


Exports have increased significantly every month except May

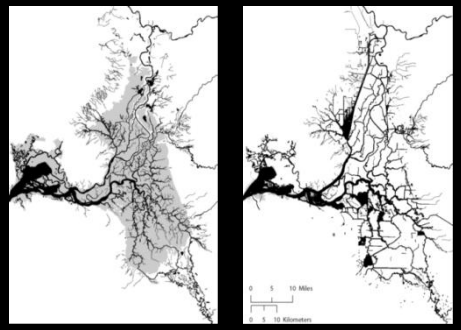
Outflow has decreased significantly in the Fall and early Winter

Dayflow data, DWR after Cloern & Jassby 2012

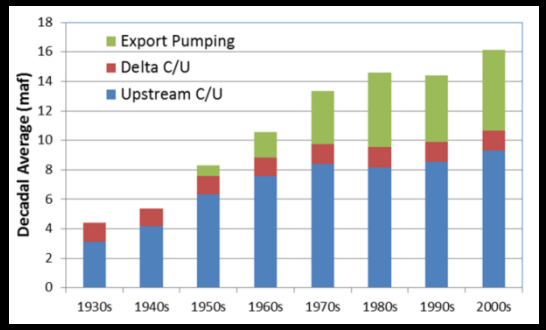
Water Quality Consequences



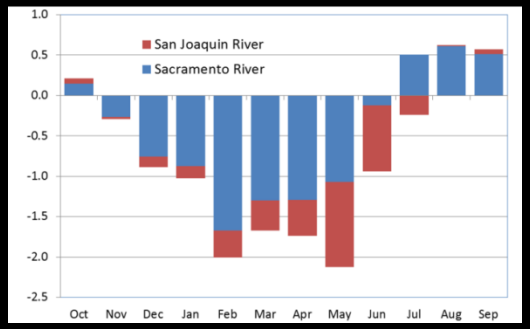
Ecosystem in stress



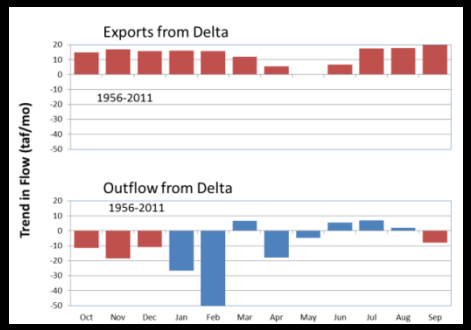
Habitat loss



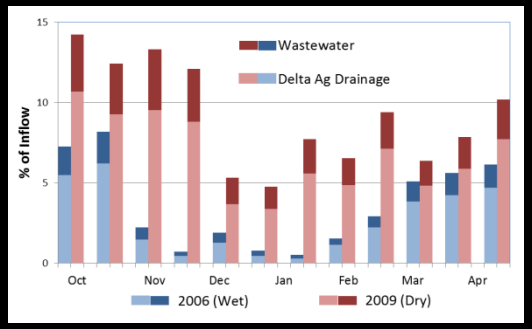
Increased CU



Decreased Inflow



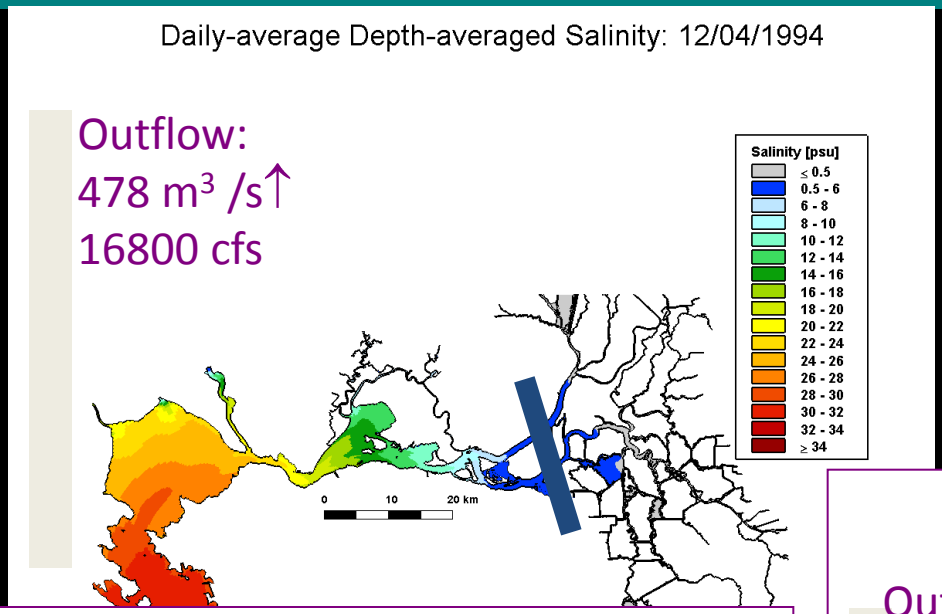
Decreased Fall Outflow

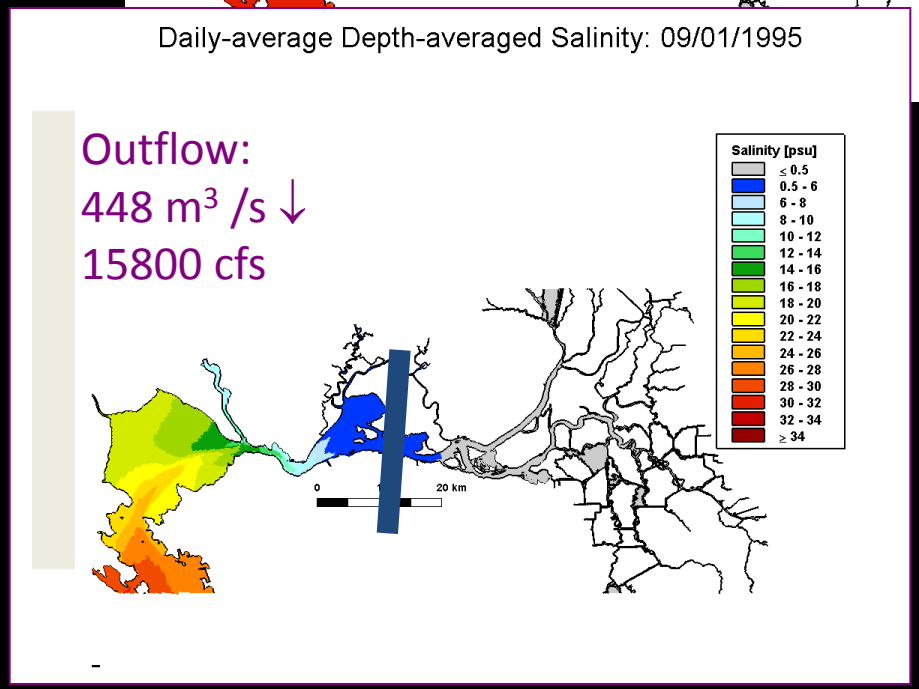


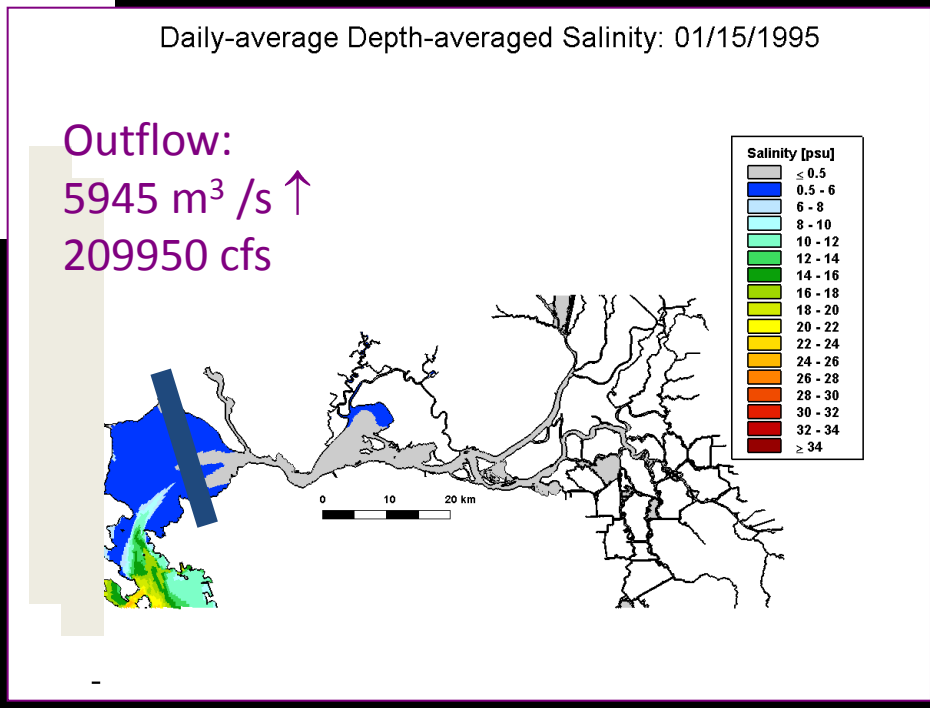
Declining WQ


Ecosystem and
Low Salinity Zone Changes

The LSZ: Where, how big?







