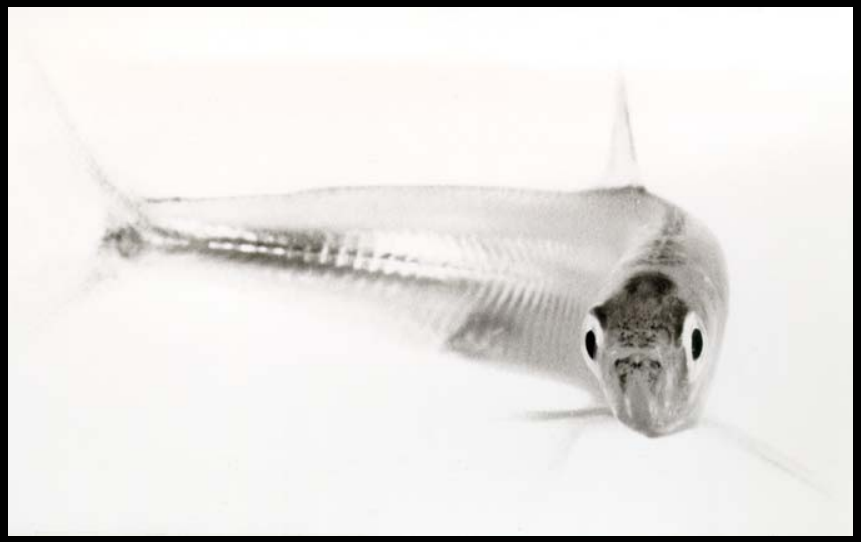
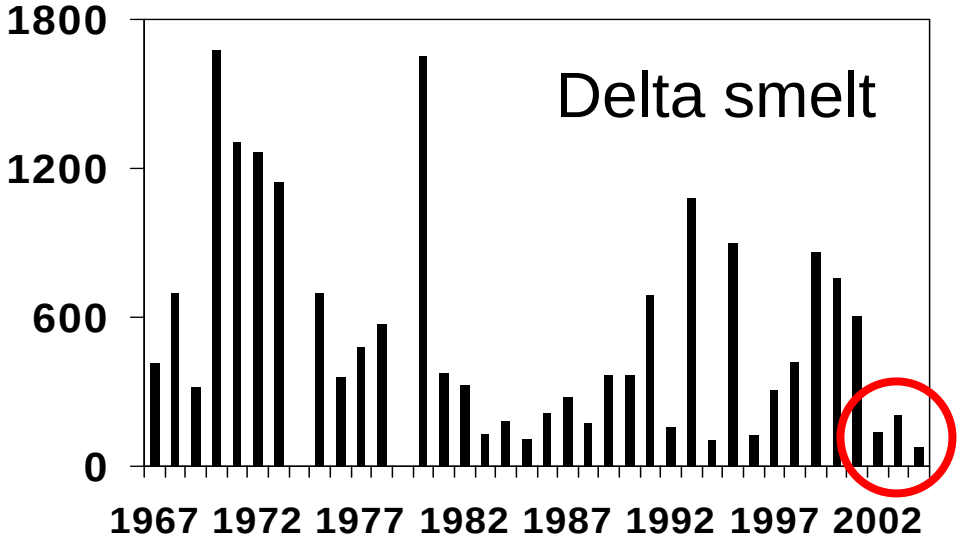
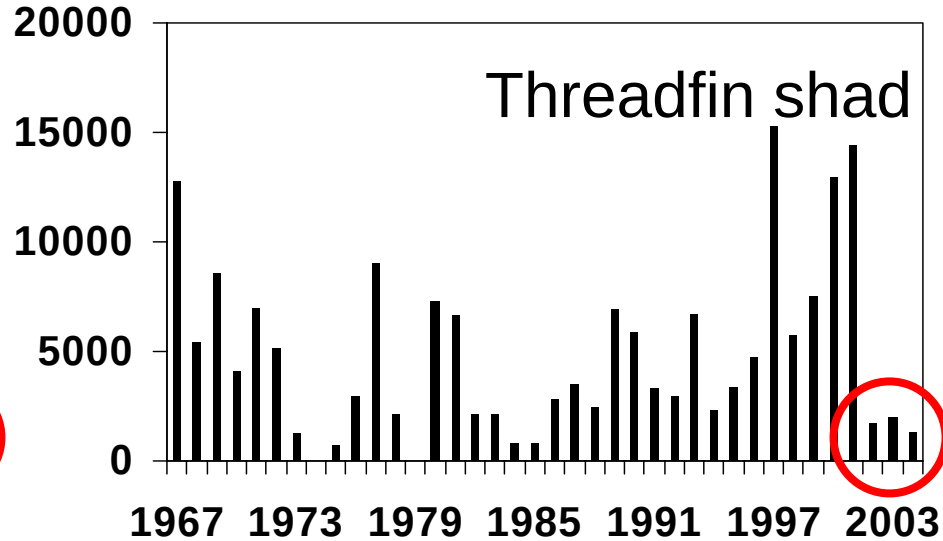
Pelagic Organism Decline: Overview of Program and Progress

