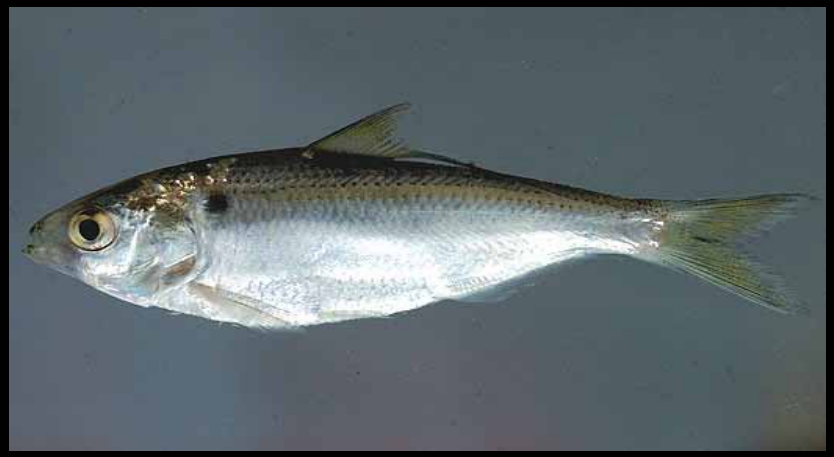
The Collapse of Pelagic Fishes in the Upper San Francisco Estuary

Bruce Herbold

US Environmental Protection Agency

Delta smelt

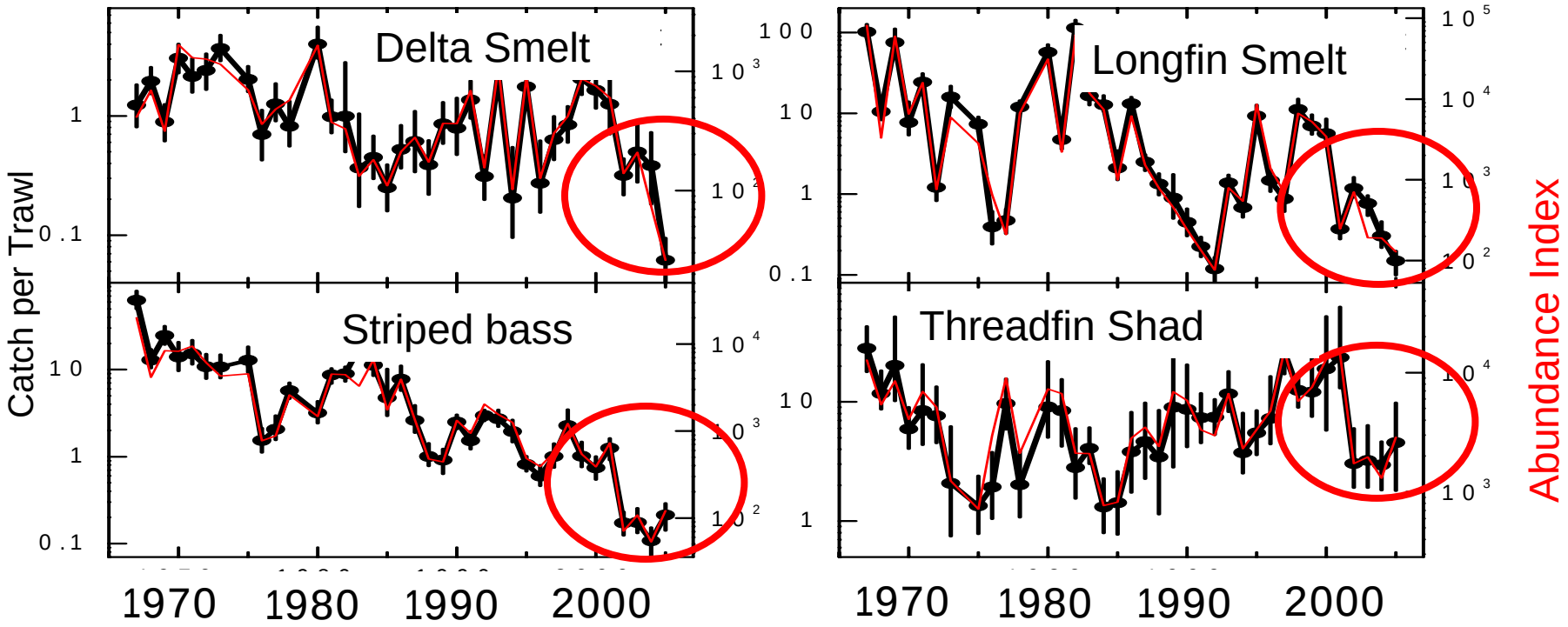
Longfin smelt



Threadfin shad

Striped bass

The Pelagic Organism Decline (POD)