Maps: UnTRIM Model
Michael MacWilliams

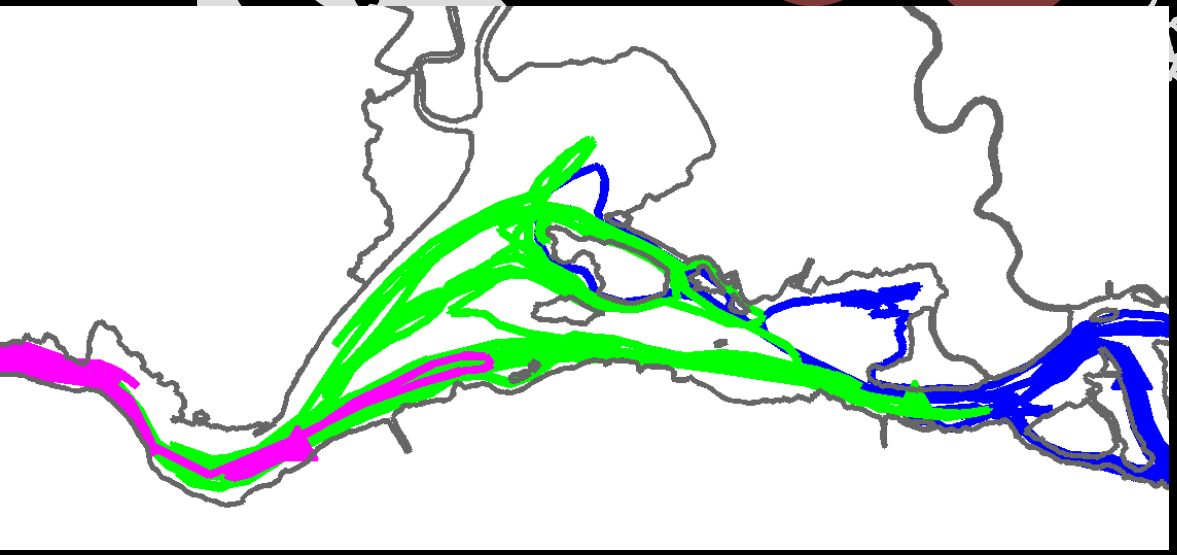
Habitat Components

Dynamic Low-Salinity Zone

High Flow

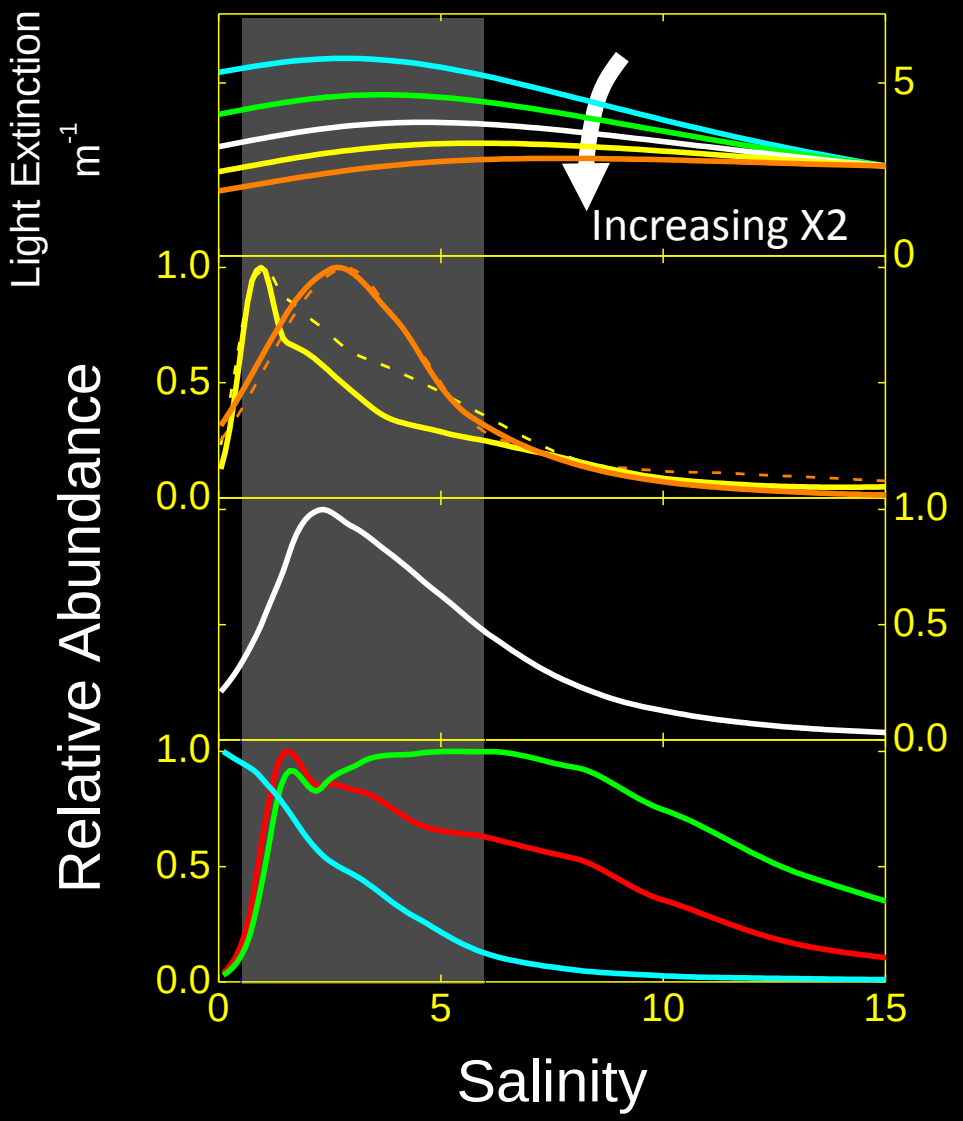
Low Flow

Static: Geographic Range of Delta Smelt



Delta Smelt

The LSZ: Key region for some species



Light Extinction

Delta Smelt
Young striped bass
Summer and Fall

Mysid shrimp

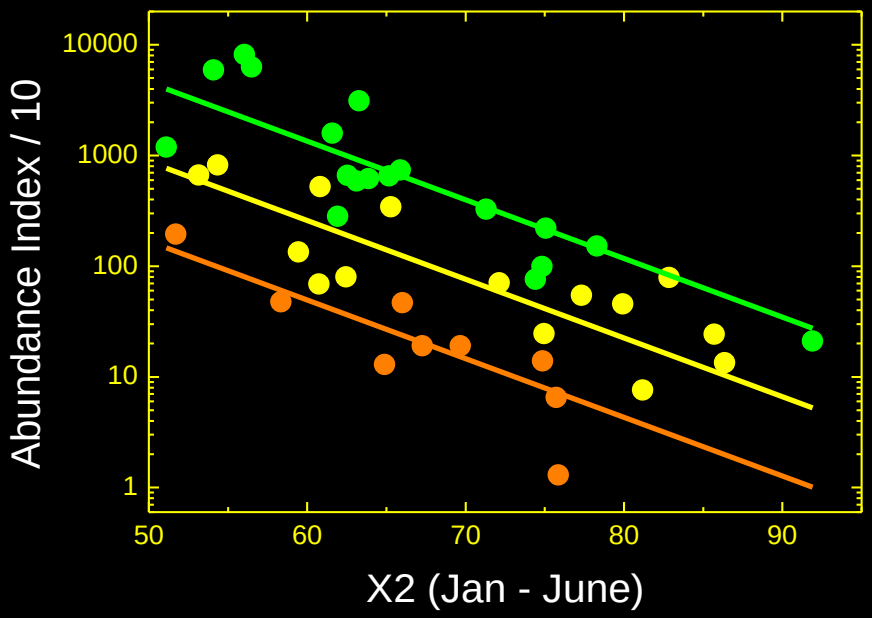
Copepods
(3 species)

IEP Monitoring Data

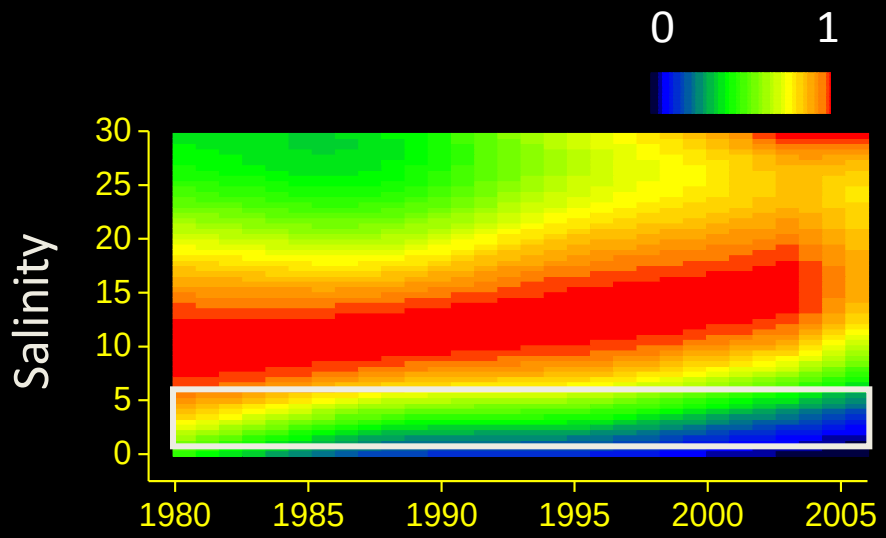
X2 Relationships and Habitat

Longfin Smelt

1967 – 1987: Pre-clam
1988 – 2002: Post-clam
2003 – 2011: Post-POD



Relative Frequency of Occurrence
Bay Study Otter Trawl



IEP Monitoring Data

Long-term Trends

Grazing by *Potamocorbula* in LSZ: Fraction / d

Phytoplankton Biomass in LSZ: mg Chlorophyll / m^3

Copepod Biomass In LSZ: mgC / m^3

Mysid Biomass In LSZ: mgC / m^3

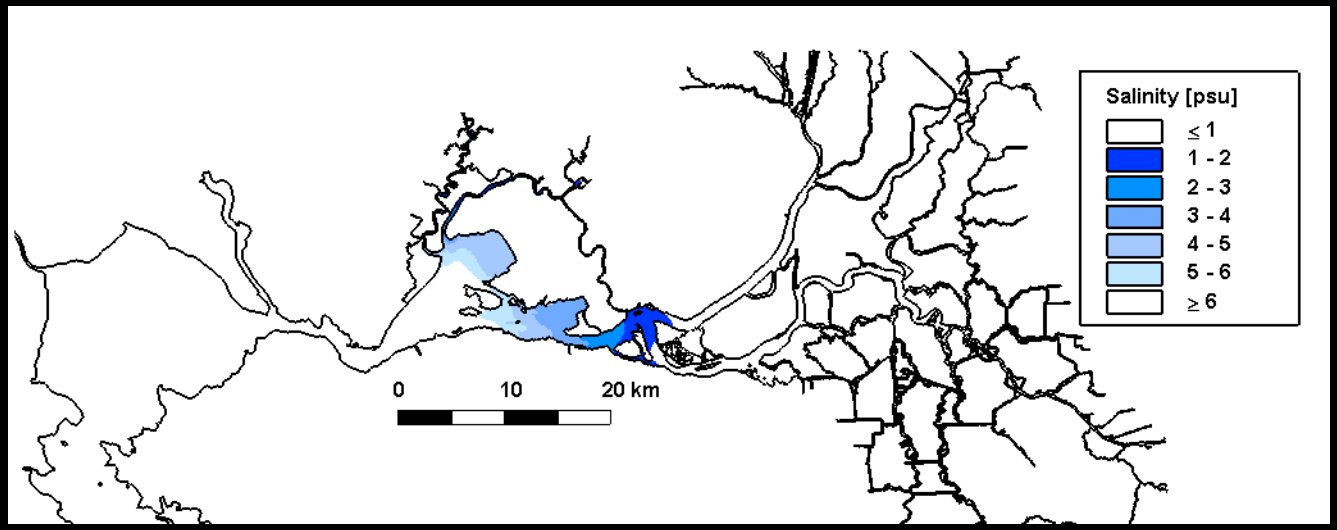
Longfin Smelt Abundance Index Residual from X2

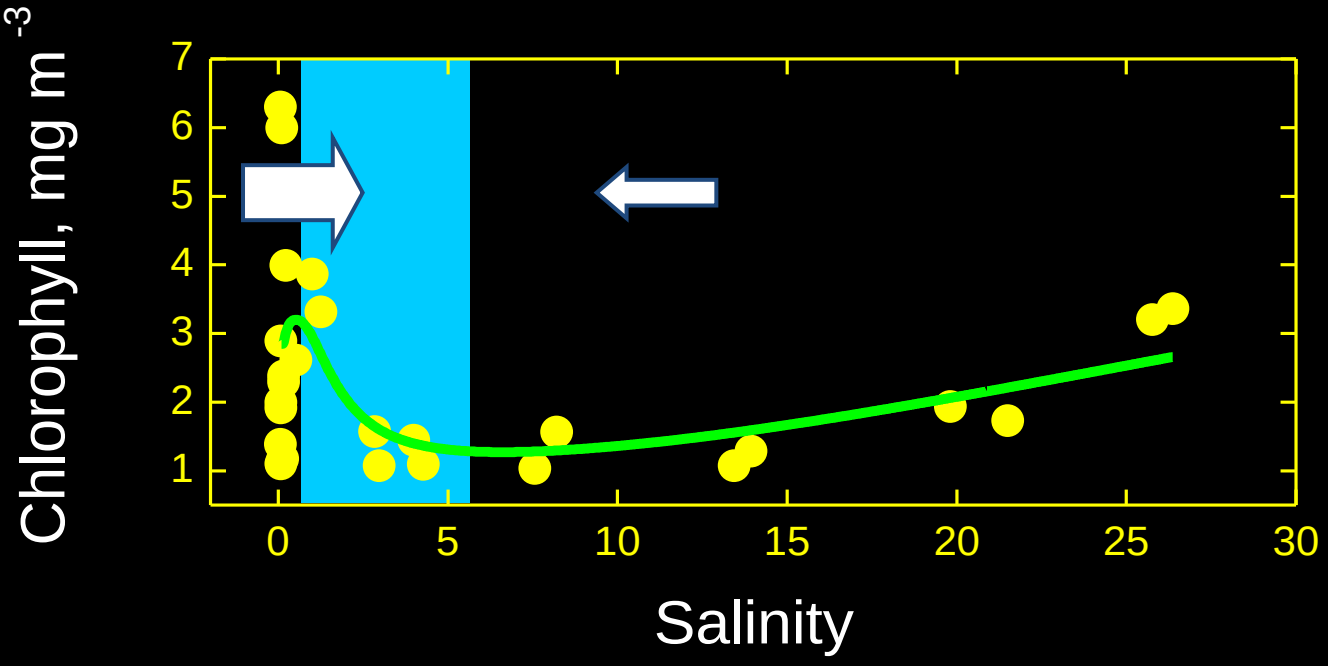
Anchovy in summer Ratio LSZ:HSZ

IEP Monitoring Data

Kimmerer and Thompson in prep.

A chlorophyll subsidy to the LSZ



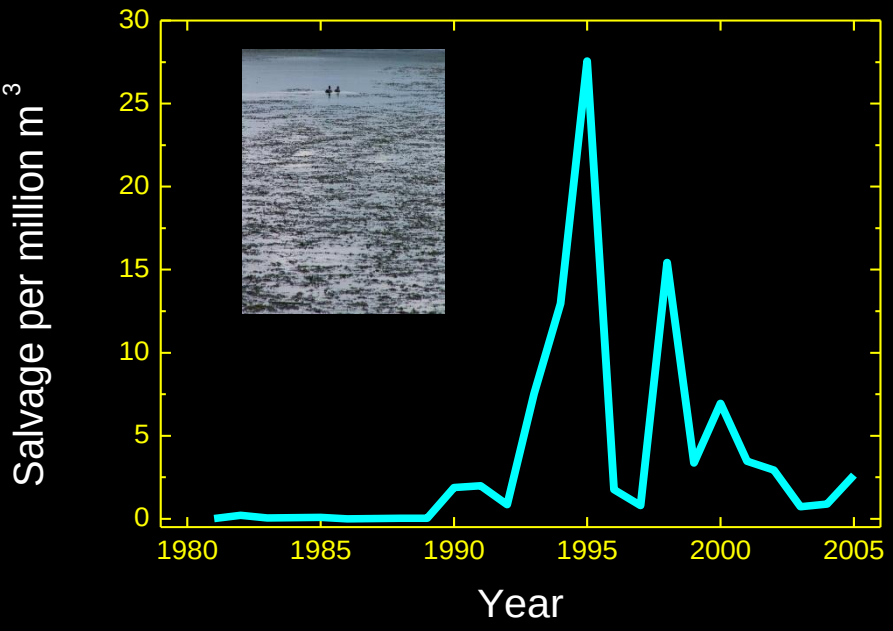


July-August 2010

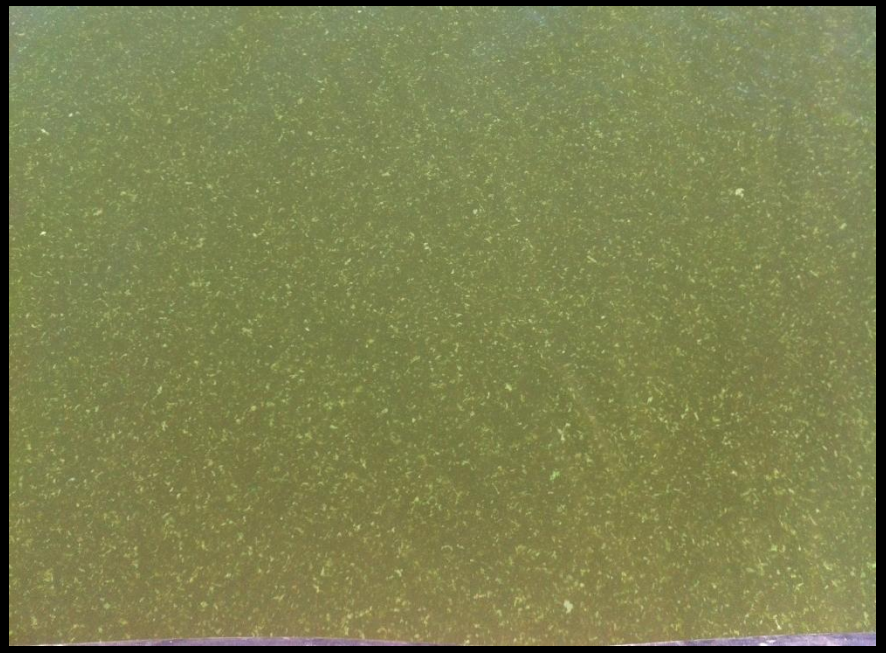
IEP Monitoring Data

Changes in the Delta

Largemouth Bass lives in *Egeria* beds



Microcystis blooms increasing?