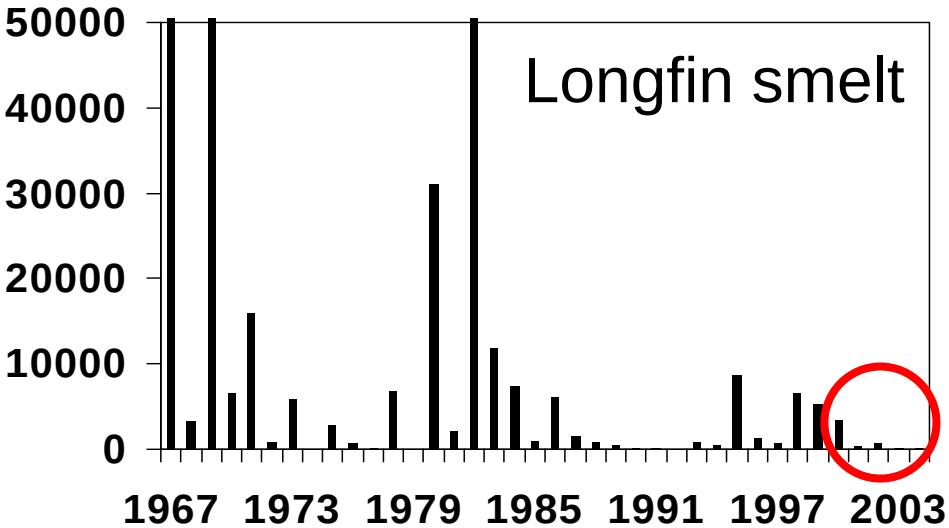


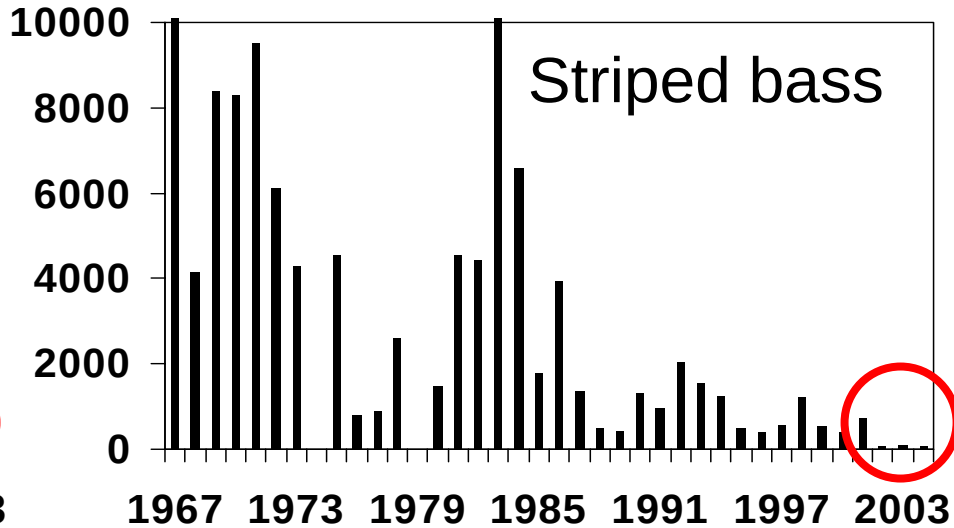
Ted Sommer

California Department of Water Resources

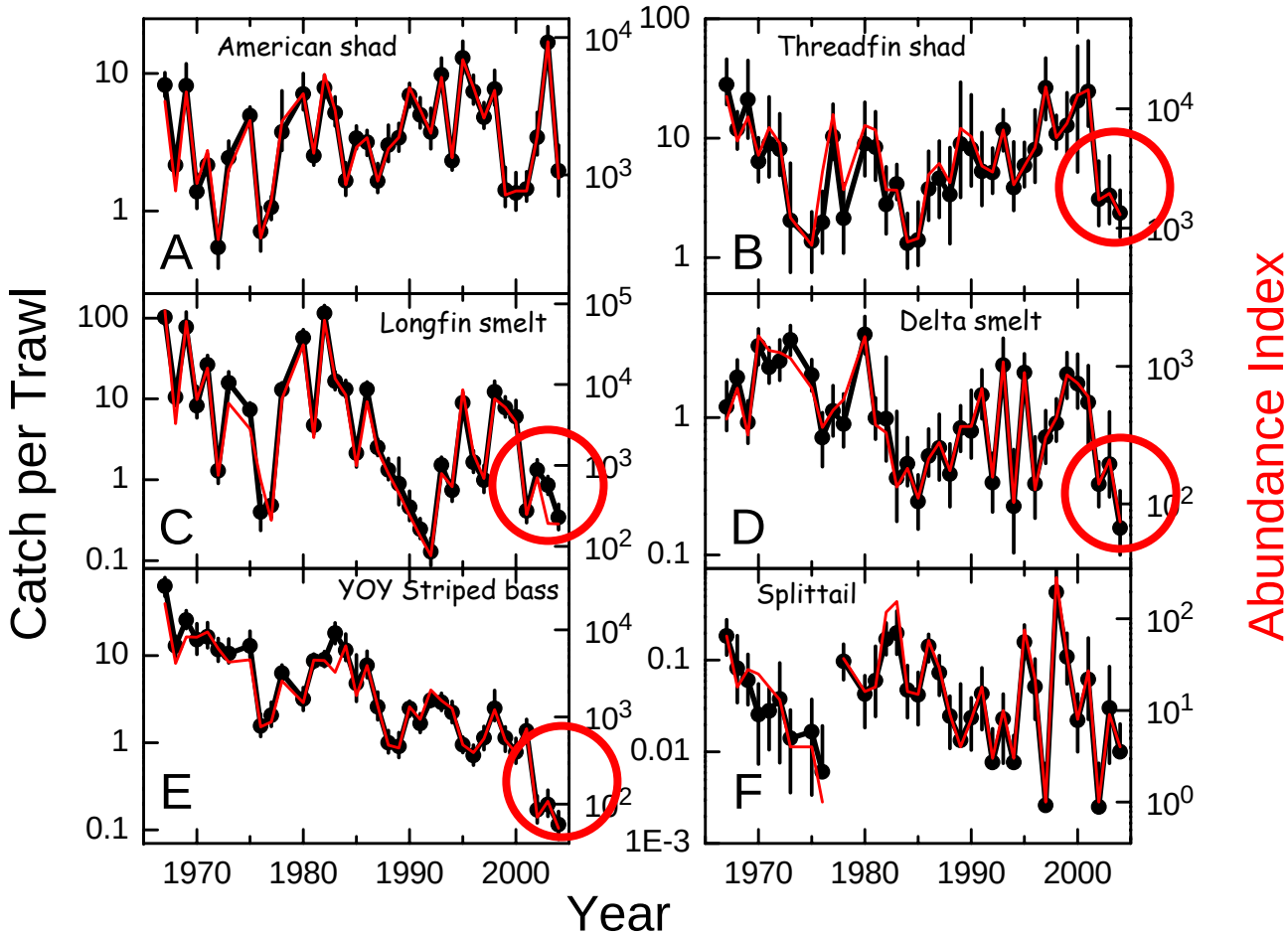

Delta smelt
1800
1200
600
0
1967 1972 1977 1982 1987 1992 1997 2002


Threadfin shad
20000
15000
10000
5000
0
1967 1973 1979 1985 1991 1997 2003


Longfin smelt
50000
40000
30000
20000
10000
0
1967 1973 1979 1985 1991 1997 2003

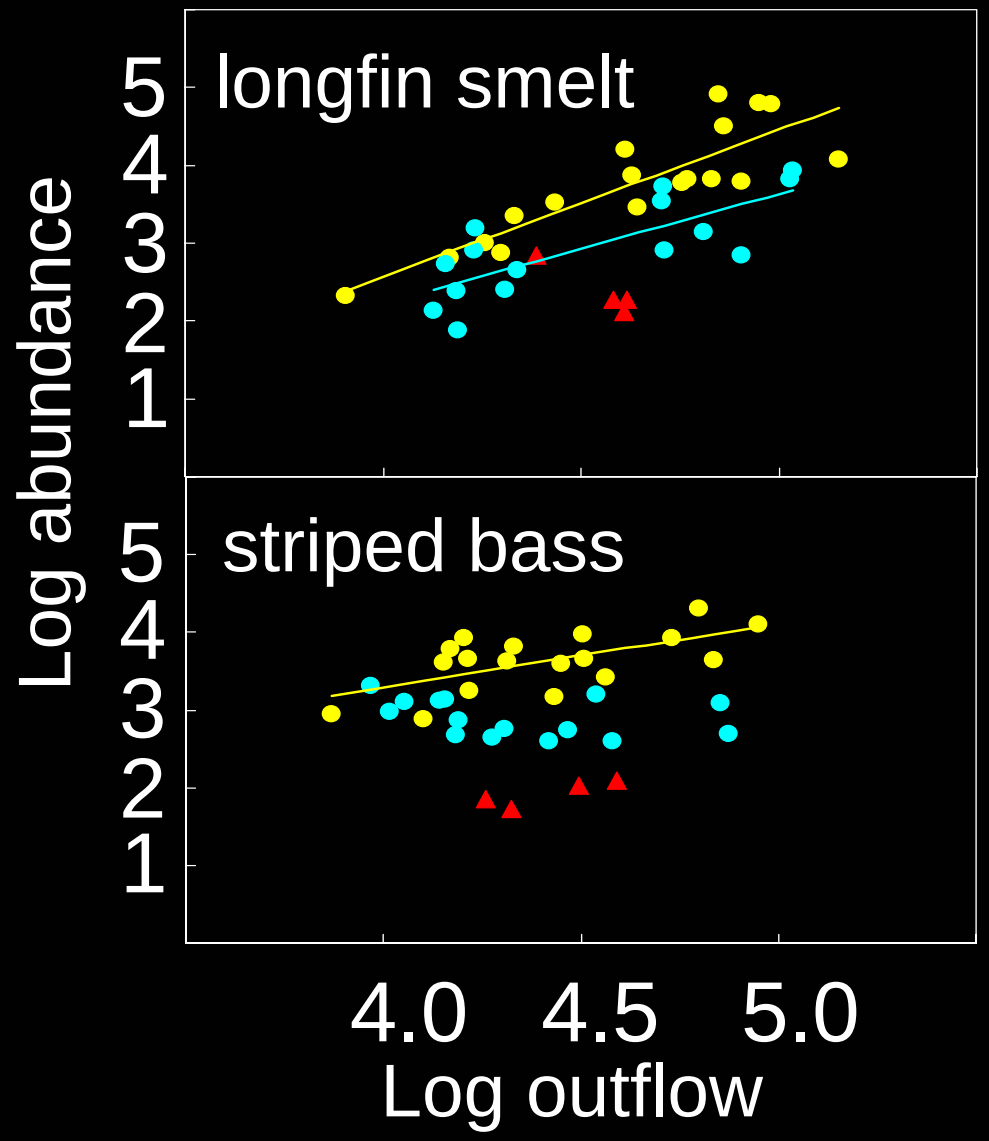

Striped bass
10000
8000
6000
4000
2000
0
1967 1973 1979 1985 1991 1997 2003

After Accounting For Variability, Recent Abundance Levels Are Still Very Low



Source: Kimmerer and Nobriga (2005)

A Shift in Abundance-Outflow Relationships



Pre-clam
Post-clam
POD

Source: Adapted from Kimmerer (2002)

Interagency Ecological Program

- Long-term monitoring program for SF estuary
- Nine member agencies

Pelagic Organism Decline ("POD") Management Team

- **DFG**
  - Chuck Armor, Randy Baxter, Marty Gingras
- **DWR**
  - Matt Nobriga, Anke Mueller-Solger, Ted Sommer
- **CBDA**
  - Steve Culberson
- **USBR**
  - Mike Chotkowski
- **USEPA**
  - Bruce Herbold
- NMFS
  - Jeff McLain

POD Principal Investigators

- Dept Fish and Game
  - Randy Baxter, Marade Bryant, Kelly Souza, Steve Slater, Kathy Hieb, Marty Gingras
- Dept Water Resources
  - Matt Nobriga, Fred Feyrer, Ted Sommer, Bob Suits, Marc Vaysierres, Heather Peterson, Zoltan Matica, Peggy Lehman, Lenny Grimaldo, Mike Mierzwa, Jim Wilde, Karen Gehrts, Tanya Veldhuizen
- US Bureau of Reclamation
  - Mike Chotkowski
- USEPA
  - Bruce Herbold
- US Geological Survey
  - Joseph Simi, Cathy Ruhl, Pete Smith
- UC Davis
  - Bill Bennett, Swee Teh, Inge Werner, Dave Ostrach, Frank Loge
- SF State University
  - Wim Kimmerer, John Durand
- SF Estuary Institute
  - Daniel Oros, Geoff Siemering, Jennifer Hayworth
- Consultant
  - Bryan Manly, BJ Miller

Caveats

- Synthesis is from POD MT, not all PIs.

Caveats

- Synthesis is from POD MT, not all PIs.
- New results = unpolished story.

Caveats

- Synthesis is from POD MT, not all PIs.
- New results = unpolished story.
- The story will change…a lot.

APRIL 2005

Conceptual Model

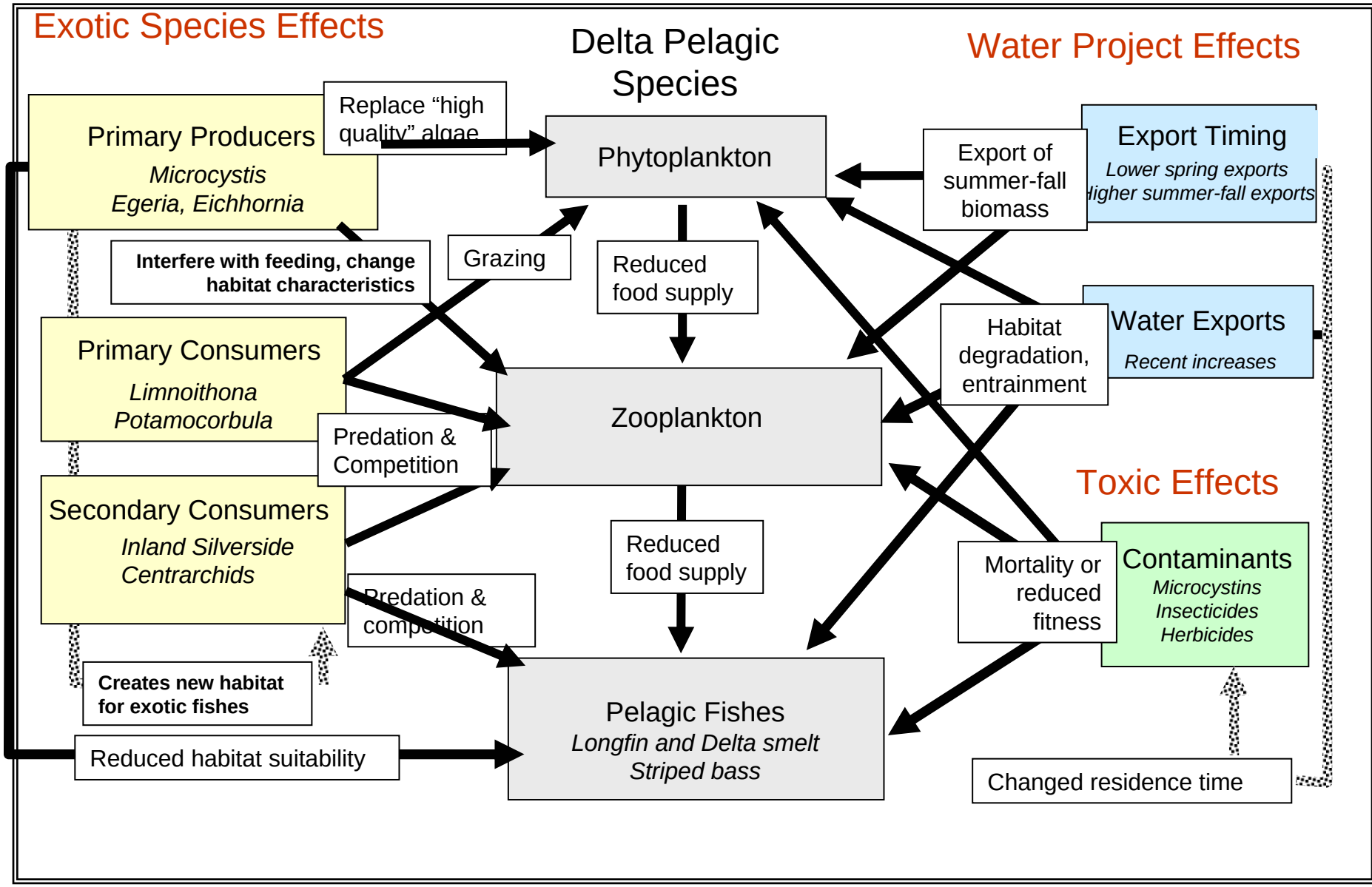
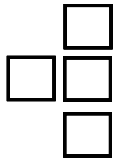
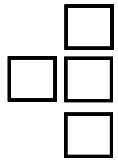
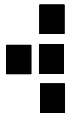
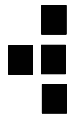
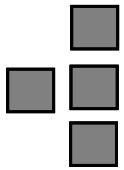
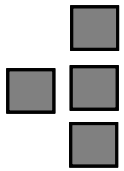
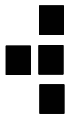
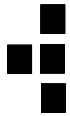
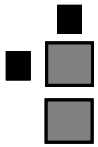
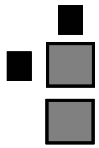
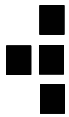
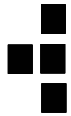
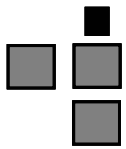
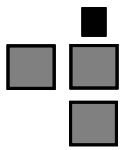
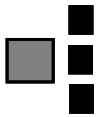
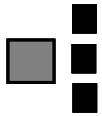


Figure 6. Longfin smelt

November 2005

Stressor	Winter Dec-Feb adults, larvae	Spring Mar-May larvae, juveniles	Summer Jun-Aug juveniles	Fall Sep-Nov juveniles
Mismatch of larvae and food				
Reduced habitat space				
Adverse water movement				
Entrainment (water projects and power plants)				

November 2005

Narrative models

- **Wintertime adult loss**
- Salvage much higher in recent years, especially relative to apparent abundance
- Significant changes in San Joaquin peak flows, export volumes

Bad Suisun Bay

Corbula impacts on food web amplified in drier years

Reduced food, growth, survival of delta smelt, longfin smelt and striped bass

Caveats

- Synthesis is from POD MT, not all PIs.
- New results = unpolished story.
- The story will change…a lot.
- We don't plan on another big public presentation until late February.

Caveats

- Synthesis is from POD MT, not all PIs.
- New results = unpolished story.
- The story will change…a lot.
- We don't plan on another big public. presentation until late February.
- Most results have not been written up.

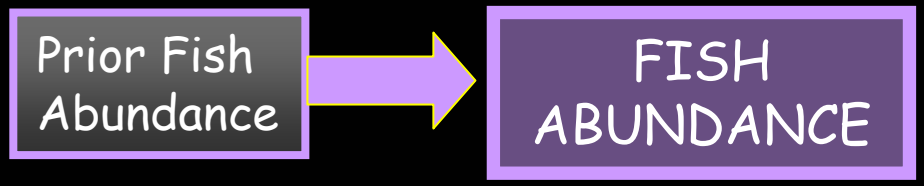
Caveats

- Synthesis is from POD MT, not all PIs.
- New results = unpolished story.
- The story will change…a lot.
- We don't plan on another big public. presentation until late February.
- Most results have not been written up.
- Very few results have been peer-reviewed.

Caveats

- Synthesis is from POD MT, not all PIs.
- New results = unpolished story.
- The story will change…a lot.
- We don't plan on another big public. presentation until late February.
- Most results have not been written up.
- Very few results have been peer-reviewed.
- The management implications of this effort. are therefore unclear.