Source: Sommer et al. (2007)

POD Management Team

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POD Principal Investigators

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- Regional Board
  - Karen Larsen
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- US EPA
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- Consultants
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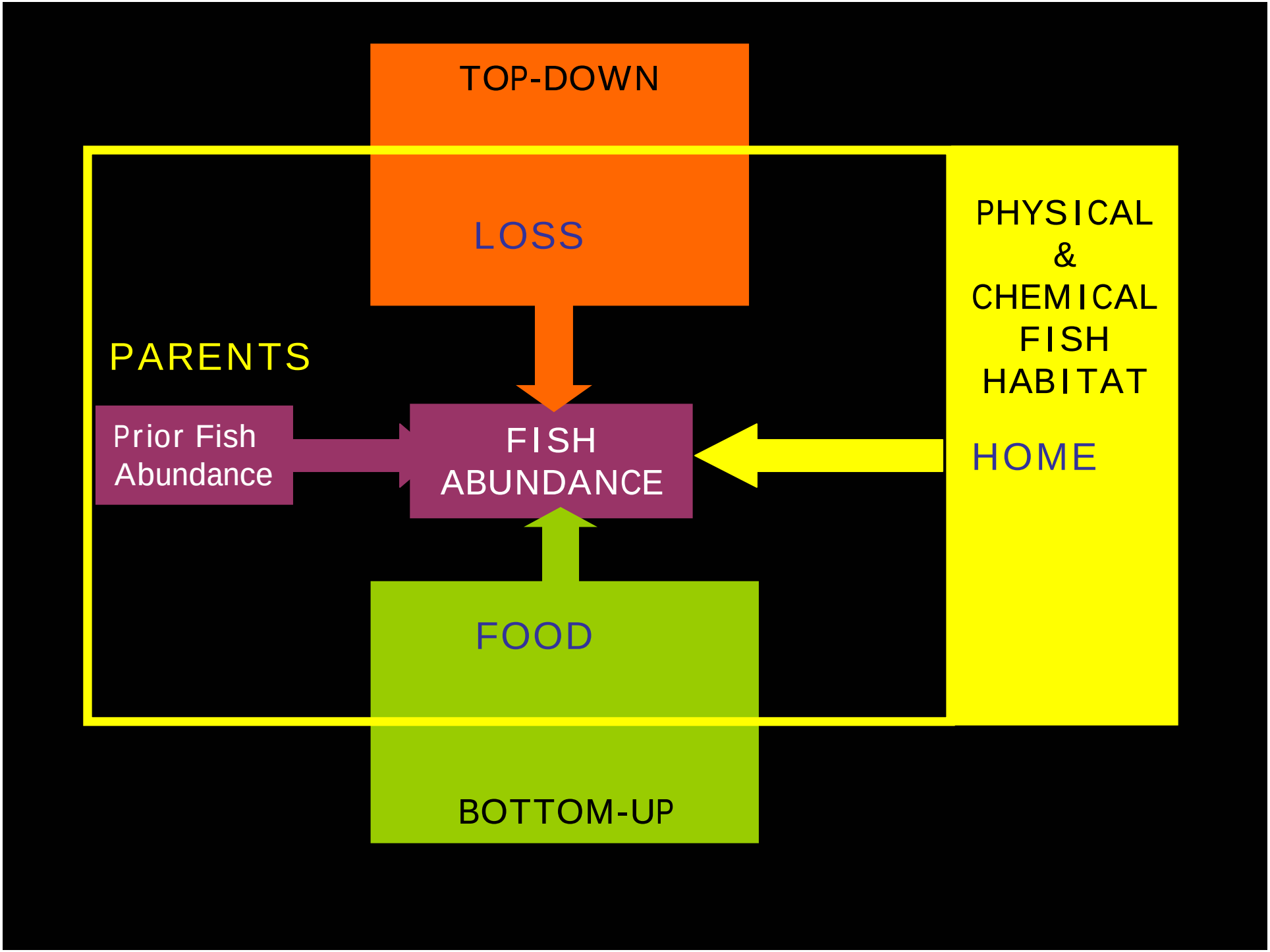
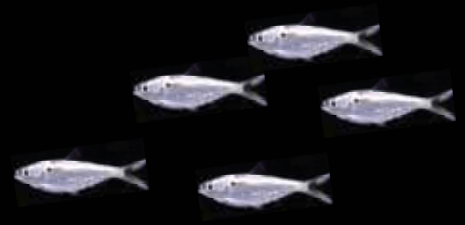
- US Fish and Wildlife Service
  - Gonzalo Castillo, Ken Newman, Scott Foott
- US Geological Survey
  - Joseph Simi, Cathy Ruhl, Pete Smith, Dave Schoellhamer, Heather Peterson
- UC Davis
  - Bill Bennett, Swee Teh, Inge Werner, David Ostrach, Frank Loge, Jim Hobbs
- SF State University
  - Wim Kimmerer, John Durand, Karen Edwards, Lindsay Sullivan
- SF Estuary Institute
  - Daniel Oros, Geoff Siemering, Jennifer Hayworth