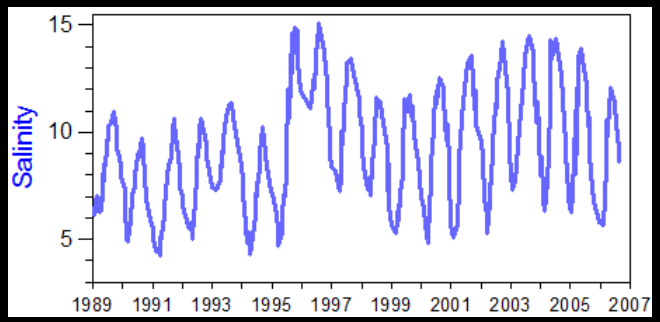
Salvage Data

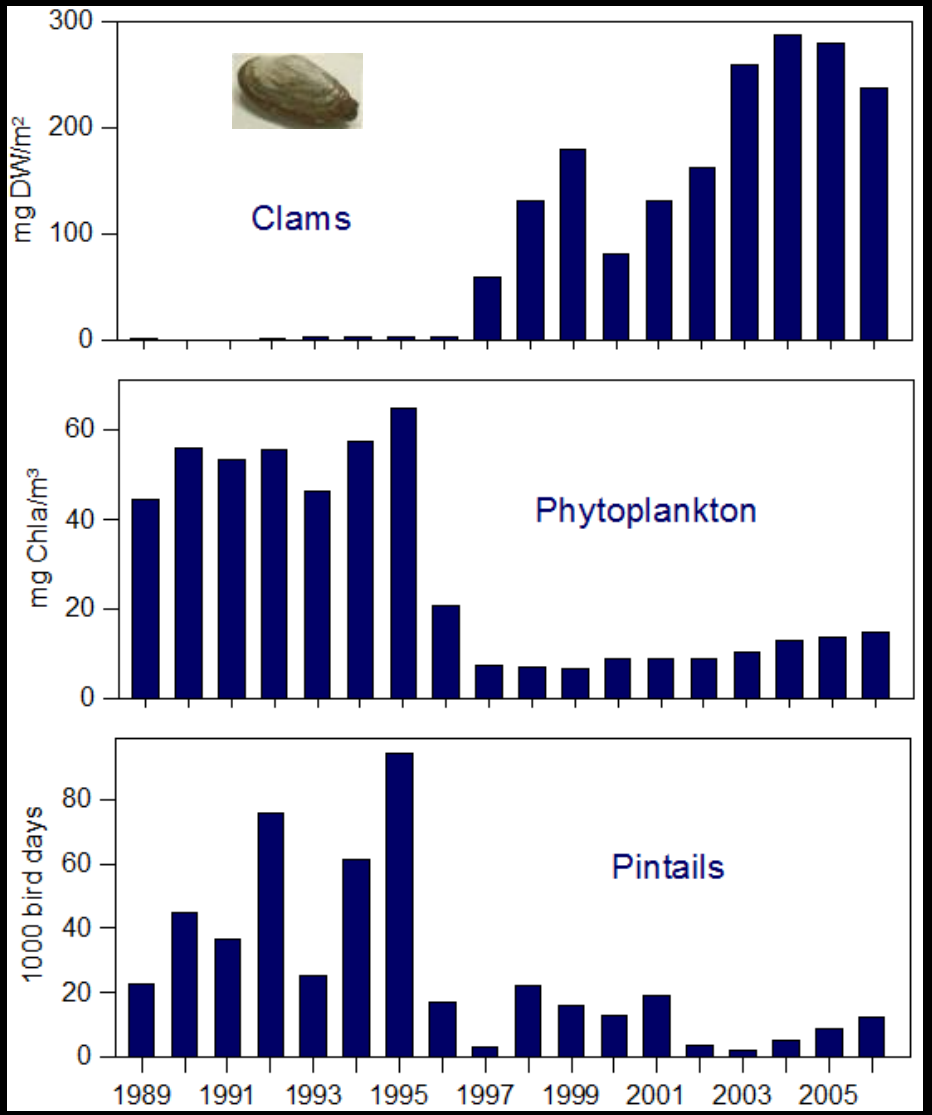
Summary

- Shape of salinity field varies with flow
- Pelagic species live in a dynamic habitat
- LSZ is a key region for some species
- LSZ is unproductive & subsidized
- Abundance – X2 relationships not only about LSZ
- Simple relationships can be misleading

Managing the Estuary for an Uncertain Future

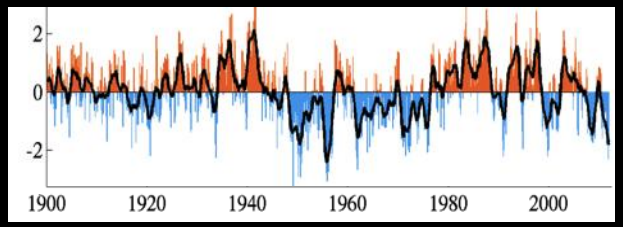
Estuarine ecosystems can be transformed by human actions

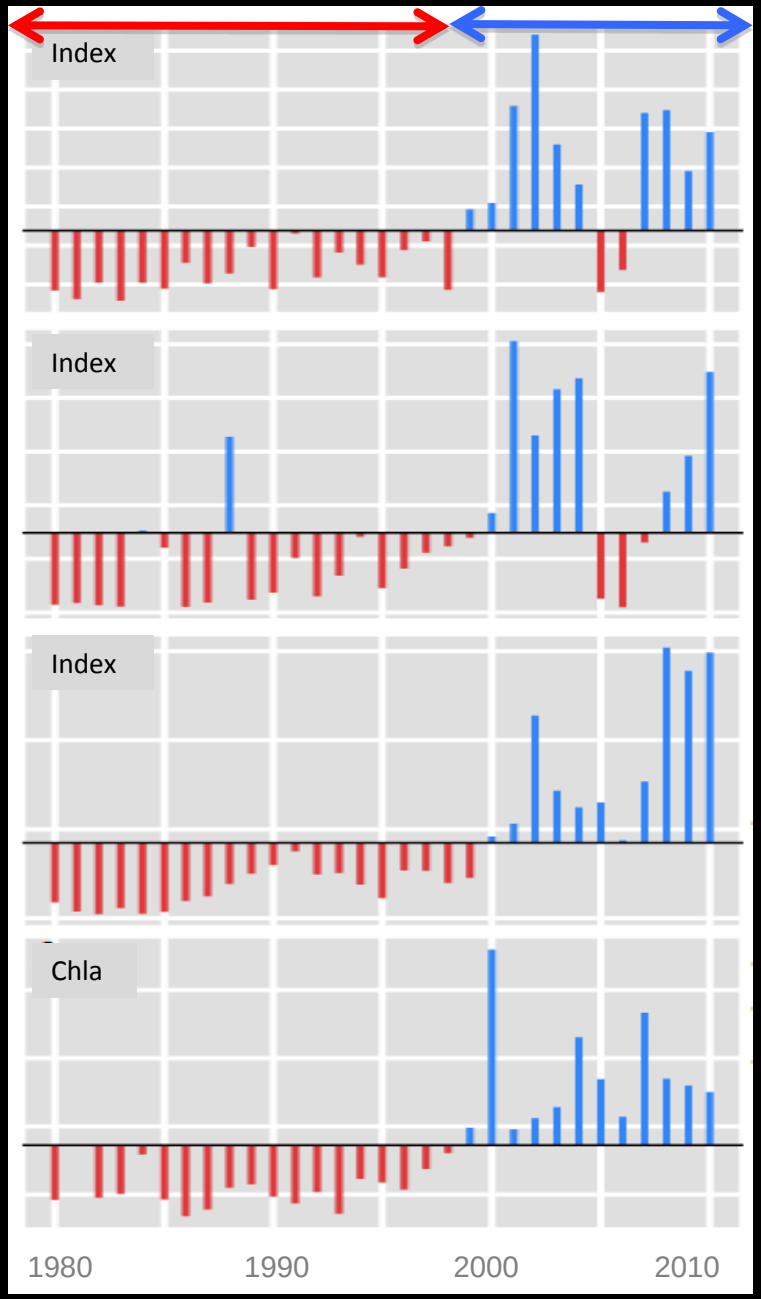




Petersen et al. 2008

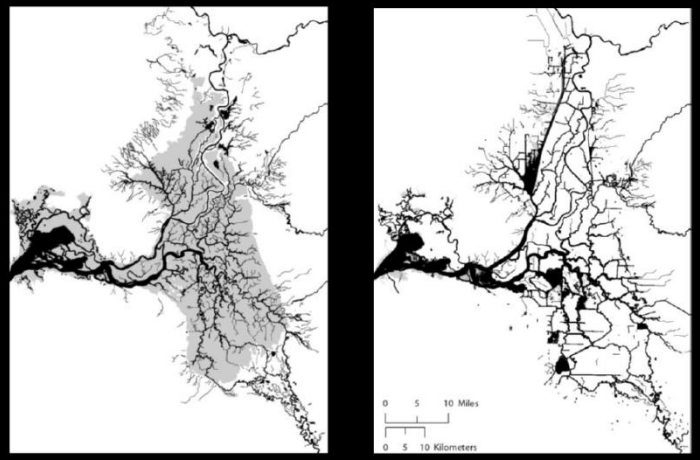
Estuarine ecosystems can be transformed by changes in the climate system



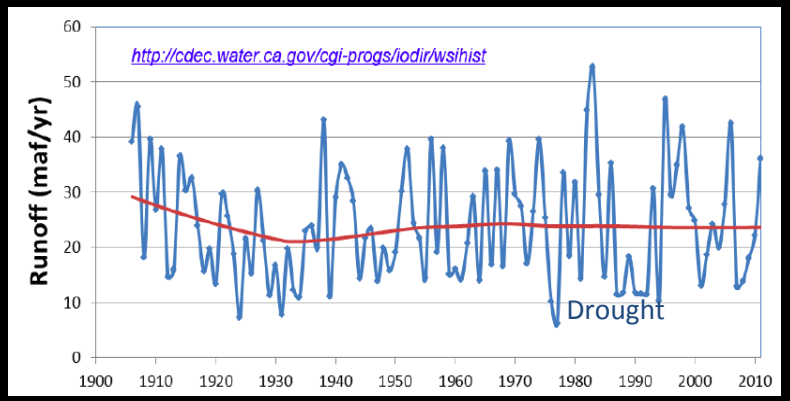


Cloern & Jassby 2012

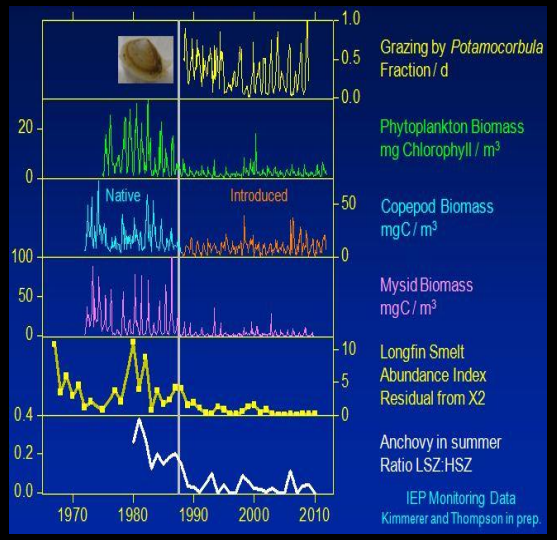
The Bay-Delta ecosystem has been transformed by cumulative effects of human actions and climate variability