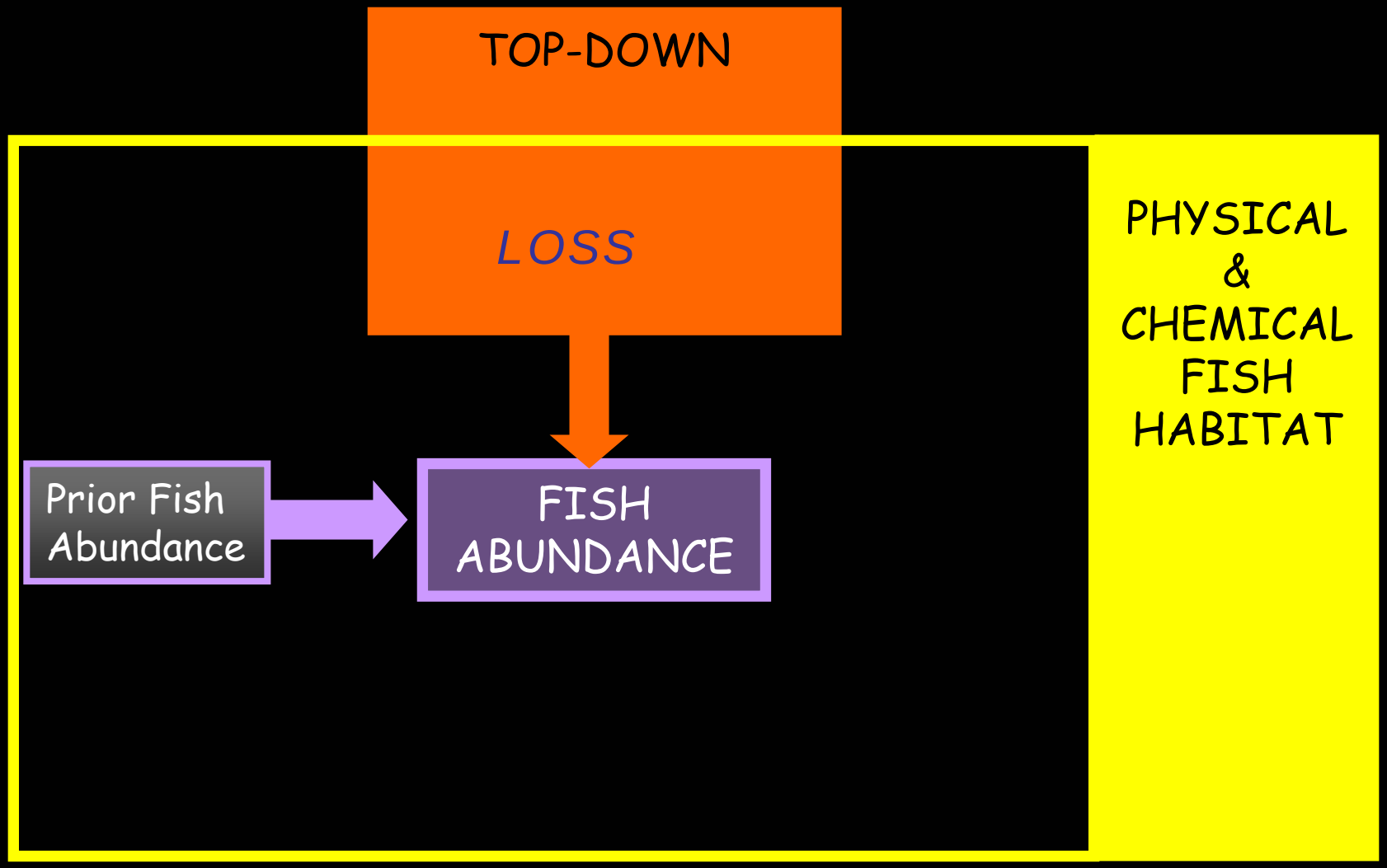
PARENTS

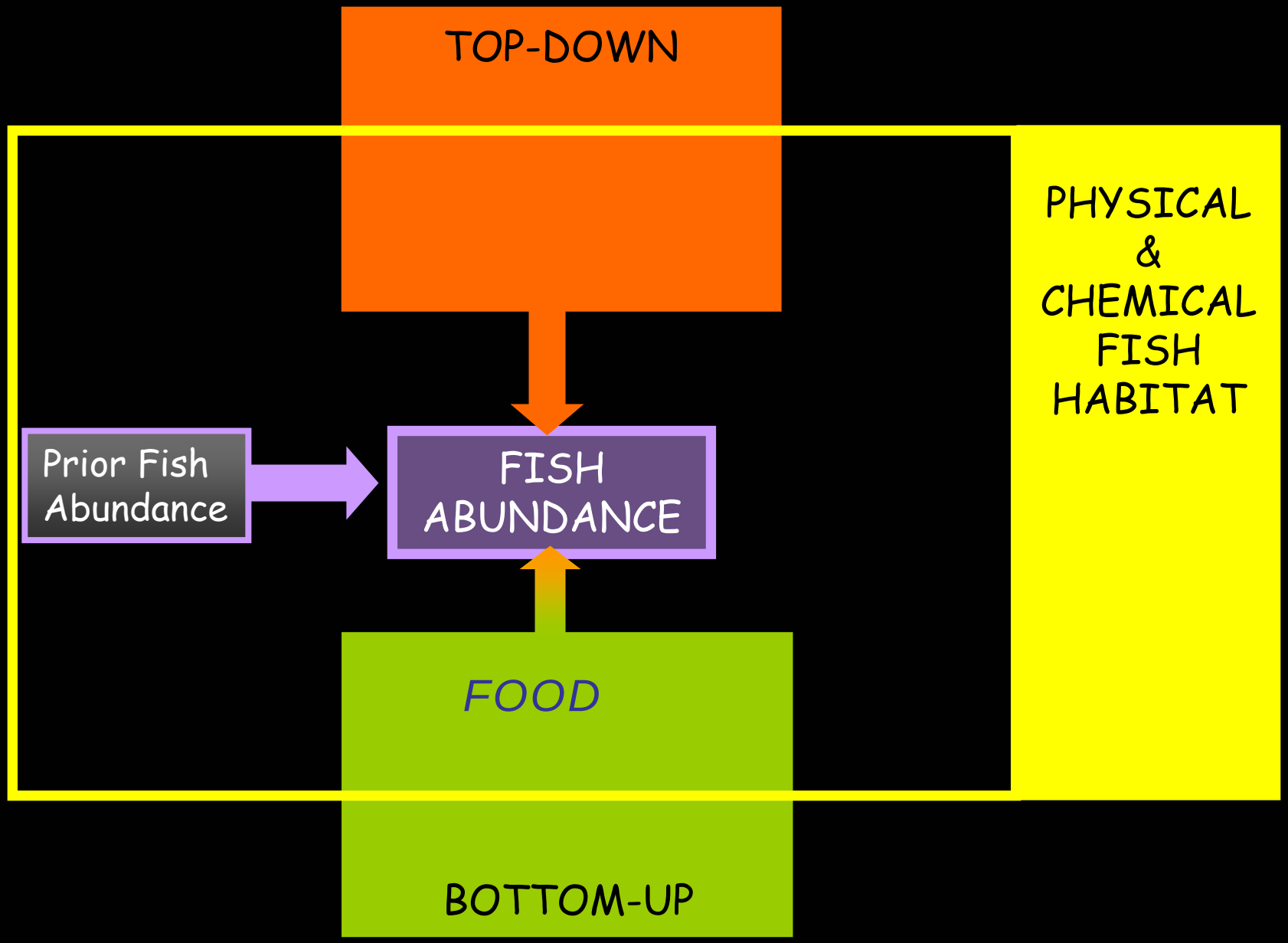


Prior Fish Abundance → FISH ABUNDANCE

PHYSICAL
&
CHEMICAL
FISH
HABITAT

HOME


TOP-DOWN
LOSS
Prior Fish Abundance
FISH ABUNDANCE
PHYSICAL & CHEMICAL FISH HABITAT

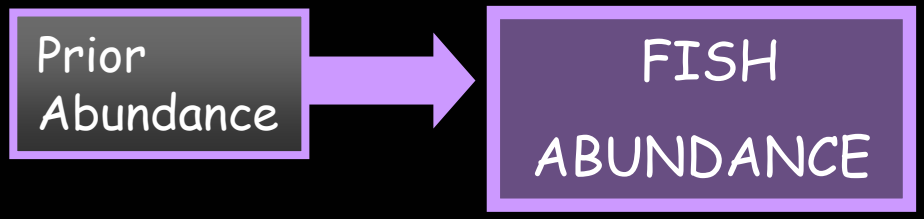

TOP-DOWN
PHYSICAL & CHEMICAL FISH HABITAT
Prior Fish Abundance
FISH ABUNDANCE
FOOD
BOTTOM-UP

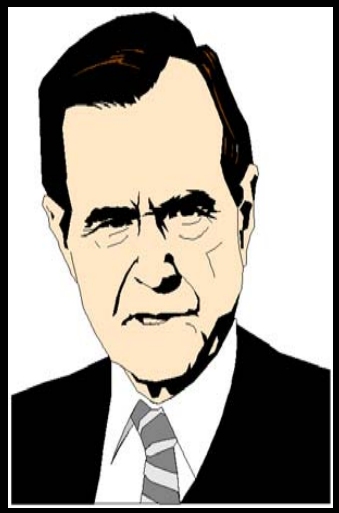
The 'Big Three' Questions

- Did anything change at the same time as the Pelagic Organism Decline?
- How and why did they change?
- What things could affect populations of pelagic organisms?

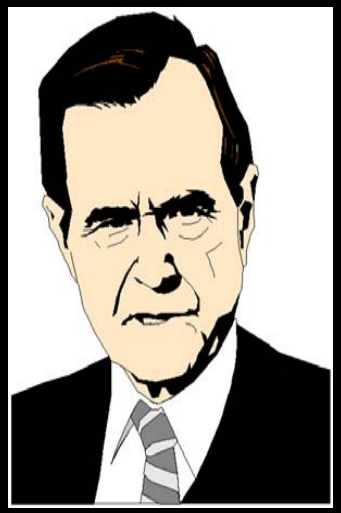
Quick Answers

	Change with POD?	Mechanism?	Population Impact?
Stock	Yes	????	Yes
Habitat	Yes	Yes	Yes
Food	Some	Some	Yes
Mortality	Yes	Yes	Yes


Prior Abundance
FISH ABUNDANCE



Prior Abundance → PRESENT ABUNDANCE



Prior Abundance → PRESENT ABUNDANCE

Stock - Recruitment Effects

- Extreme low levels suggest that stock – recruitment may be more limiting than before.

Stock - Recruitment Effects

- Extreme low levels suggest that stock – recruitment may be more limiting than before.

- For all these species, environmental variables strongly affect recruitment

Stock - Recruitment Effects

- Extreme low levels suggest that stock – recruitment may be more limiting than before.
- For all these species, environmental variables strongly affect recruitment
- Environmental stressors probably more important at smaller population sizes

FISH ABUNDANCE

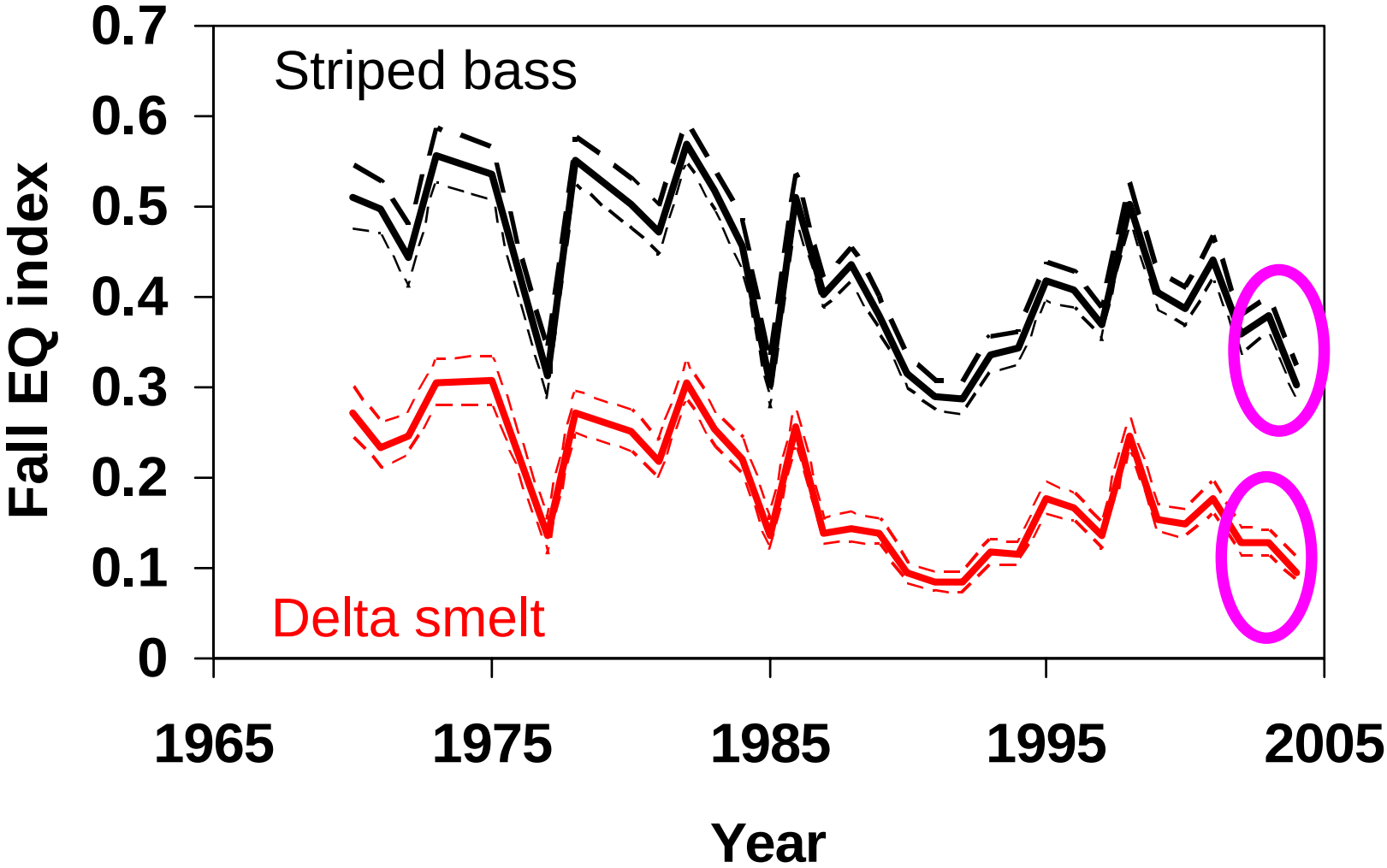
PHYSICAL & CHEMICAL FISH HABITAT

PHYSICAL & CHEMICAL FISH HABITAT

- *Temperature*
- *Turbidity*
- *Salinity*
- *Contaminants*
- *Disease*
- *Toxic algae*

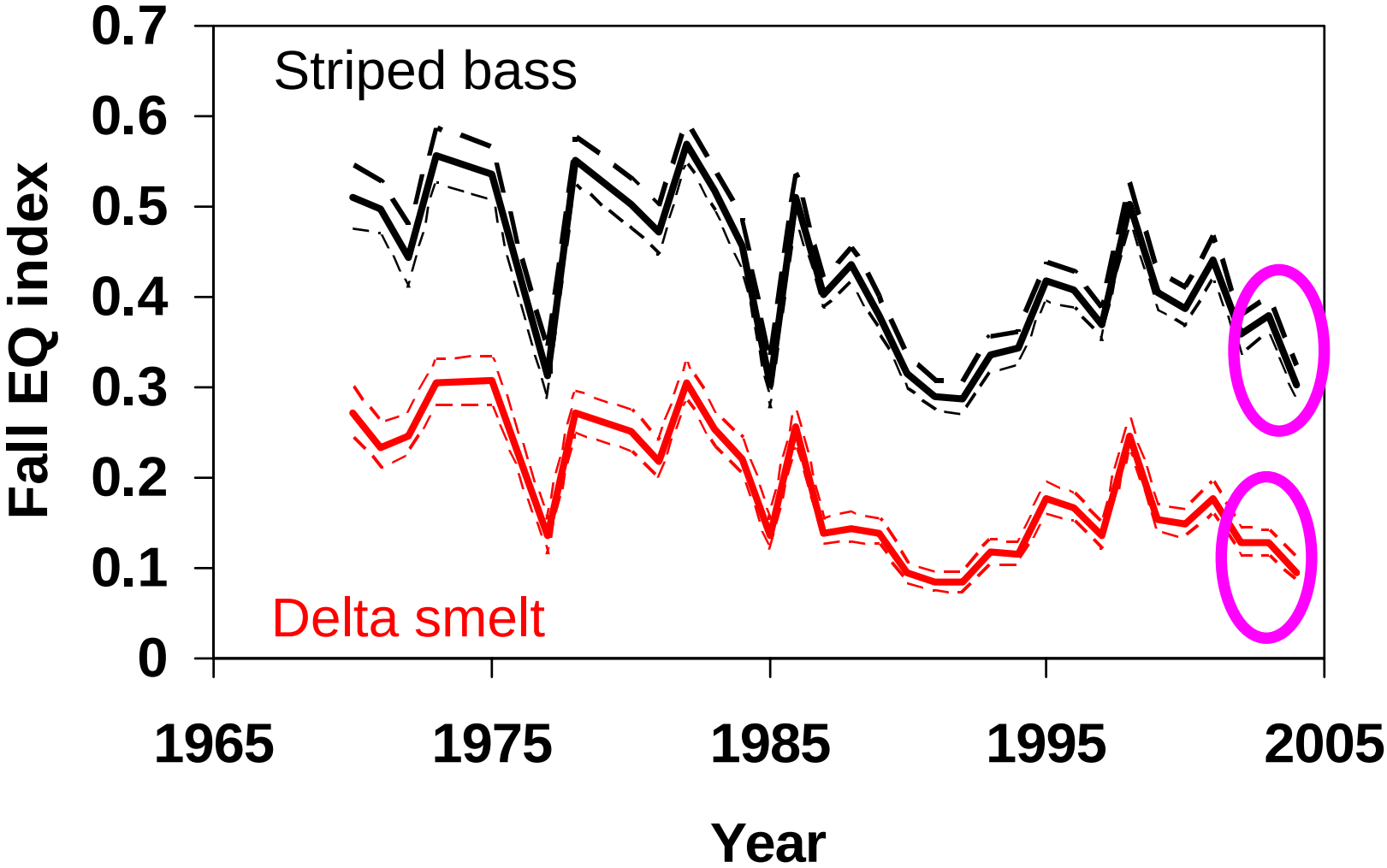
FISH ABUNDANCE

Fall "habitat quality" has deteriorated



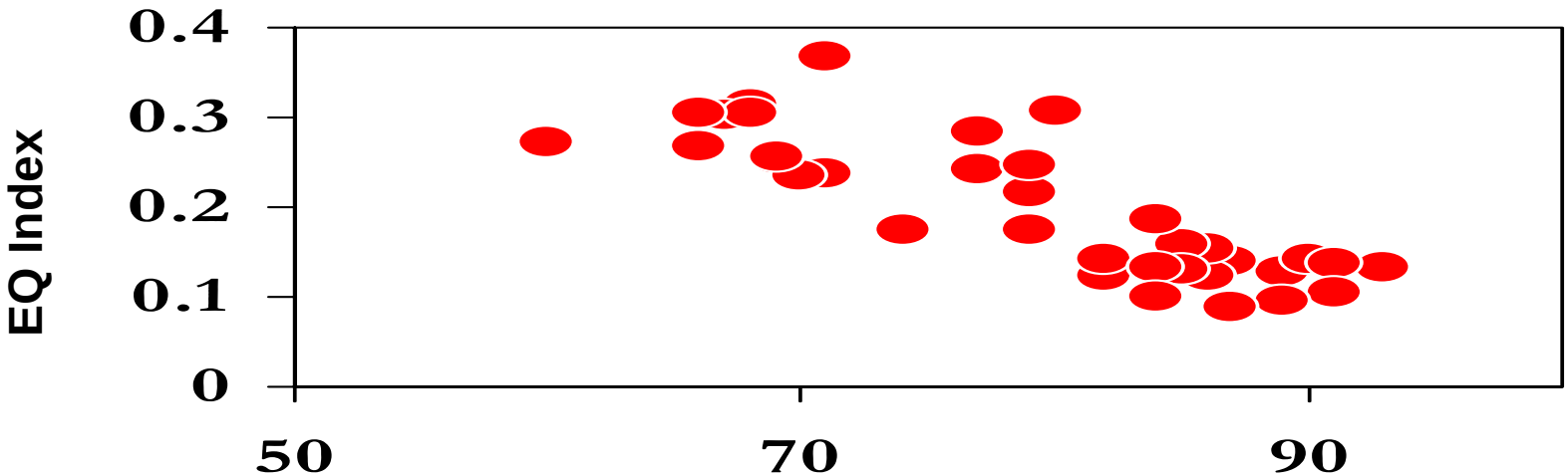
Source: Feyrer et al. (CJFAS, In revision)

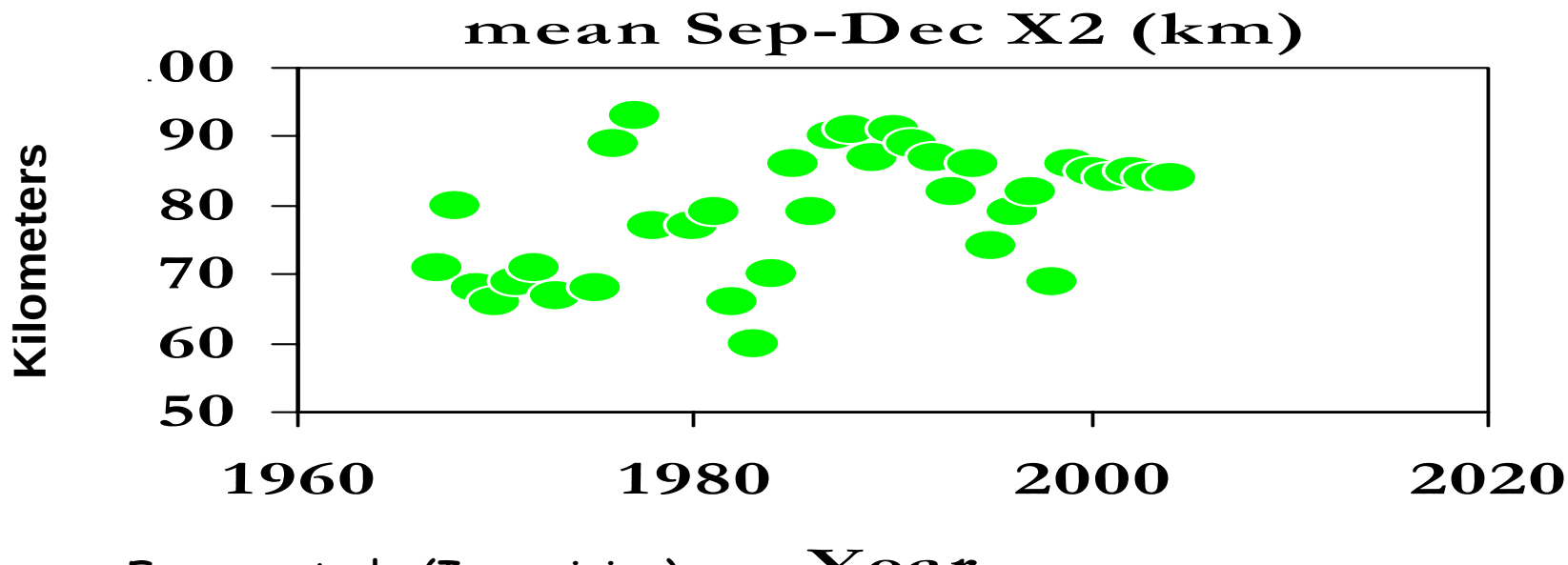
Fall "habitat quality" has deteriorated



Fall EQ Correlated with juvenile production

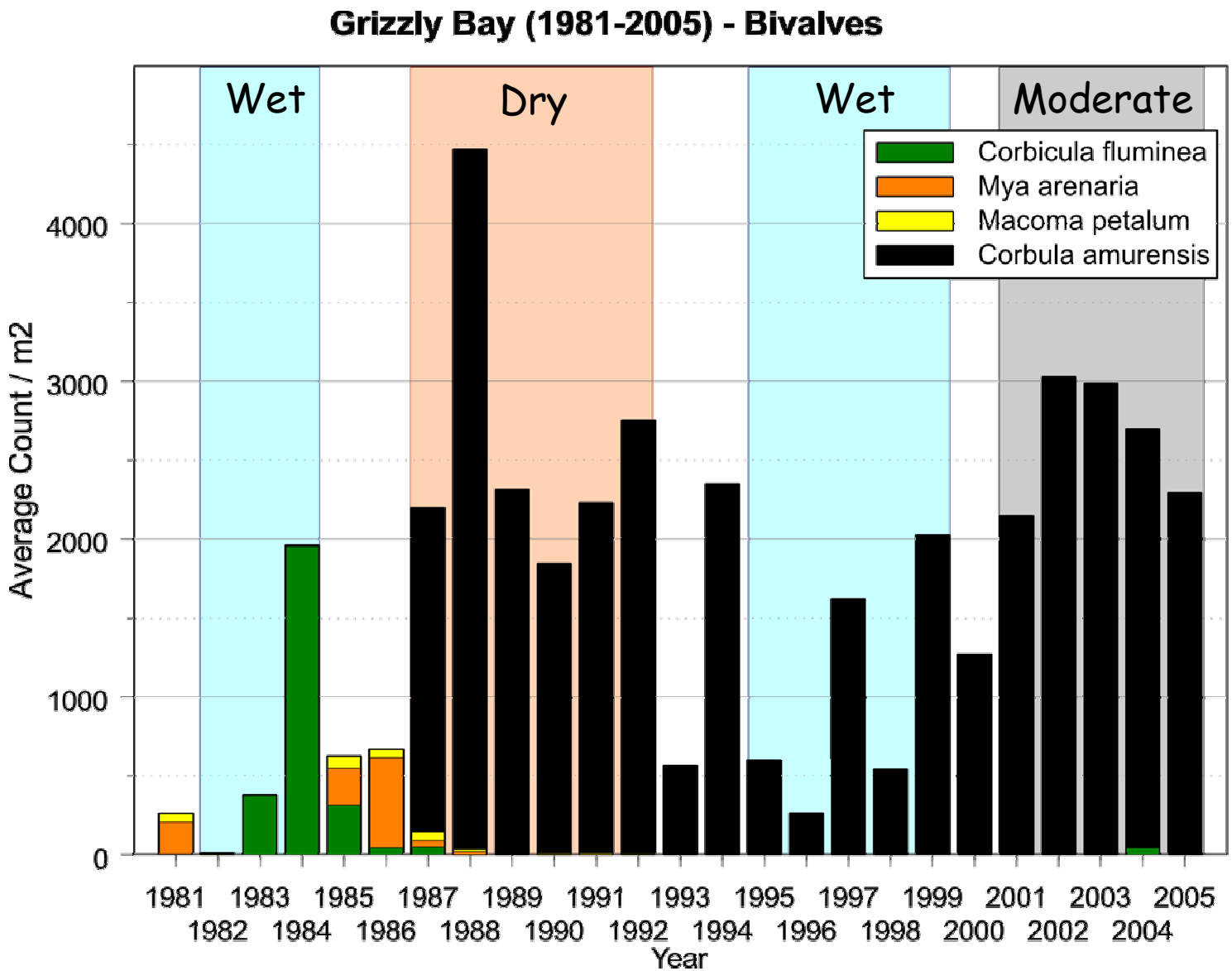
The main reason habitat quality decreased is salinity intrusion