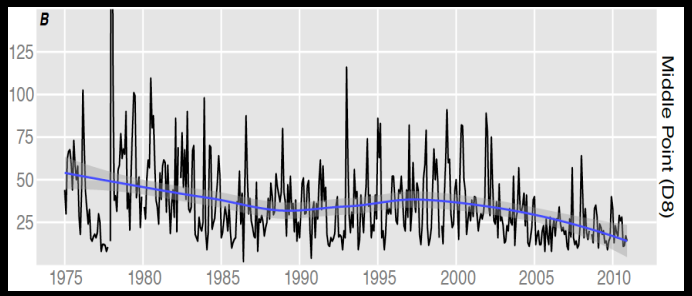
Landscape transformations

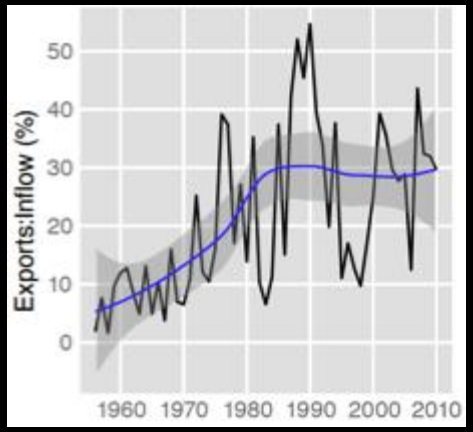


Introduced Species



Reduced sediment supply



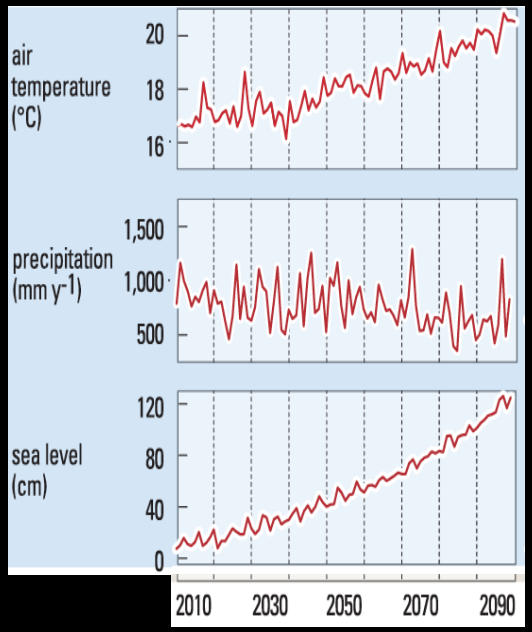


Water consumption and export

"The Delta of the future will be different"

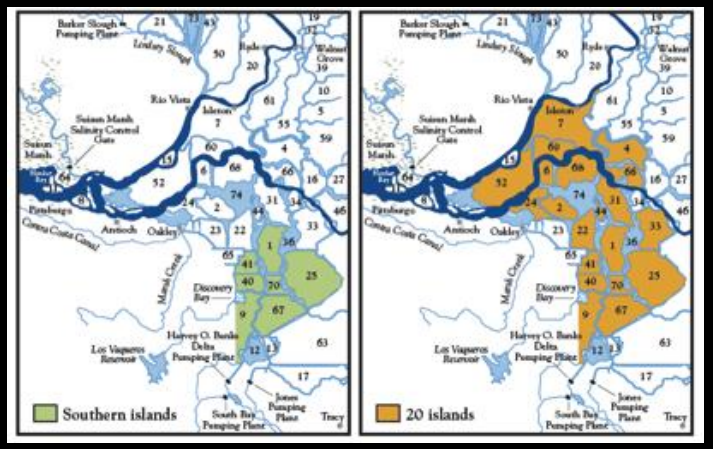
COMPARING FUTURES
FOR THE SACRAMENTO–SAN JOAQUIN DELTA

Climate Change

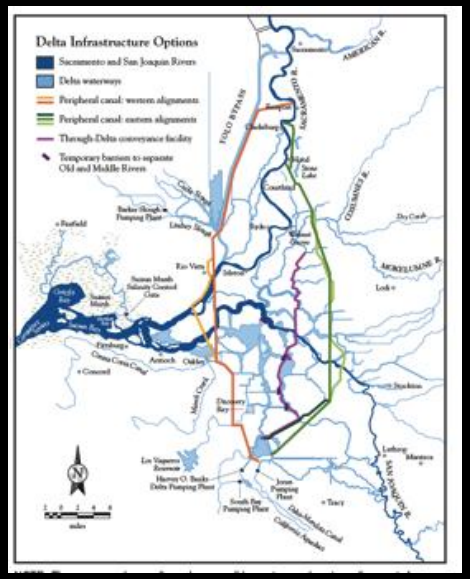


New Species

Flooded Islands



New Conveyances



Toxic Algae

durable policies will **anticipate** and **adapt** to these changes

Science can contribute in two ways:

First, develop models for **anticipating** change

Global Circulation Models

Downscaled to Region

Watershed Model

Sea Level – Golden Gate

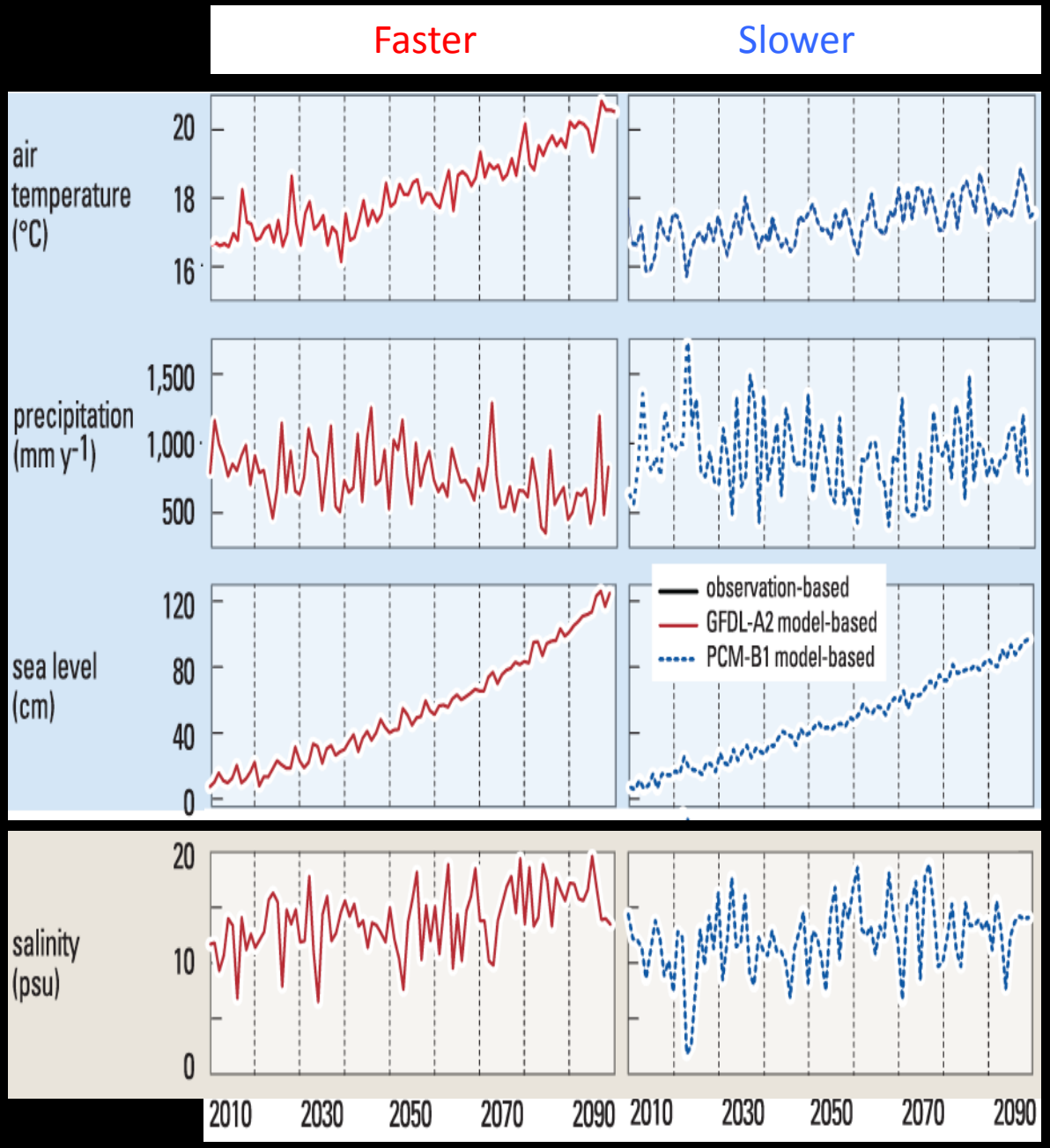
Delta Models

warmer

perhaps drier

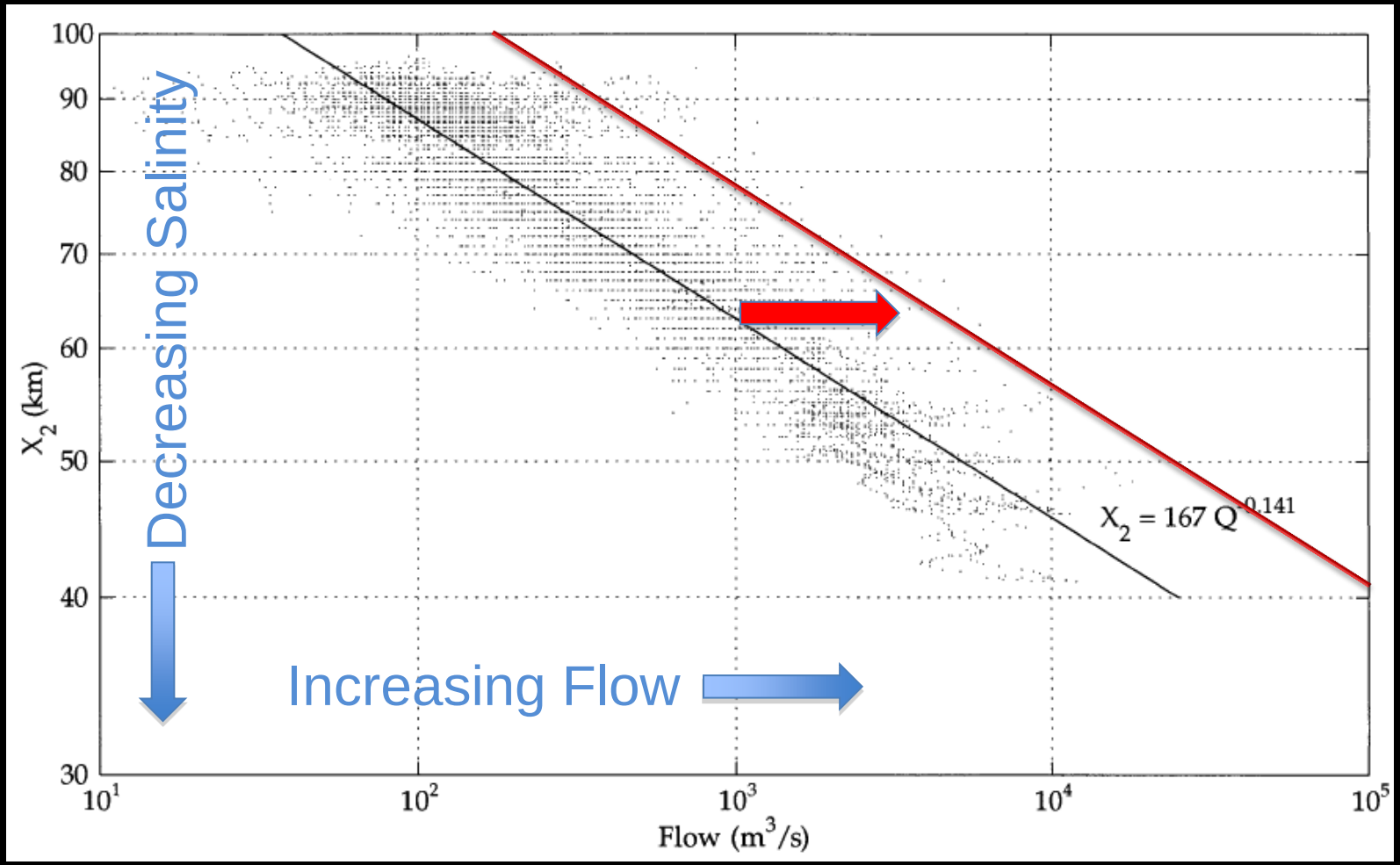
higher sea level

saltier estuary



Cloern et al. 2011

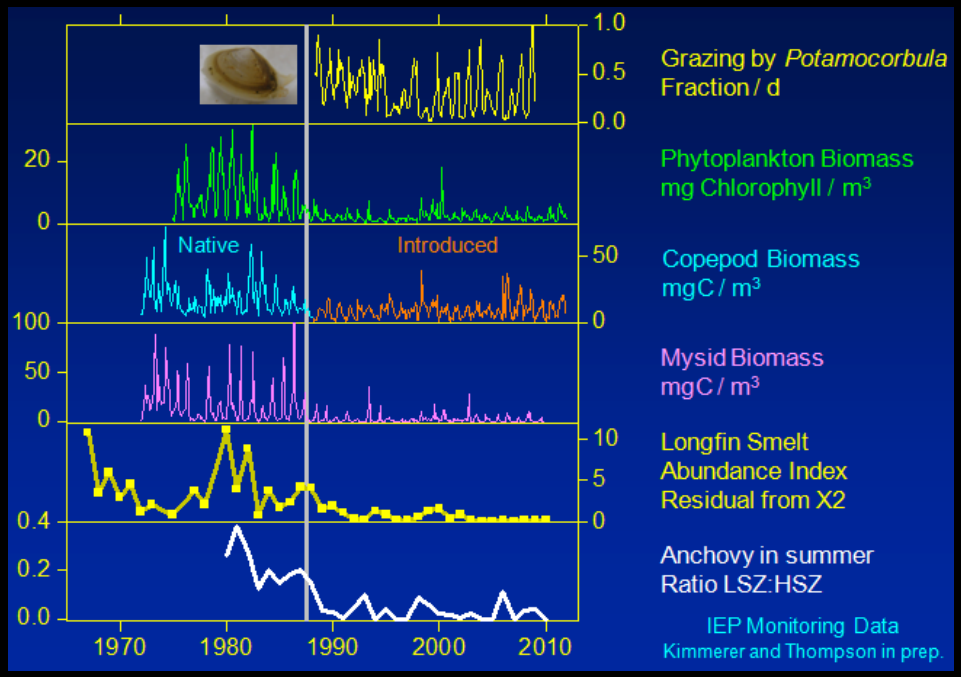
Durable policy will, e.g. adapt to anticipated changes in the flow-X2 relationship