Source: Feyrer et al. (In revision)

Salinity Variation Also Affects Other Species

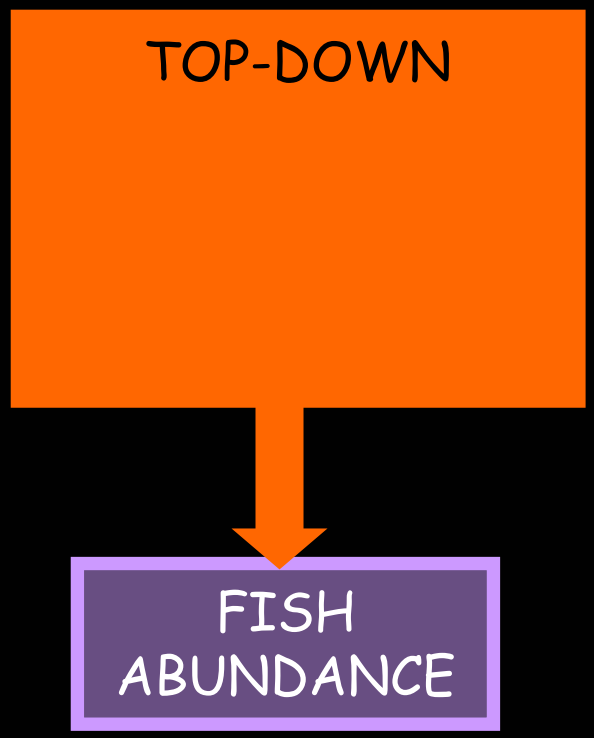


Source: Marc Vaysierres and others (DWR)

Habitat stressors

- Bioassays, which test for both natural toxins (e.g. Microcystis) and antropogenic chemicals, showed little effect (<5 %) in 2005 or 2006, both wetter years.
- <15% adult delta smelt show evidence of contaminant effects, disease, or food stress
- 100 % of young striped bass showing multiple infections

Source: Inge Werner, Swee Teh, and Dave Ostrach (UCD)


TOP-DOWN
FISH ABUNDANCE

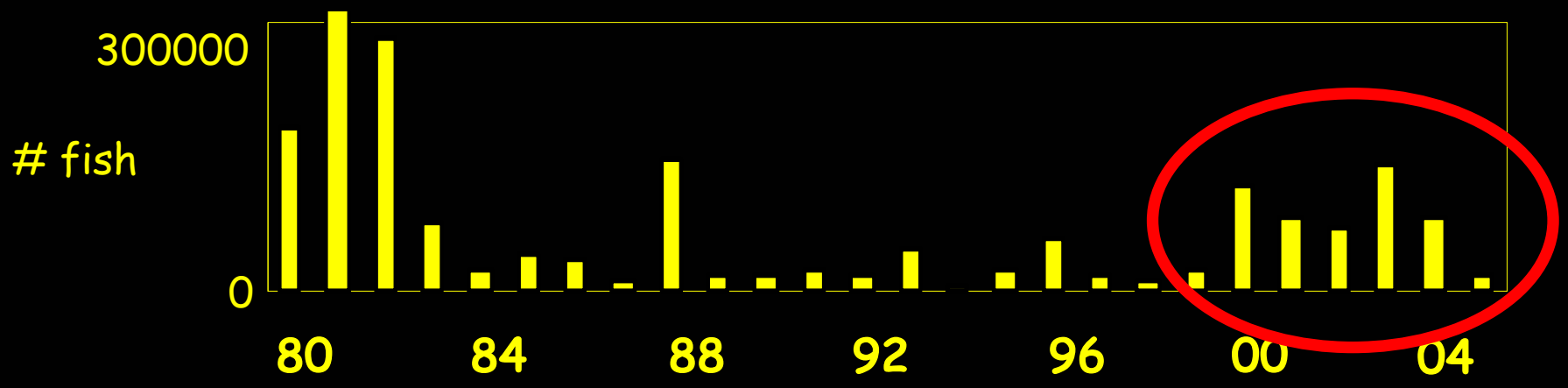
TOP-DOWN

Water Diversions

Predation

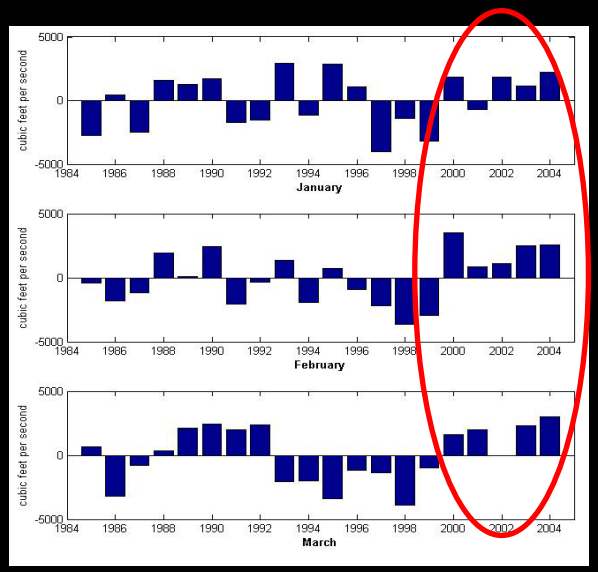
FISH ABUNDANCE

Winter Salvage of Delta Smelt (Nov-Mar)

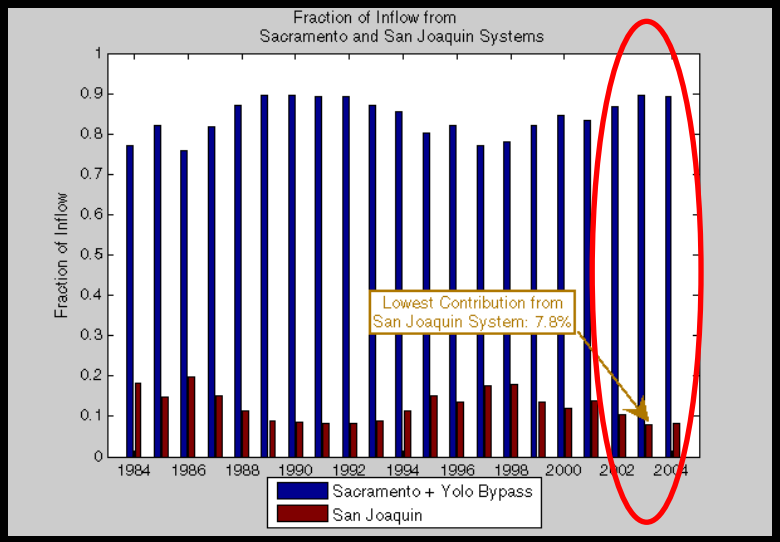


Source: IEP (2005)

Increased winter exports

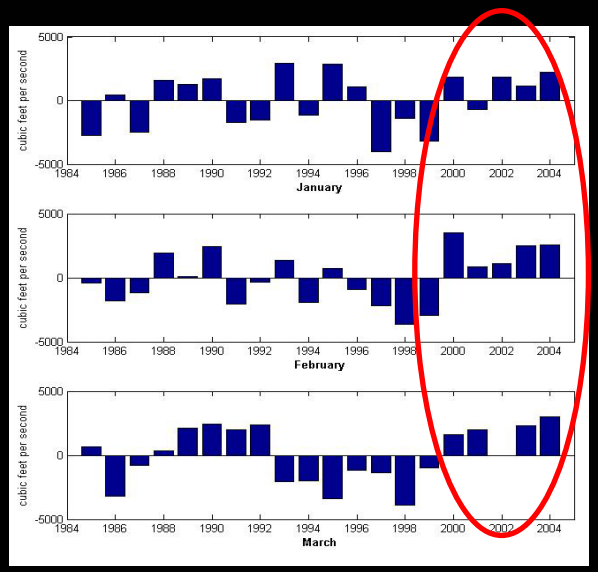


Shifts in tributary flow

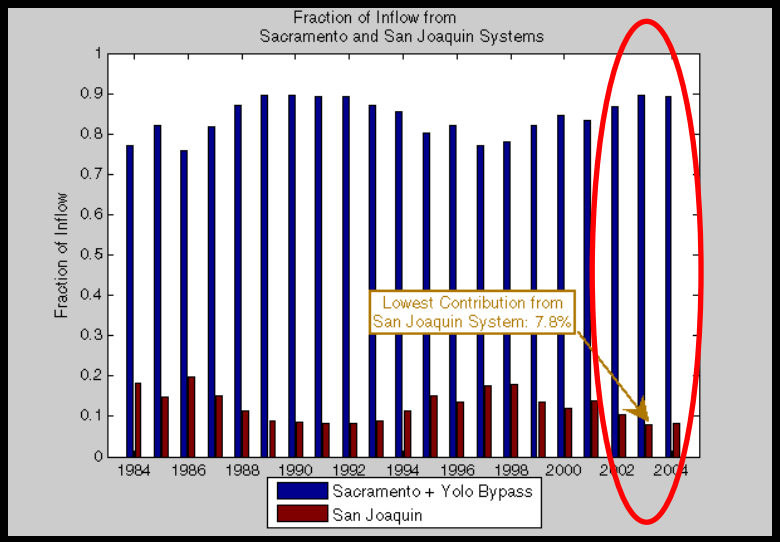


Source: Simi and others (USGS)

Increased winter exports



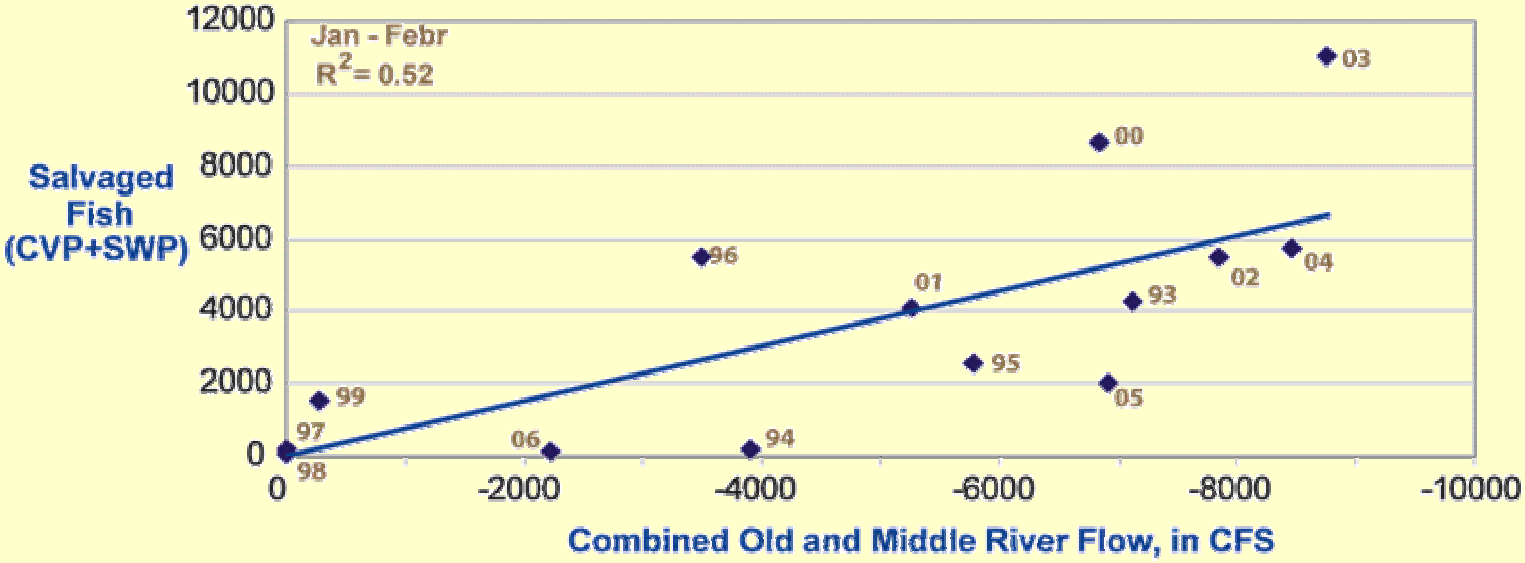
Shifts in tributary flow

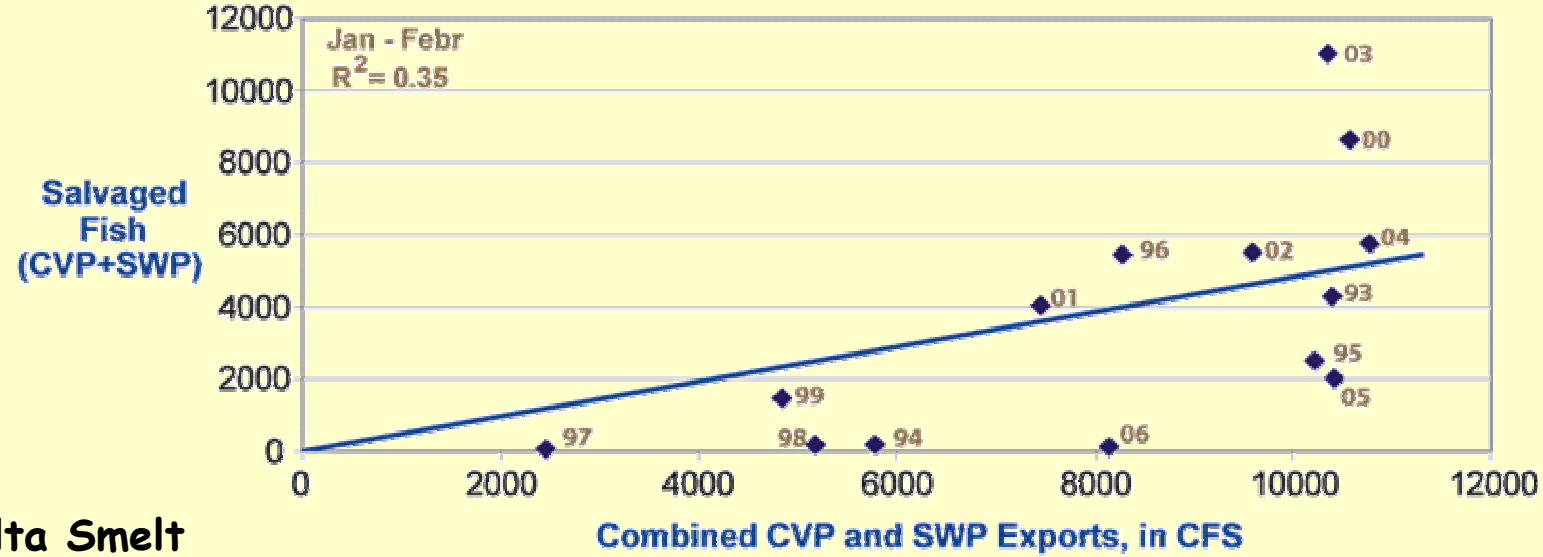


Entrainment

Increase in winter salvage.

Negative Old & Middle River Flows Apparently Increase Entrainment

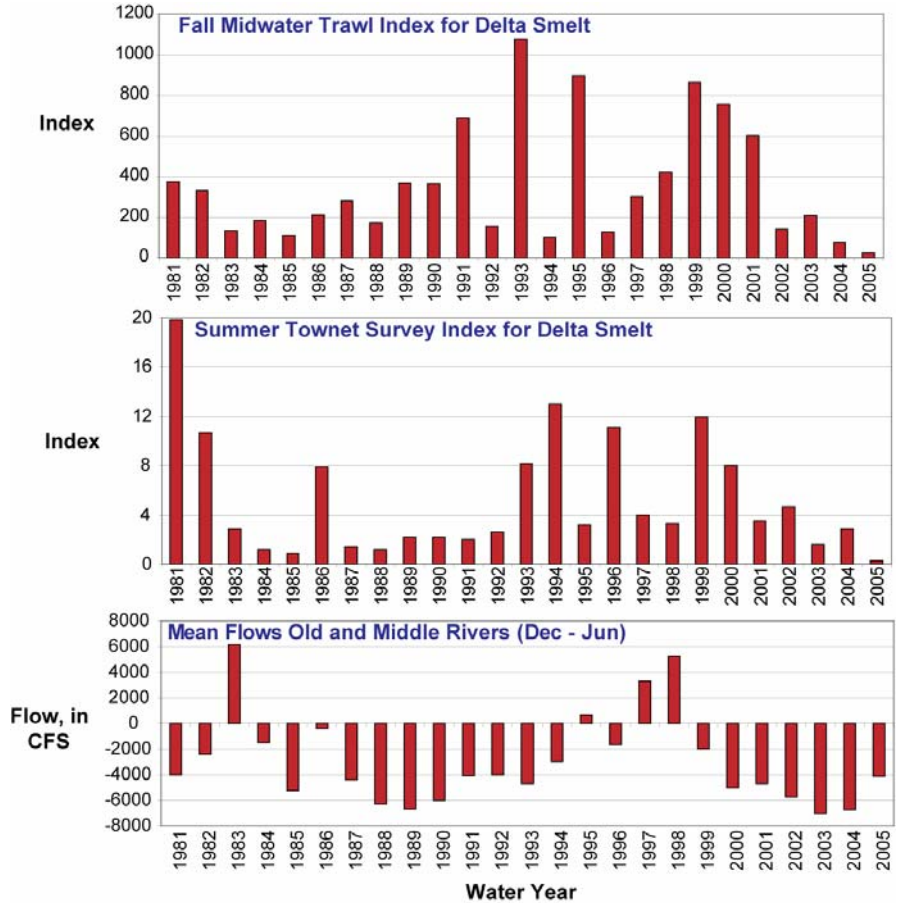




Delta Smelt 1993-2006

Source: Pete Smith (USGS)

Drop in Smelt Indices Coincided with Low Old & Middle River Flows



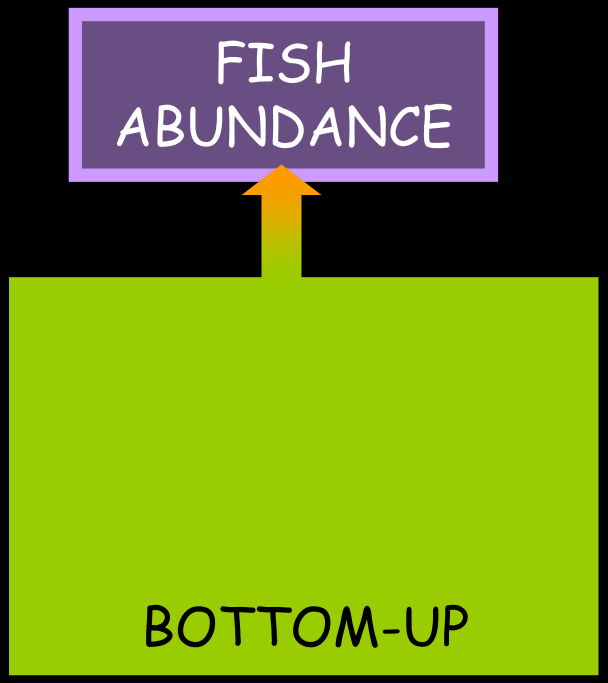
But: Log-Linear Modeling Indicates Operations Explain Little Variability in Abundance

Source: Bryan Manly and Mike Chotkowski (USBR)

Bennett Hypothesis:
Not All Smelt Are Created Equal

Larger/older females:

- Have higher fecundity.
- Spawn early and repeatedly.
- Produce larger offspring that have higher fitness.
- Are more subject to water project effects.


FISH
ABUNDANCE
BOTTOM-UP

FISH ABUNDANCE

Food availability

Food quality

BOTTOM-UP

Trends in the Pelagic Food Web

Phytoplankton

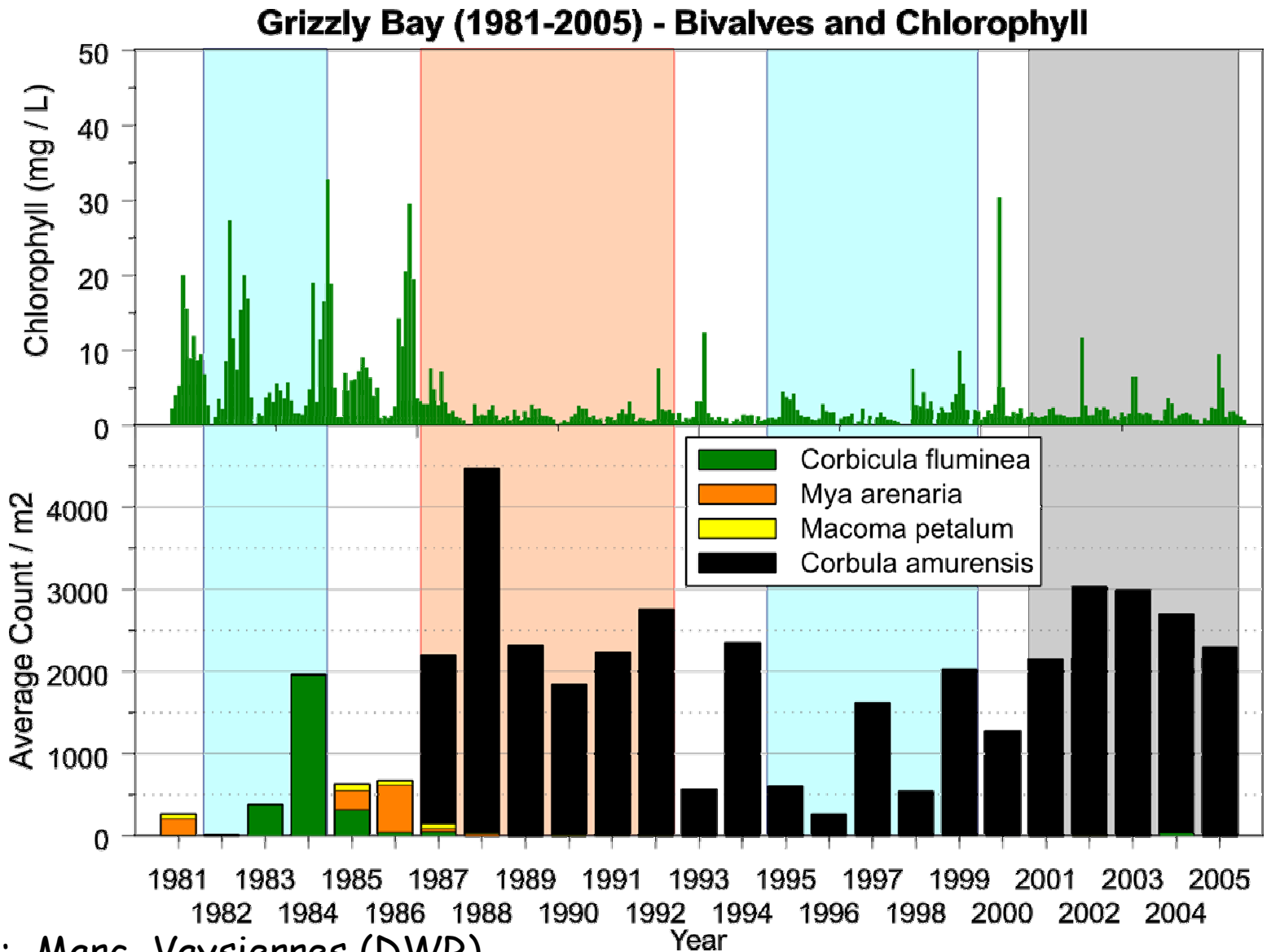
- Chlorophyll levels very low compared to other estuaries.
- Long term declines.
- But: No evidence of a recent decline in the Delta.