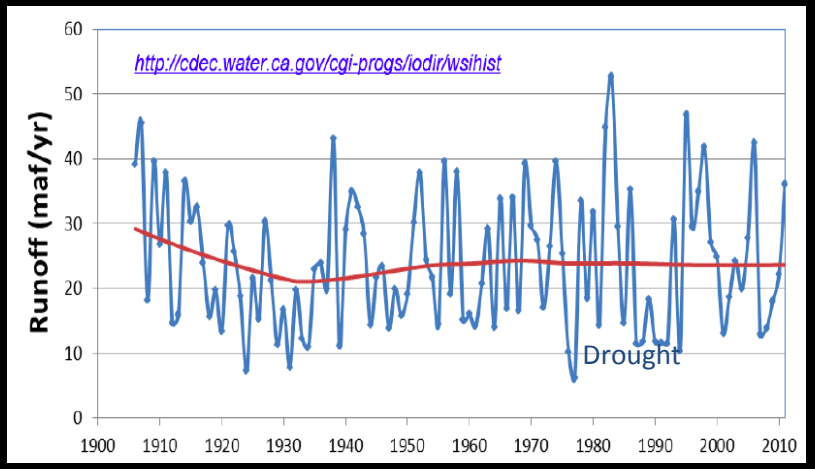


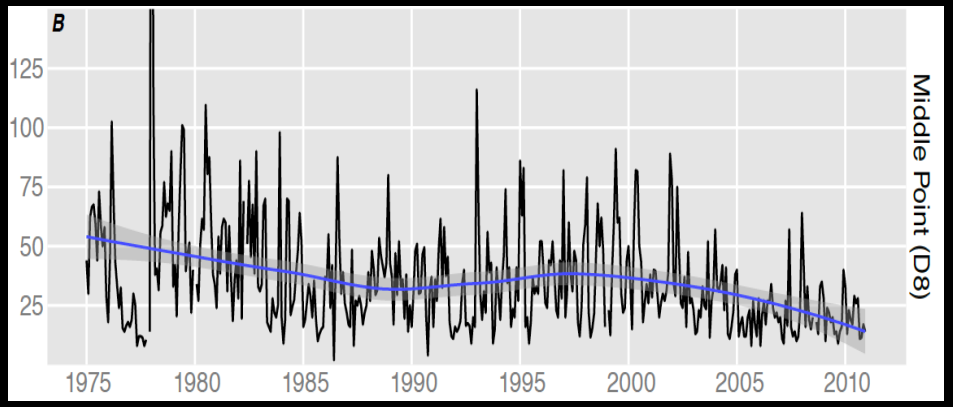
"With one foot of sea level rise, an annual average of at least 475,000 acre-feet of additional Delta outflow would have been required to maintain 1981 to 2000 salinity conditions at the western edge of the Delta ...With continued sea level rise, the volume of required outflows would continue to increase."

COMPARING FUTURES
FOR THE SACRAMENTO–SAN JOAQUIN DELTA

Second, regular observations detect changes for **adaptation**



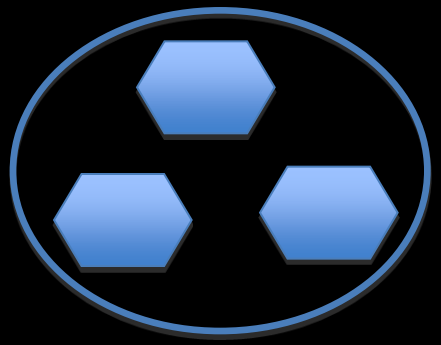


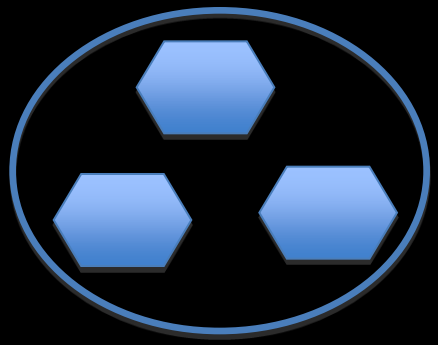


But these 3 components are weakly coupled

Policy

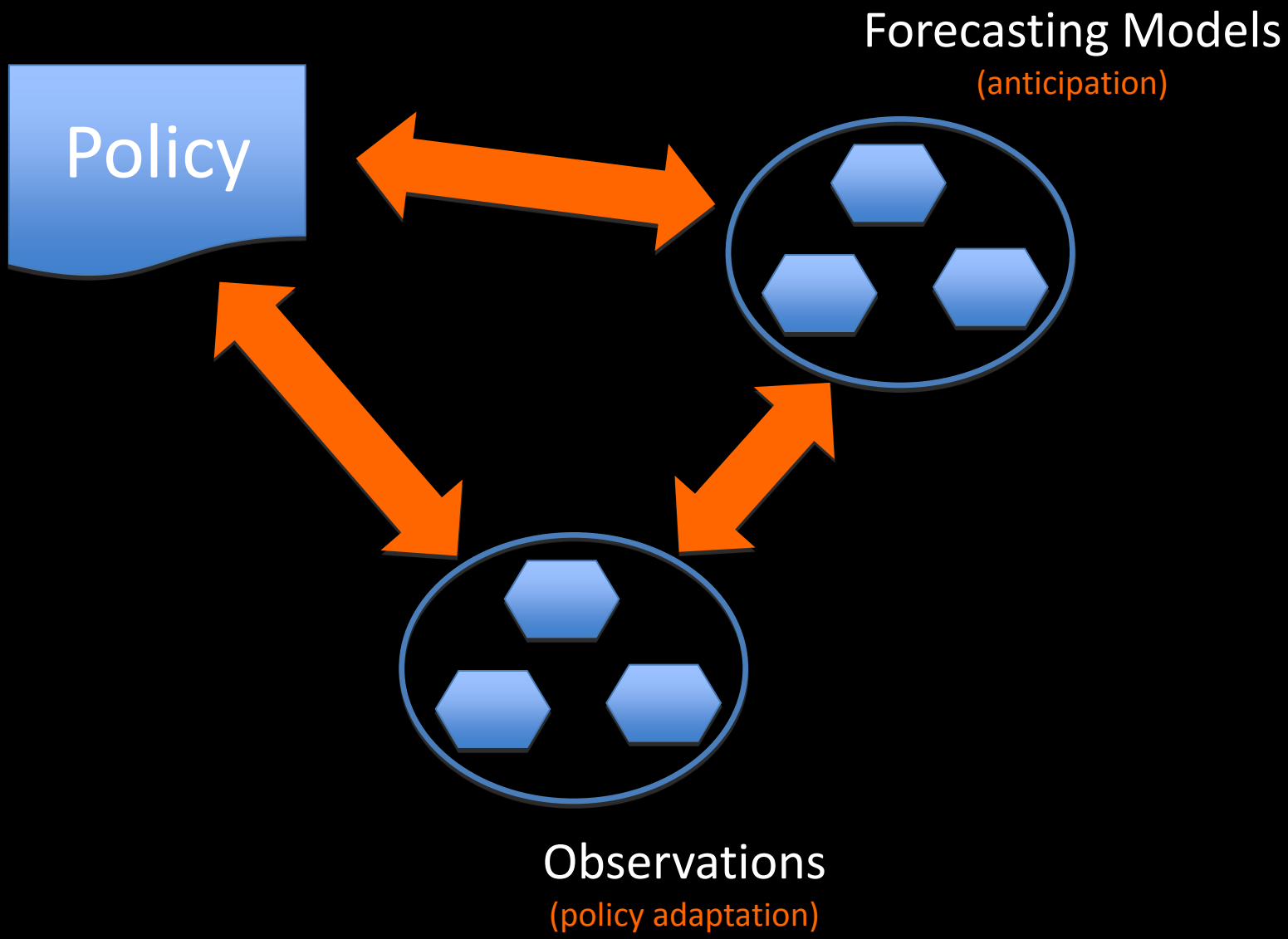
Forecasting Models
(anticipation)





Observations
(policy adaptation)

Durable policies require stronger couplings



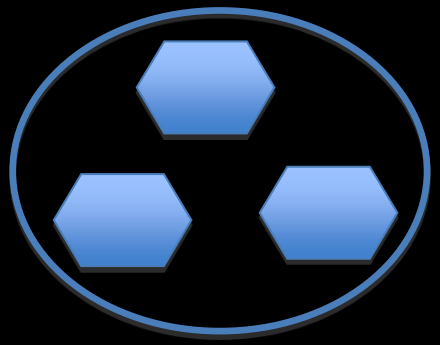
Changing Science for a Changing Estuary

Change + Multiple Drivers = Uncertain Future

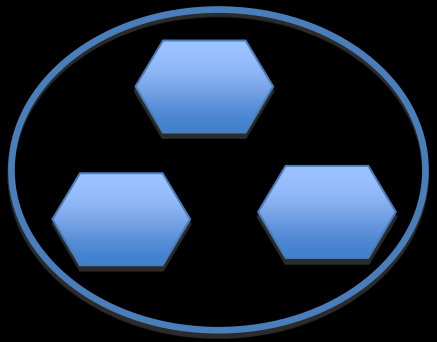
Change + Multiple Drivers = Uncertain Future
+ Weak Couplings = "Wicked" Problem!

Policy

Forecasting Models
(anticipation)



Observations
(policy adaptation)

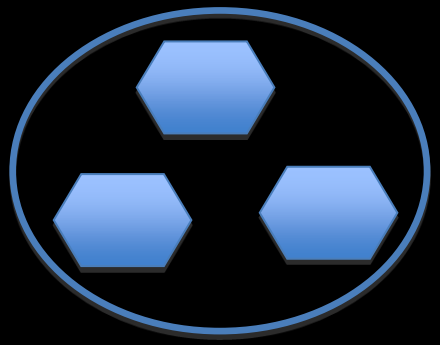


Change + Multiple Drivers = Uncertain Future + Weak Couplings = “Wicked” Problem!

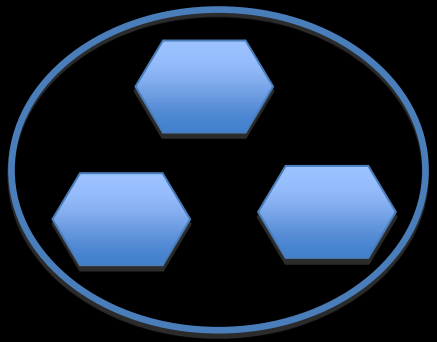
Needed: New Approach

Policy

Forecasting Models
(anticipation)

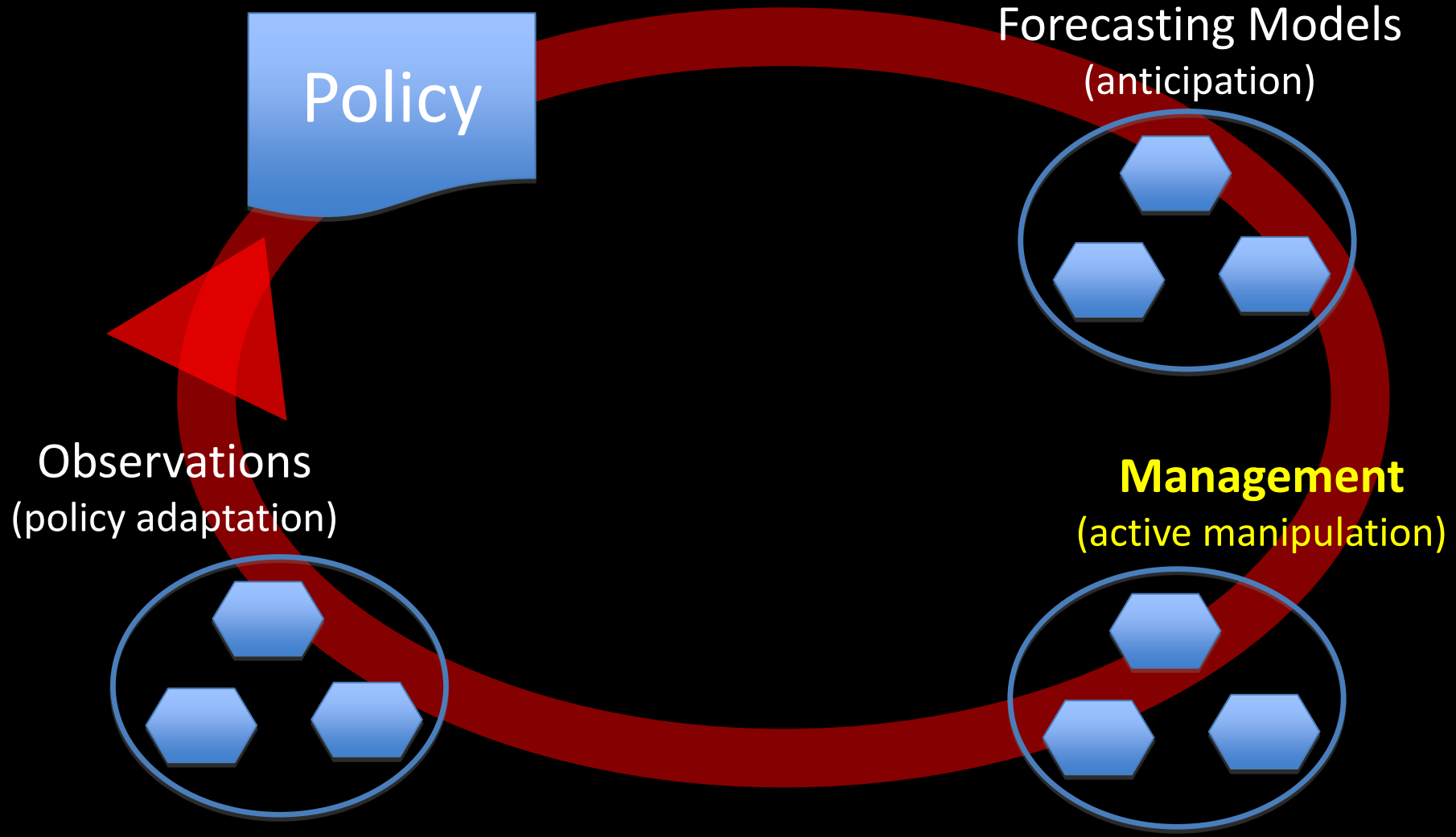


Observations
(policy adaptation)



Change + Multiple Drivers = Uncertain Future + Weak Couplings = "Wicked" Problem!