Zooplankton (fish food species)

- Plankton levels low compared to other estuaries.
- Long term declines.
- An apparent recent decline in key nursery region (Suisun Bay and the west Delta)

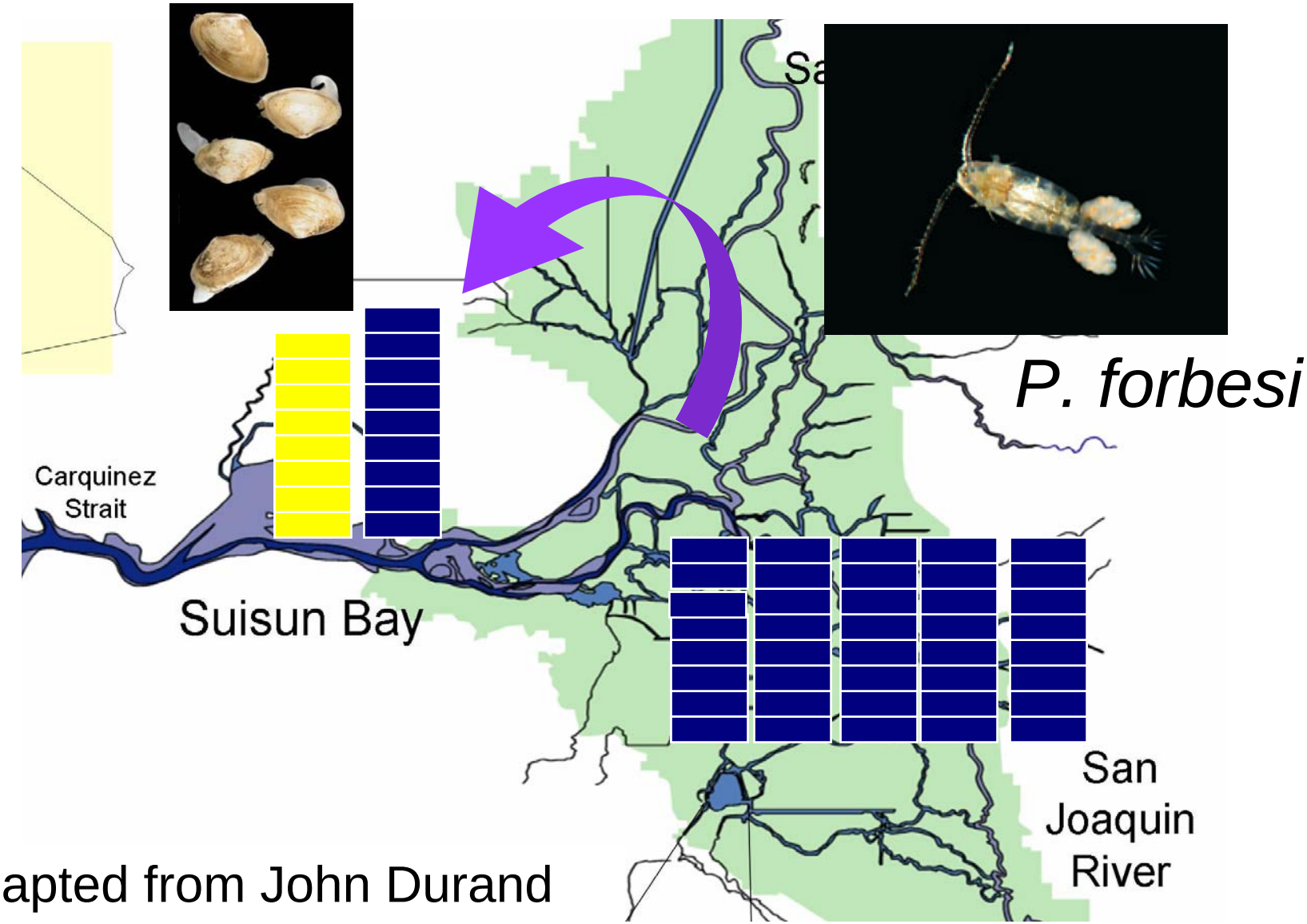
Sources: Alan Jassby, Anke Mueller-Solger, Wim Kimmerer

The Long-Term Decline in Chlorophyll is Associated with Bivalve Trends



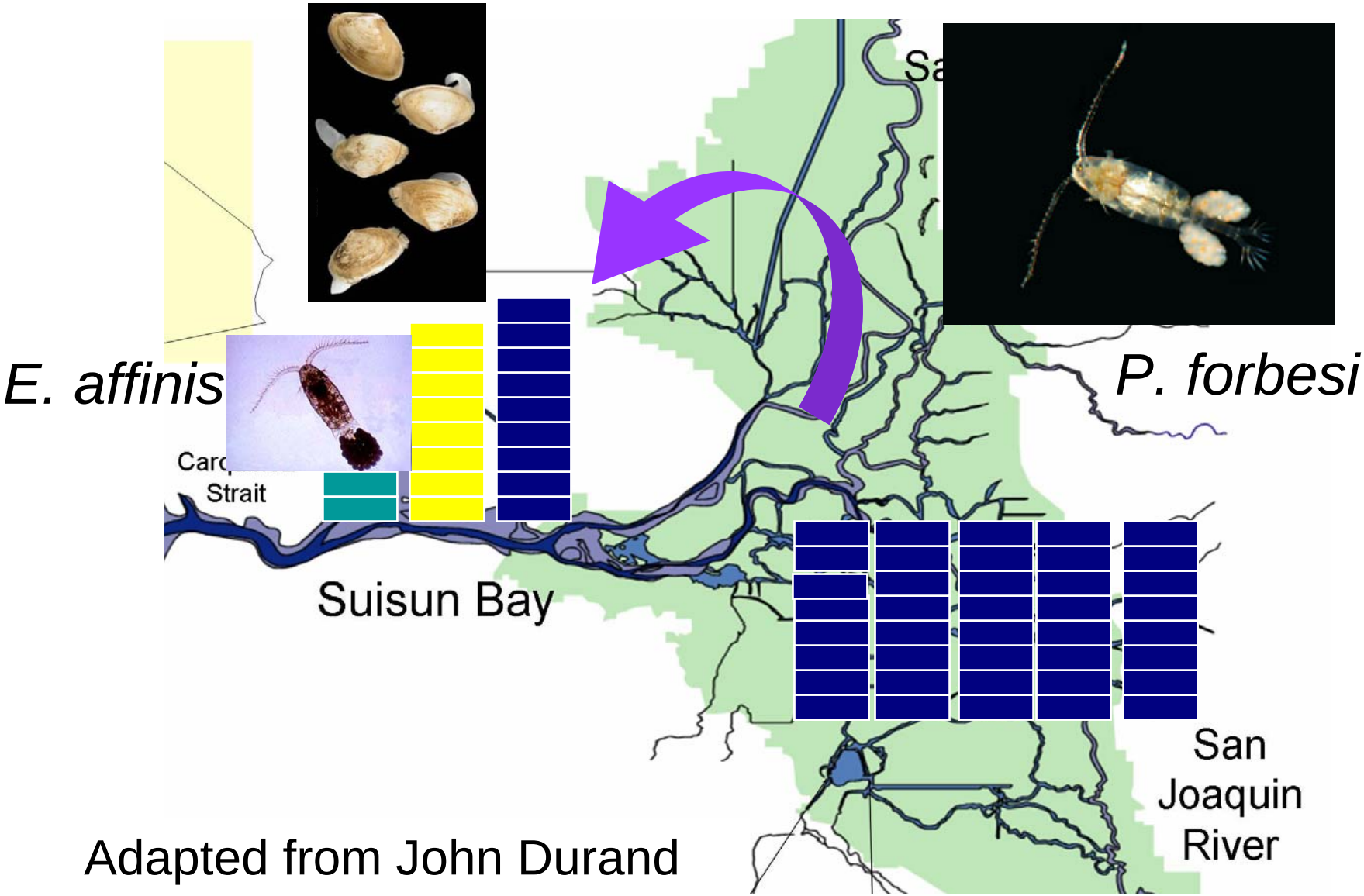
Source: Marc Vaysierres (DWR)

Calanoid Copepod Abundance is Affected by Upstream Subsidies and Clam Grazing



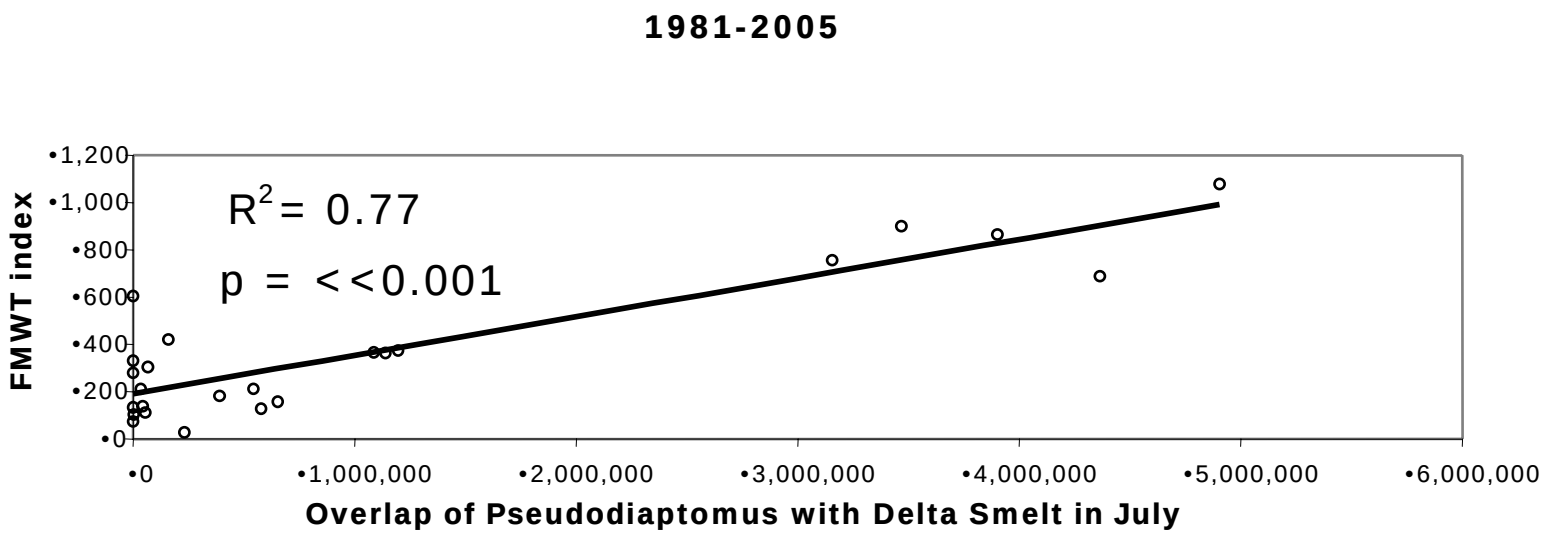
Adapted from John Durand (SFSU)

Calanoid Copepod Abundance is Affected by Upstream Subsidies and Clam Grazing



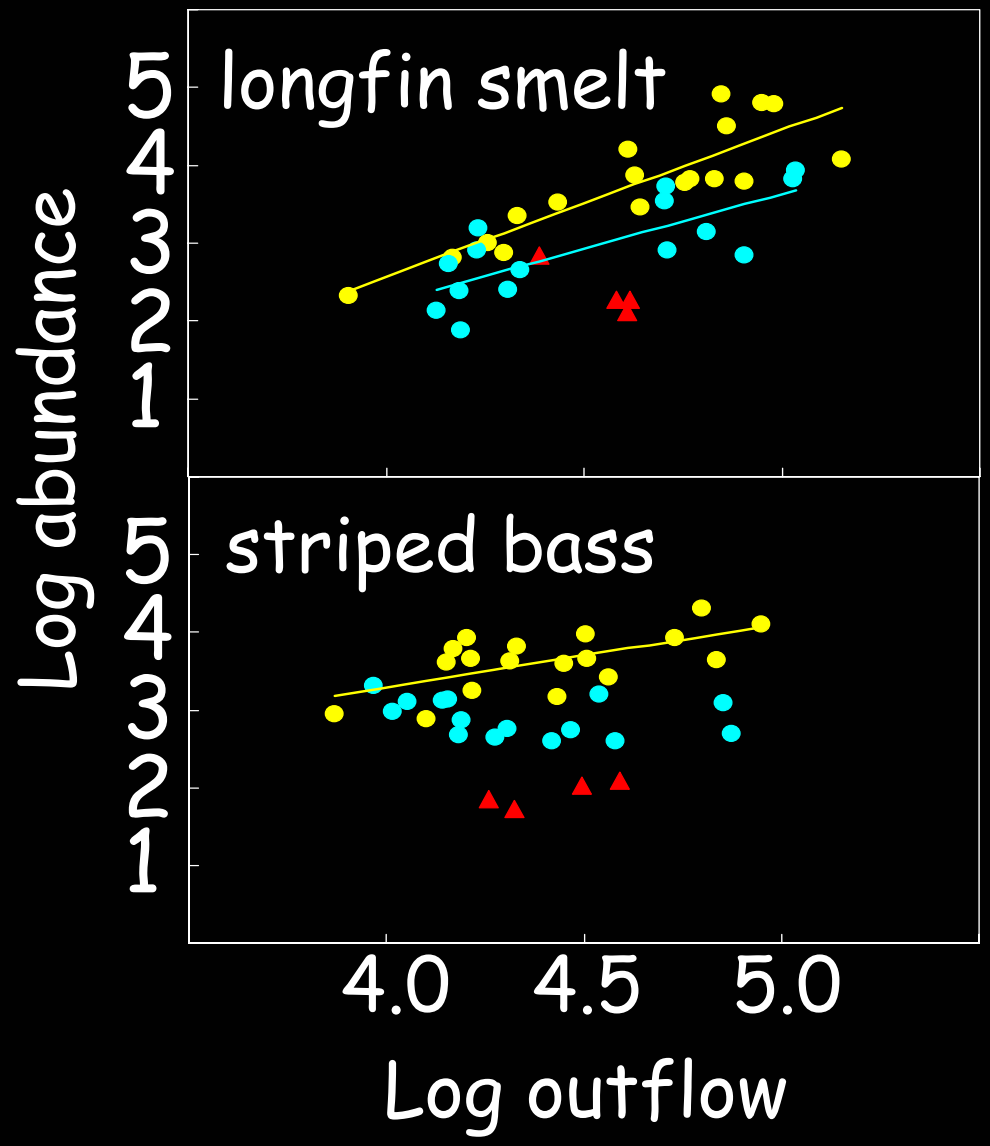
Adapted from John Durand (SFSU)