Adaptive Management

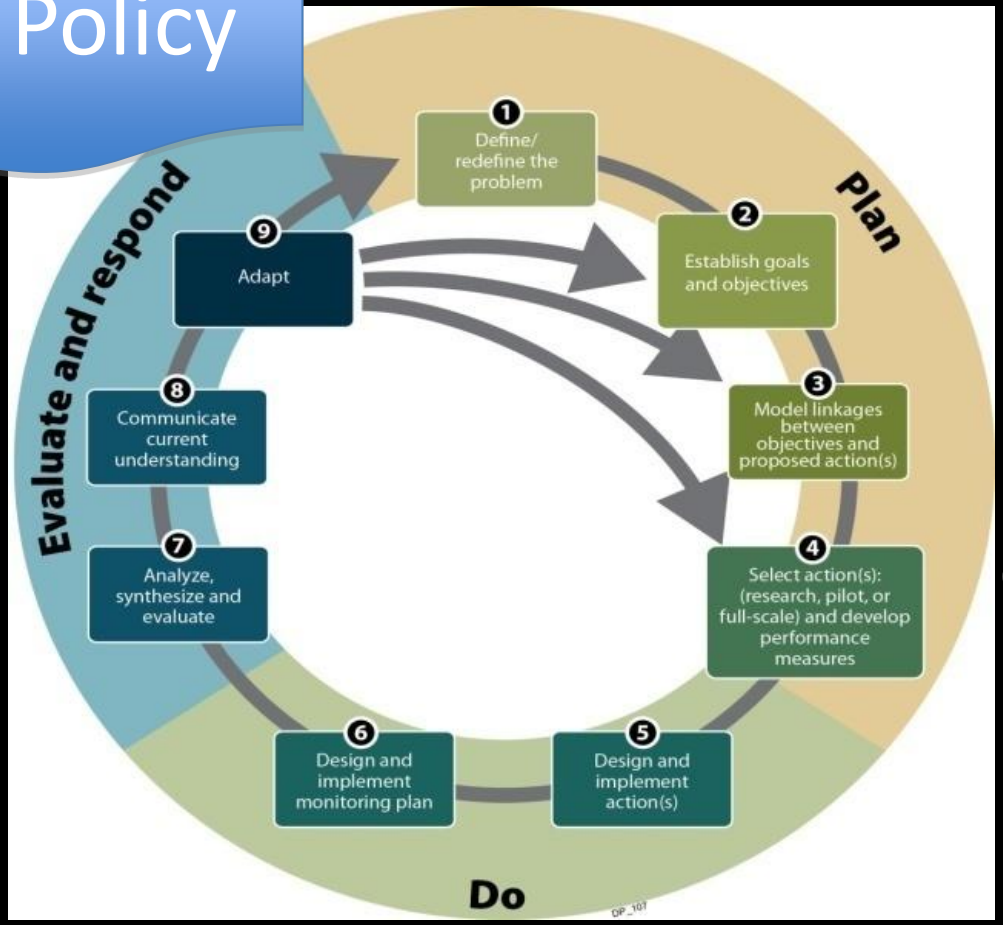


Change + Multiple Drivers = Uncertain Future + Weak Couplings = "Wicked" Problem!

Adaptive Management

Policy

Forecasting Models
(anticipation)



Observations
(policy adaptation)

Management
(active manipulation)

Delta Plan
(DSC 2012)

An Example and Local Test Case:
Fall Outflow Adaptive Management, Fall Low Salinity Habitat (FLaSH) Study

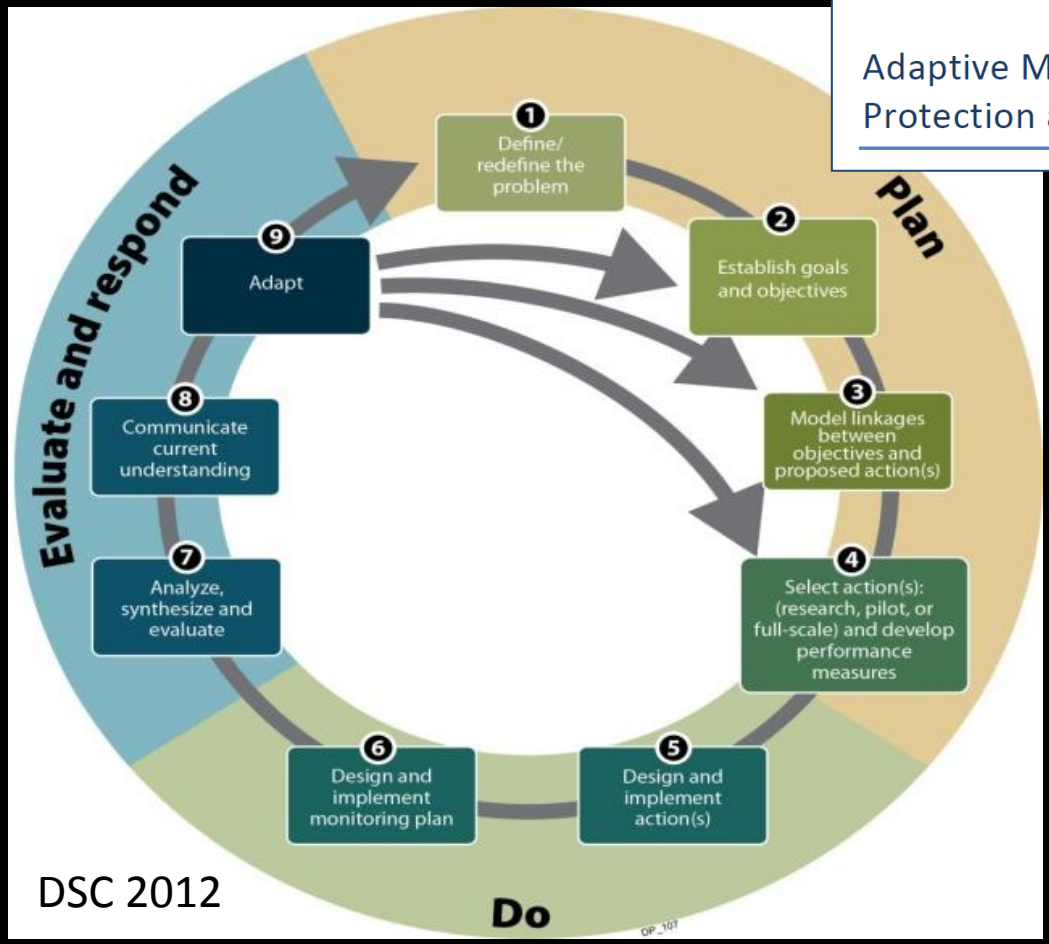
Interagency Ecological Program
Cooperative Ecological Investigations in the San Francisco Estuary since 1970

6/28/2012

BOR 2012

FALL OUTFLOW ADAPTIVE MANAGEMENT PLAN
REVISED MILESTONE DRAFT

Adaptive Management of Fall Outflow for Delta Smelt Protection and Water Supply Reliability



DSC 2012

"The [Fall Outflow] AMP is one of the highest-profile and highest-impact ecosystem manipulations in the country (and likely the world)."

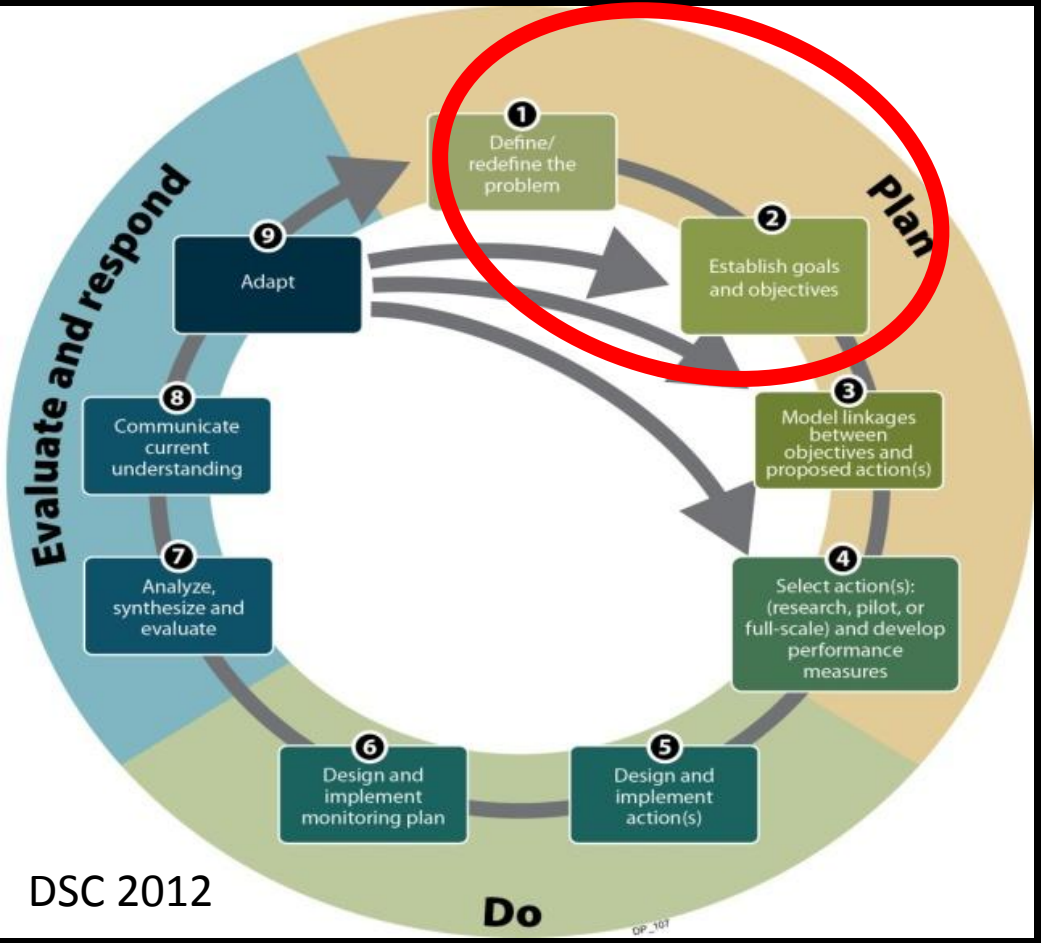
DSP FLaSH Review Panel, 9/4/2012

Fall outflow management "should be implemented within an adaptive framework"

SWRCB 2010

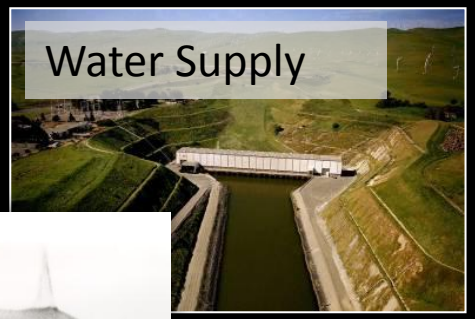
More info.: http://deltacouncil.ca.gov/events/science-program-review/fall-low-salinity-habitat-flash-studies-and-adaptive-management-plan-r