Prey Occurrence Helps Predict Adult Recruitment



Source: BJ Miller

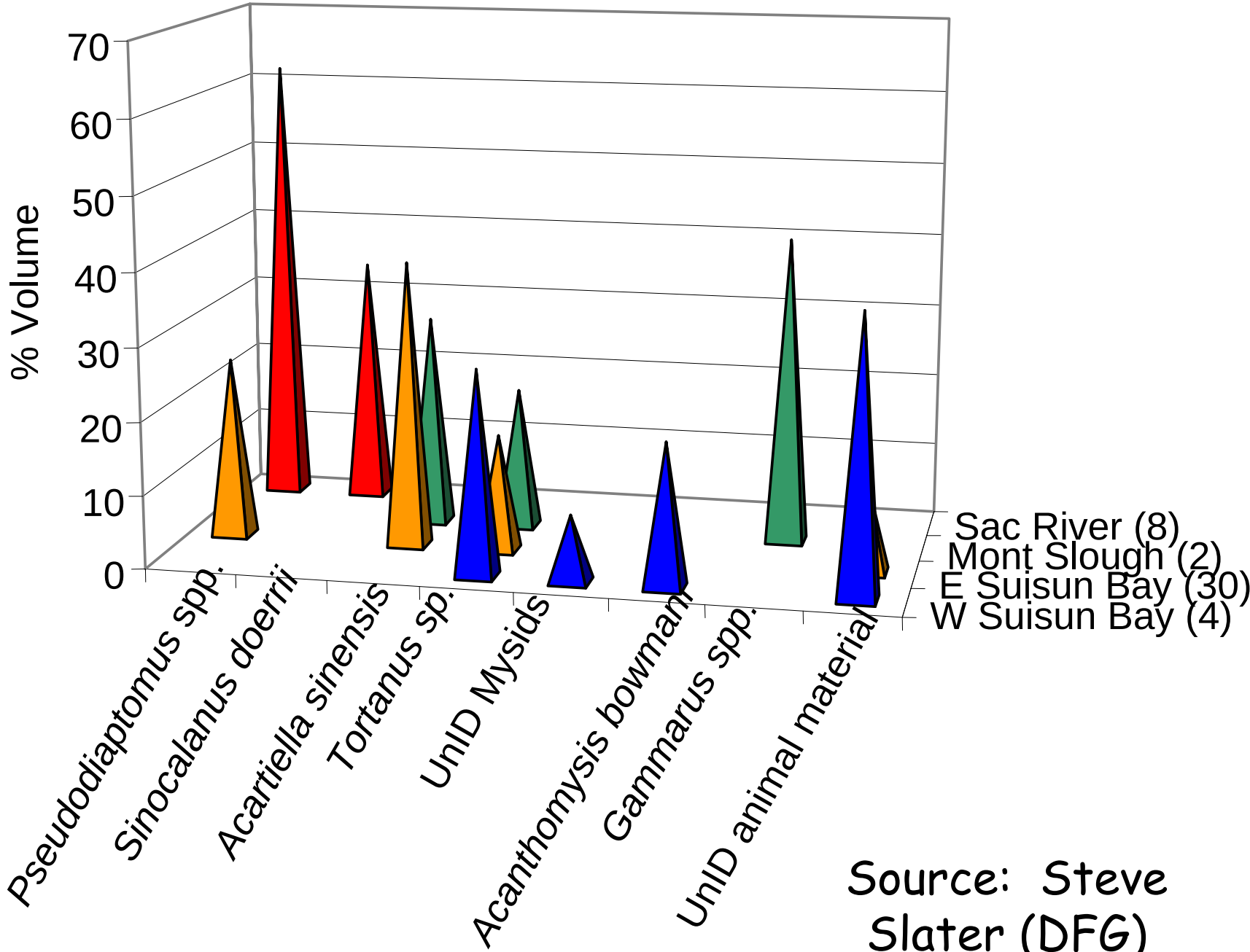
A Shift in Abundance-Outflow Relationships



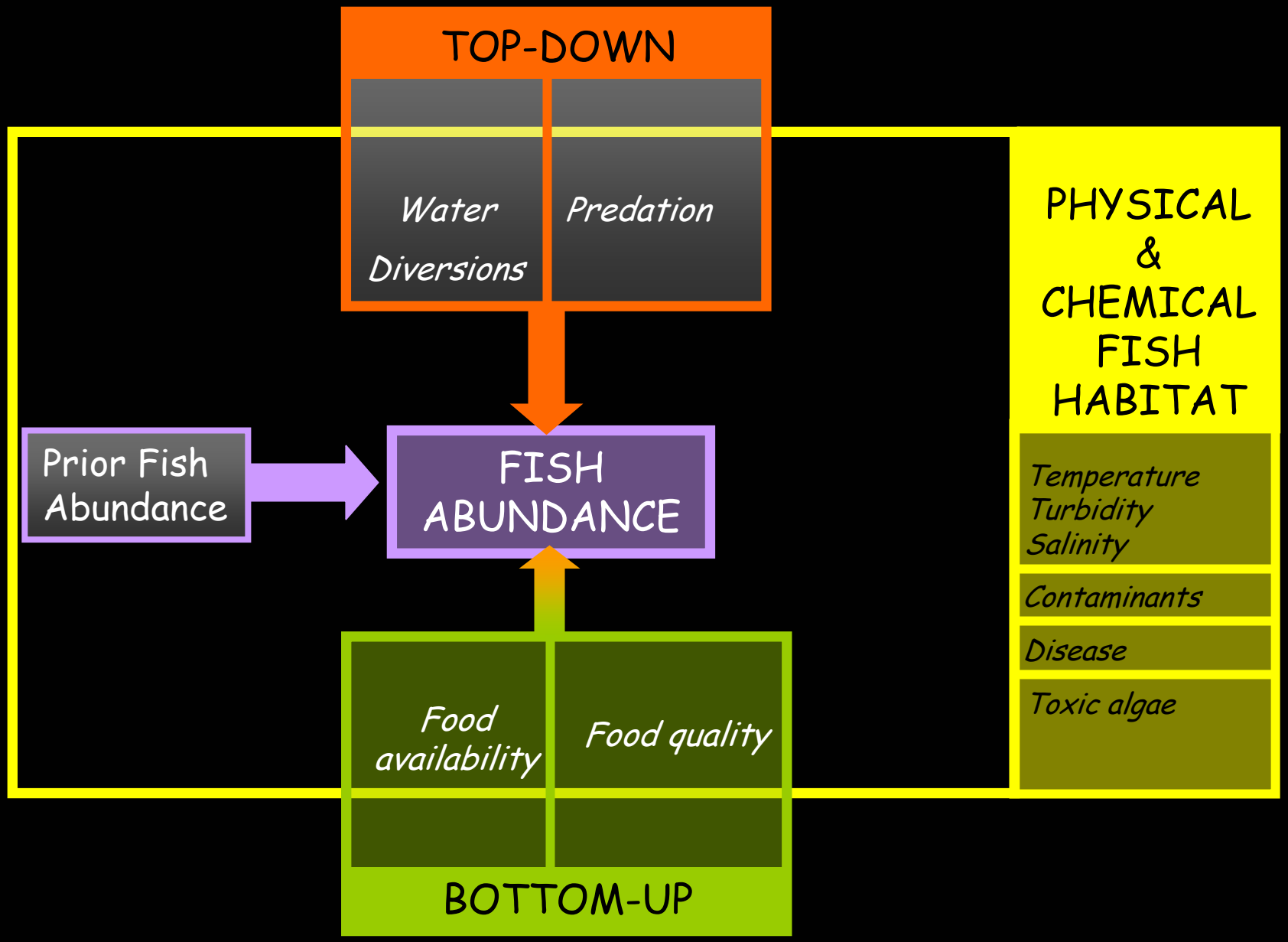
Pre-clam
Post-clam
POD

Source: Adapted from Kimmerer (2002)

An Increase in the Diversity of Delta Smelt Diets?



Source: Steve Slater (DFG)


TOP-DOWN
Water Diversions
Predation
Prior Fish Abundance
FISH ABUNDANCE
PHYSICAL & CHEMICAL FISH HABITAT
Temperature
Turbidity
Salinity
Contaminants
Disease
Toxic algae
Food availability
Food quality
BOTTOM-UP

Synthesis

-Delta smelt life cycle and individual-based models

Bill Bennett UCD; Wim Kimmerer SFSU; Kenny Rose, LSU

-Striped bass life cycle, individual-based, and dose-response models

Frank Loge UCD; Kenny Rose, LSU

-Statistical analysis of environmental effects on pelagic fish abundance

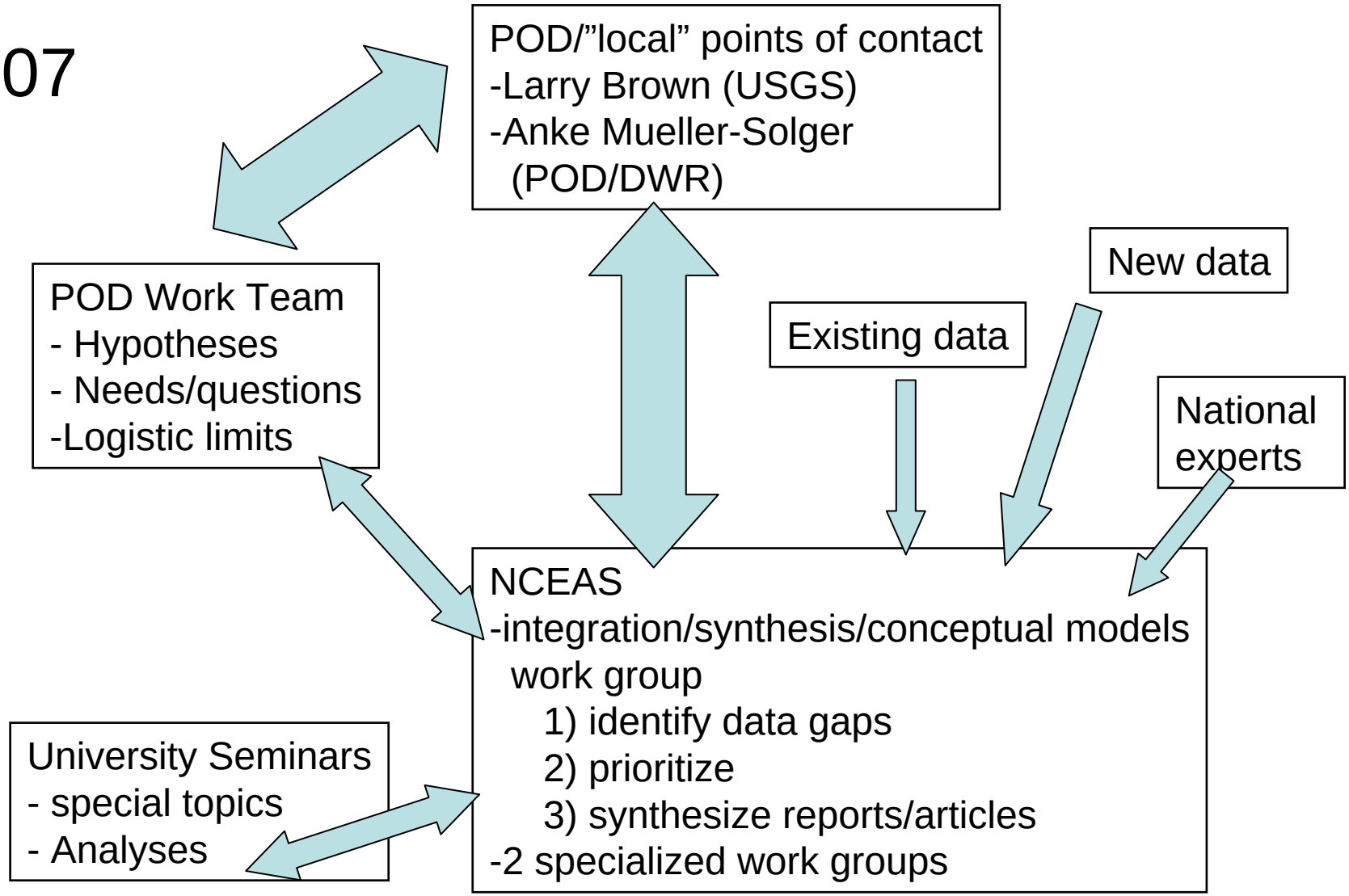
Bryan Manly, Consultant: Mike Chotkowski, USBR

-Synthesis and evaluation

National Center for Environmental Analysis and Synthesis (NCEAS), UCSB

NATIONAL CENTER for ECOLOGICAL ANALYSIS and SYNTHESIS UCSB

2007



2006-2007 POD Summary

- 2006 Budget $3.7 + million
- 45 study components
- Milestones

  -Agency Director Briefings (Continuous)

  -Information to other groups (Continuous)

  -IEP Annual Meeting (February 2007)

  -American Fisheries Society National Meeting (September 2007)

  -POD Synthesis Report (Late 2007)