Fall Outflow Adaptive Management

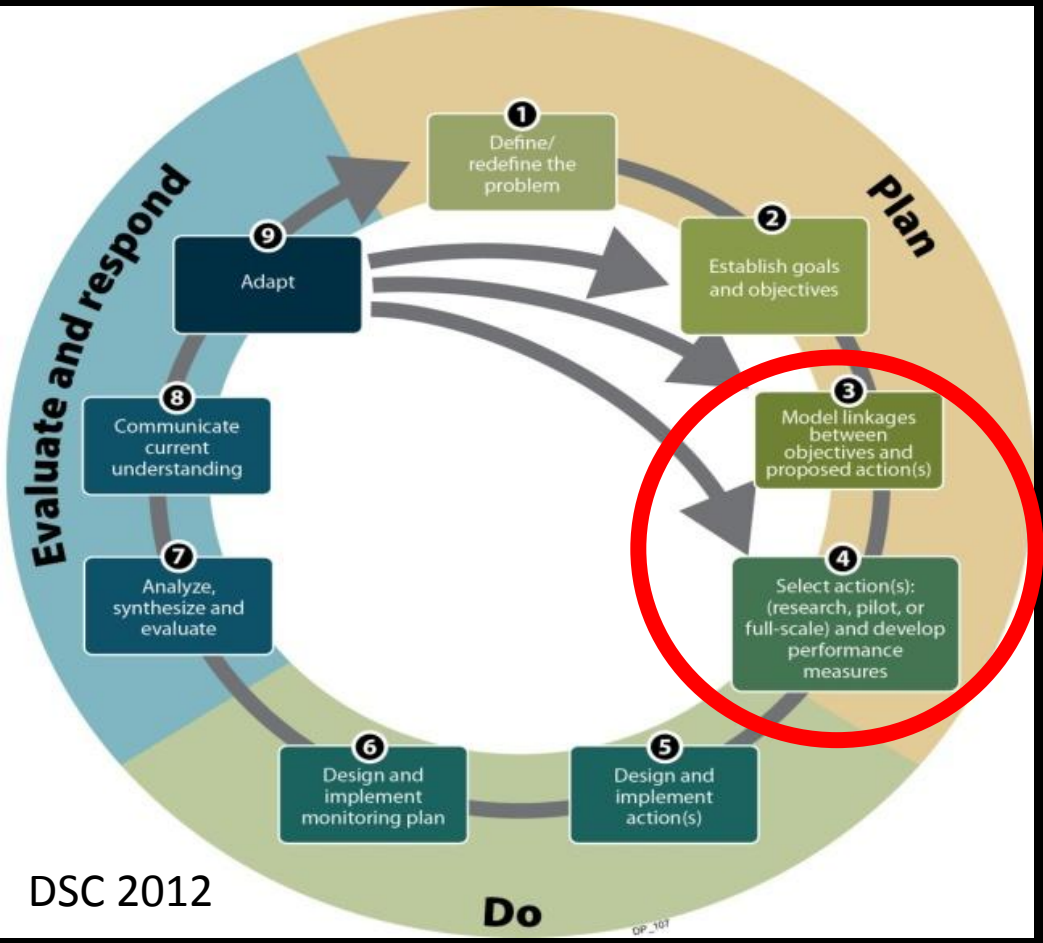


DSC 2012

1. Problem: Delta smelt endangered, constraints on water supply
2. Goal: Improve both – and learn!



Fall Outflow Adaptive Management



DSC 2012

3.Model Linkages: Statistical and conceptual models relating flows to delta smelt indices

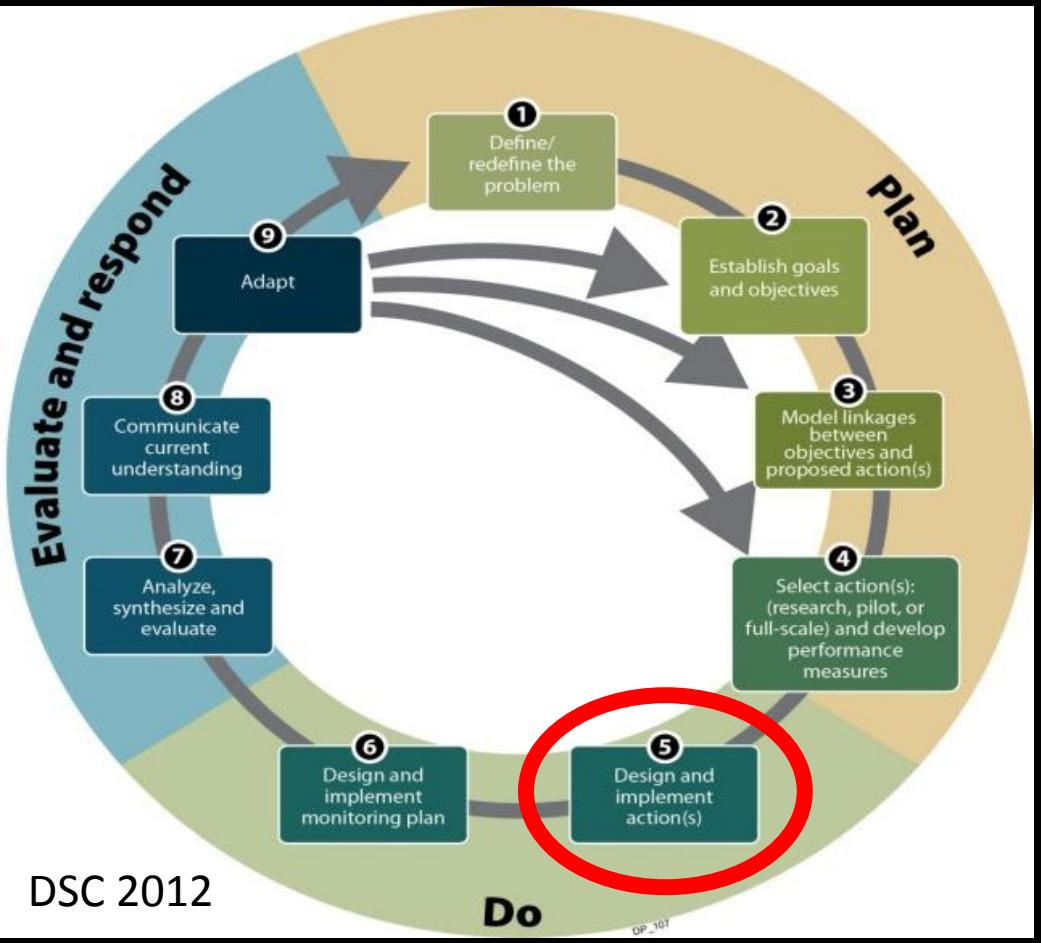
4.Select Action: Increase interannual fall outflow variability

→ Wet: Fall X2=74 km

→ AN: Fall X2=81 km

(1 of many actions in FWS 2008 BiOp)

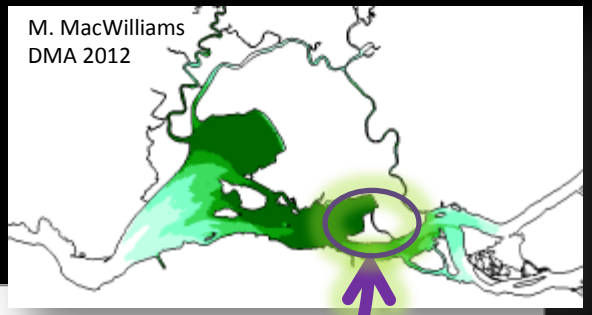
Fall Outflow Adaptive Management

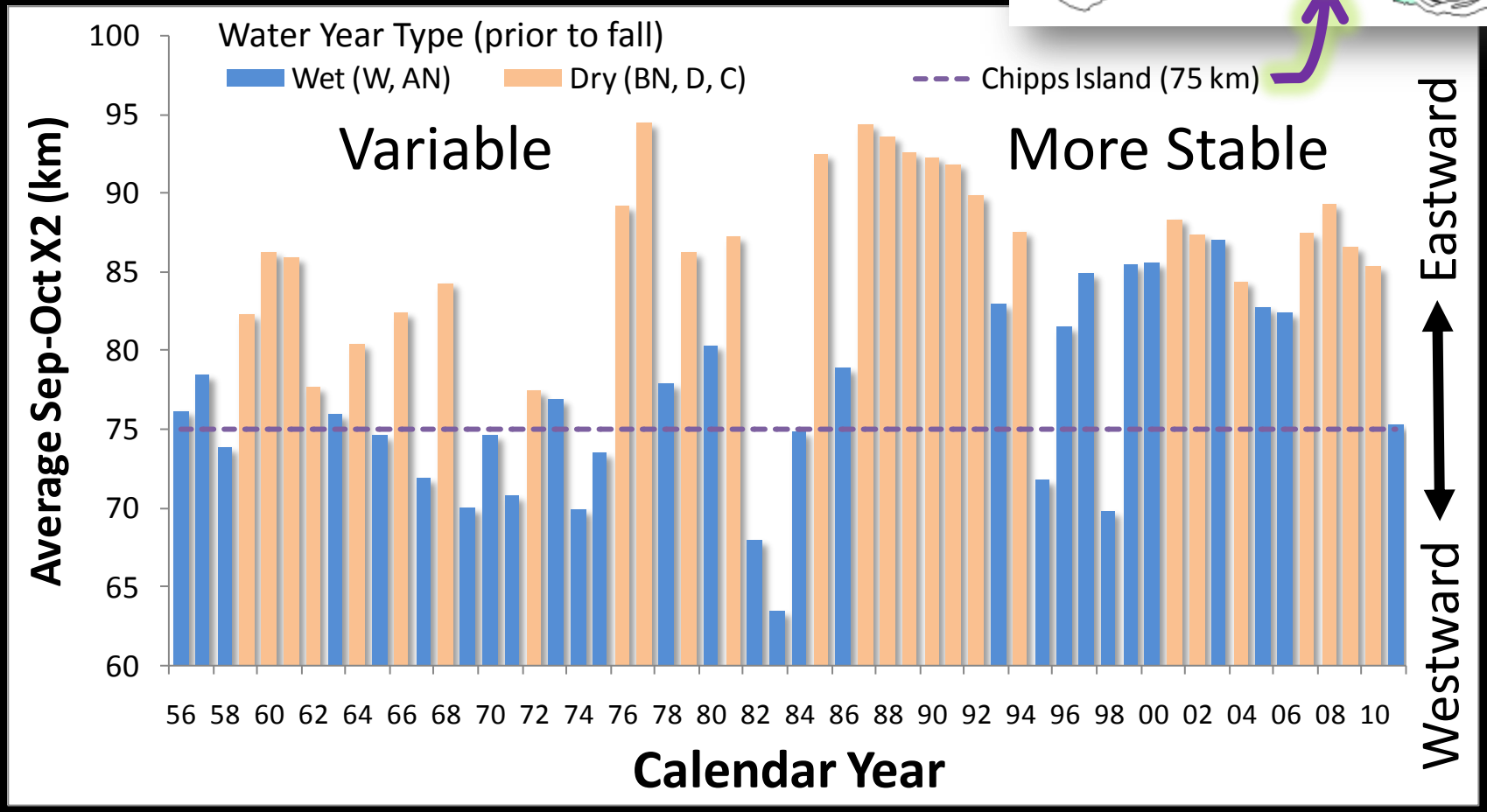


DSC 2012

5. Action: 2011 – a wet year

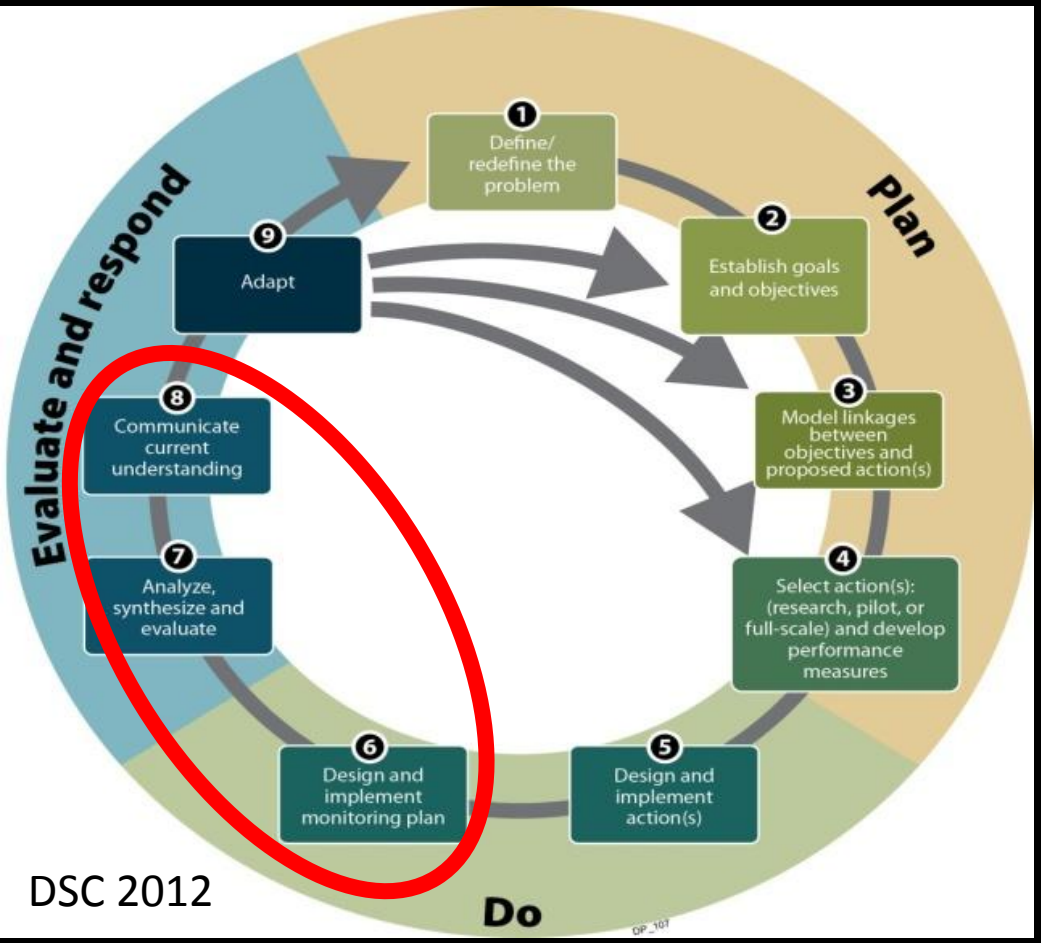
2011: high inflows and outflows, record high exports, low (westward) Sep-Oct X2





Fall Outflow Adaptive Management

Fall Low Salinity Habitat (FLaSH) Study



DSC 2012

5.-8. Observations: IEP

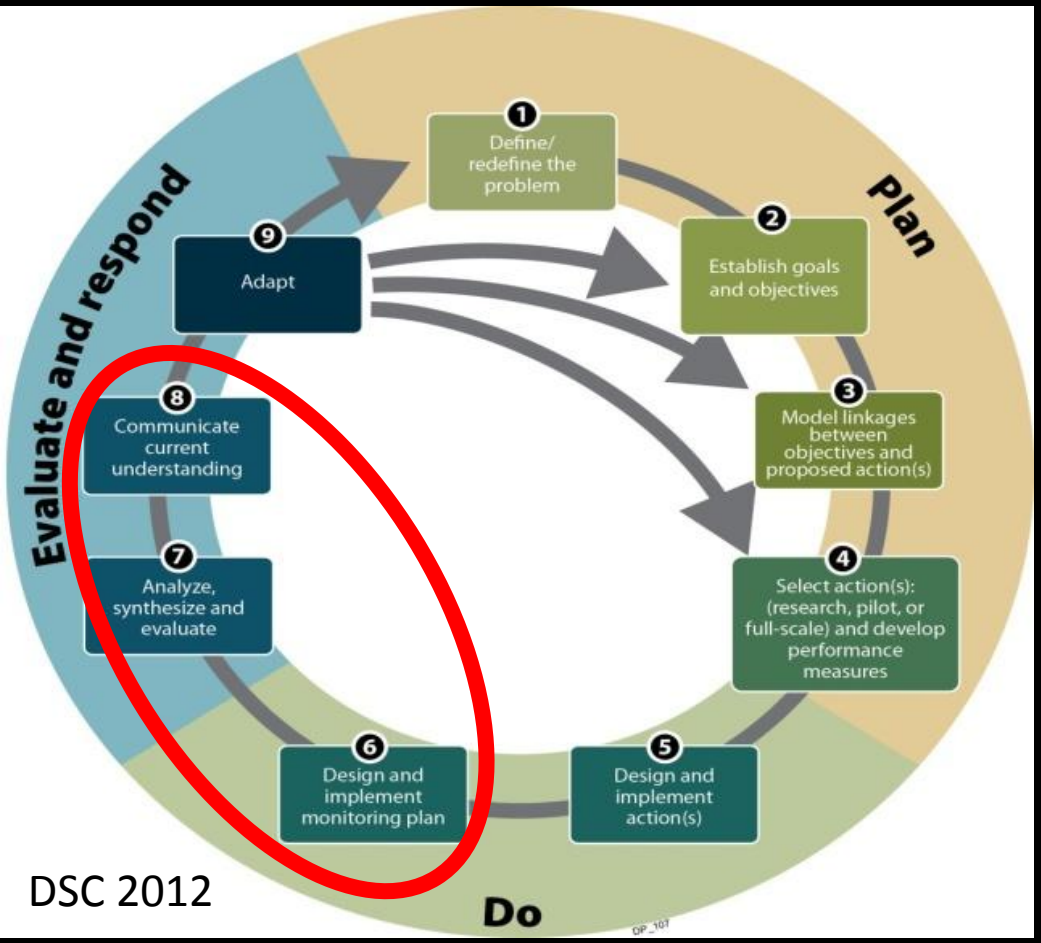
DWR • USBR • USFWS • SWRCB • DFG • USEPA • USACE • NMFS • USGS

Interagency Ecological Program

COOPERATIVE ECOLOGICAL INVESTIGATIONS SINCE 1970

Fall Outflow Adaptive Management

Fall Low Salinity Habitat (FLaSH) Study



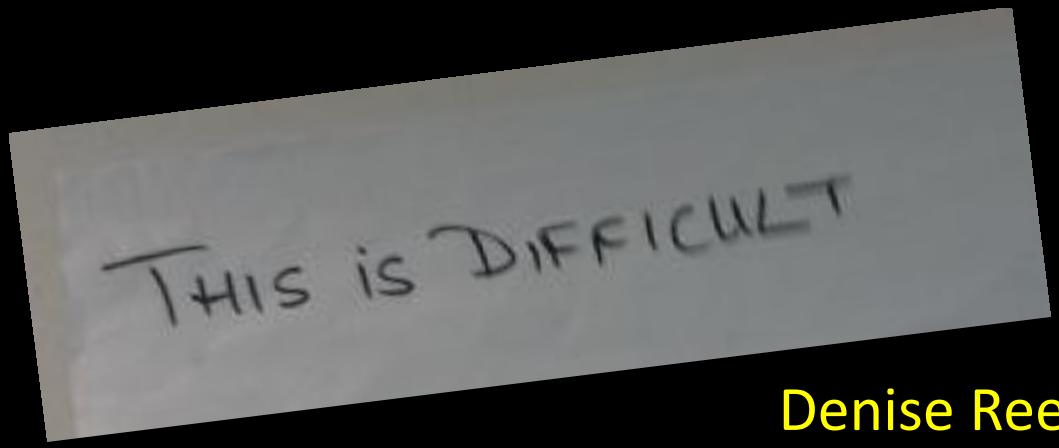
DSC 2012

5.-8. Observations: IEP

- Did action work?
- Mechanisms and processes?
- New action options based on new insights?

FLaSH Study, Year 1:

- Conceptual Model, 93 Predictions
- Observations to test predictions – so far 17 predictions supported, 9 not)
- Modeling
- Draft FLaSH report (USGS)
- DSP Science Panel Review (7/31-8/1/2012)



Denise Reed, 8/1/2012

FLaSH Study, Year 1:

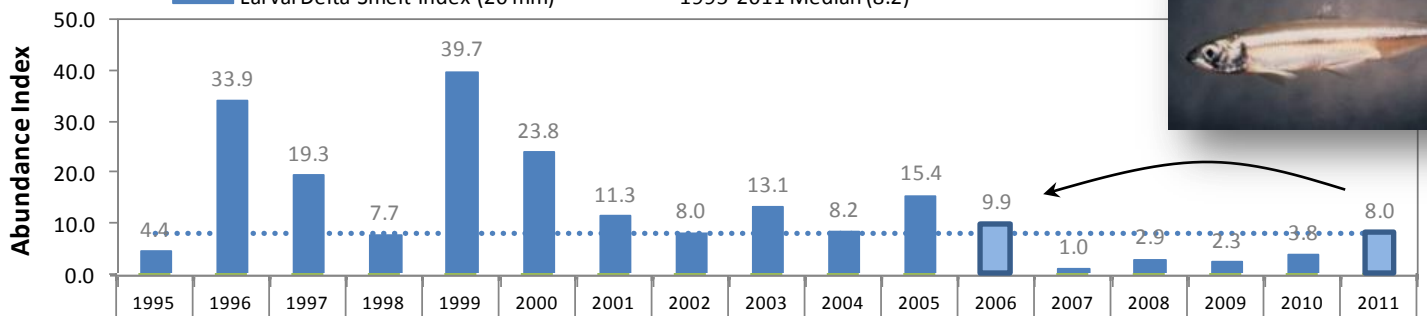
- Conceptual Model, 93 Predictions
- Observations to test predictions – so far 17 predictions supported, 9 not)
- Modeling
- Draft FLaSH report (USGS)
- DSP Science Panel Review (7/31-8/1/2012)

Draft DSP Science Panel Review Report (9/4/2012):

- "*Impressive Mobilization*" (by & of already busy people)
- "*Learning from such an extensive effort will take time*" (n>1)
- "*No fatal errors*" but room for improvement, e.g.:
  - Leadership: Chief scientist with support staff, 10+ years
  - Linkages: Integrative modeling; Other seasons, processes

Other seasons: all delta smelt indices increased in 2011

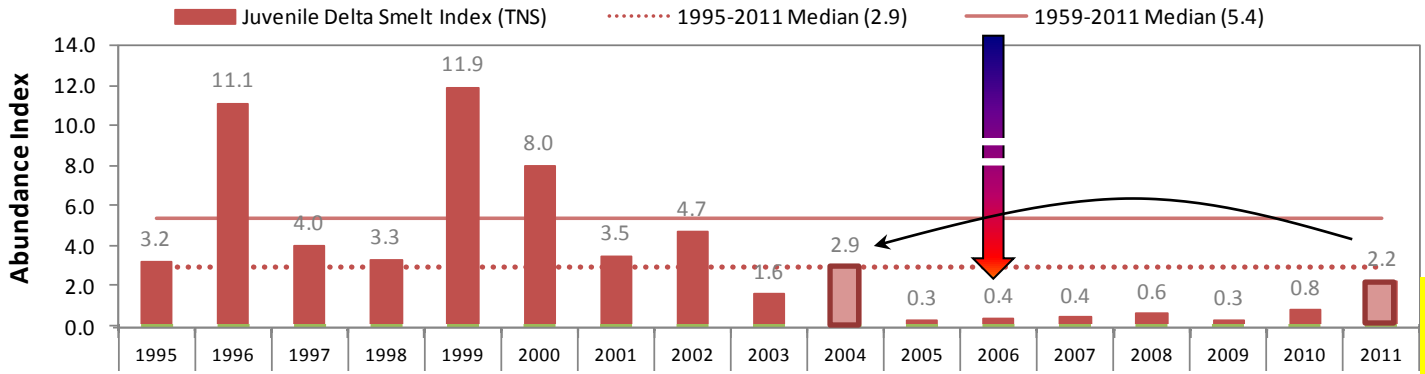
Spring: Larval Delta Smelt Index (20 mm)



Data: DFG

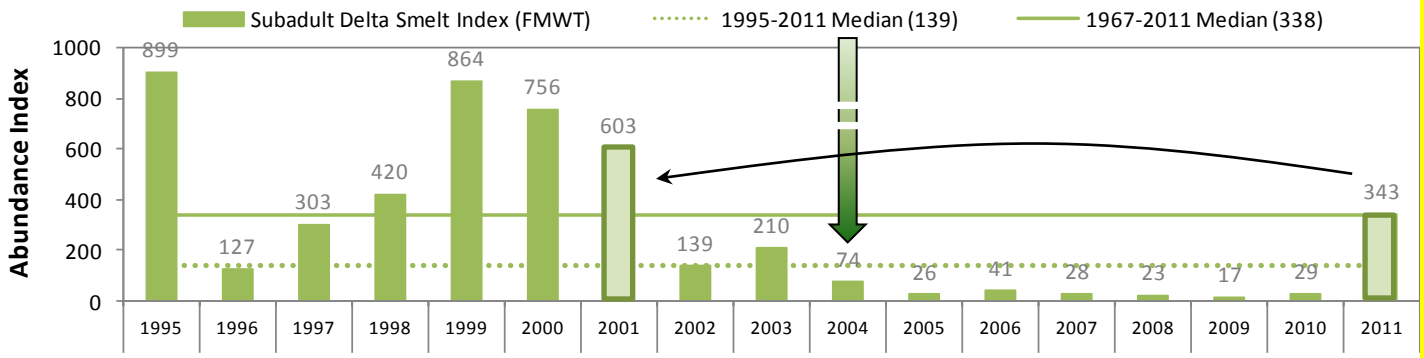
2012: 11.1

Summer: Juvenile Delta Smelt Index (TNS)



2012: 0.9

Fall: Subadult Delta Smelt Index (FMWT)



Fall is important, but other seasons are, too. And other species… AM needs Integration! (*IEP "MAST"*)

FLaSH Lessons for Science & Adaptive Management

- Strong "Inter-..." Lines: *Coupling*
- Appropriate Time Lines (n>1) – *"This is Difficult!"*
- Year-Round, Integrative Approach (e.g. "MAST")
- Assigned, Funded, Knowledgeable Leaders & Staff
- Plan, Do, Observe – "*Magnitude?*"
- Respond: Anticipate, Adapt – but how exactly?

Conclusions and Recommendations

SWRCB - Invited Panel in 2010

Five Key Points

1. Environmental flows are more than just volumes of inflows and outflows
2. Recent flow regimes both harm native species and encourage non-native species
3. Flow is a major determinant of habitat and transport
4. Recent Delta environmental flows are insufficient to support native Delta fishes for today's habitats
5. A strong science program and a flexible management regime are essential to improving flow criteria




Ecosystem Changes and the Low Salinity Zone
Some Take Home Messages

Today's Invited Panel Presentations:

1. Hydrologic Changes - Bill Fleenor
2. Ecosystem and Low Salinity Zone Changes - Wim Kimmerer
3. Managing the Estuary for an Uncertain Future - Jim Cloern
4. Changing Science - Anke Mueller-Solger and Larry Brown

Some Guiding Principles for Setting Flow Standards

2010-2012 – Two Years of Scientific Progress

Flows Do Matter – Streams, Rivers, and Estuaries