2007 POD Progress Report

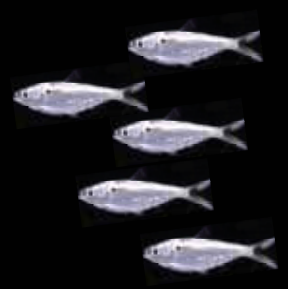
- Printed version available shortly.
- Primarily results through August 2007.
- “Weight of evidence” approach.
- Synthesis is from POD MT.
- Most results not yet published.
- Management implications are still being evaluated.


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

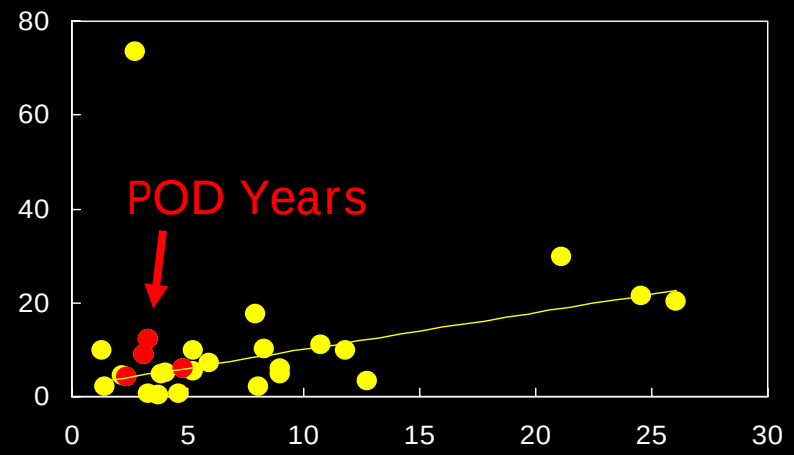


Prior Abundance → PRESENT ABUNDANCE

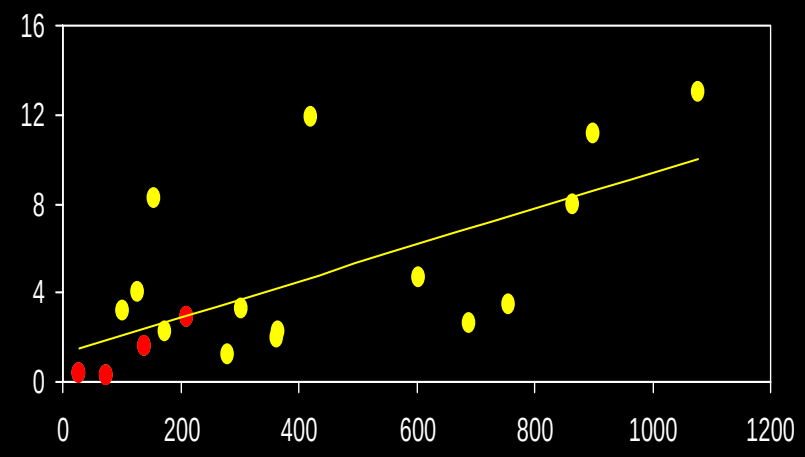
Stock - Recruitment Effects



Juvenile Production



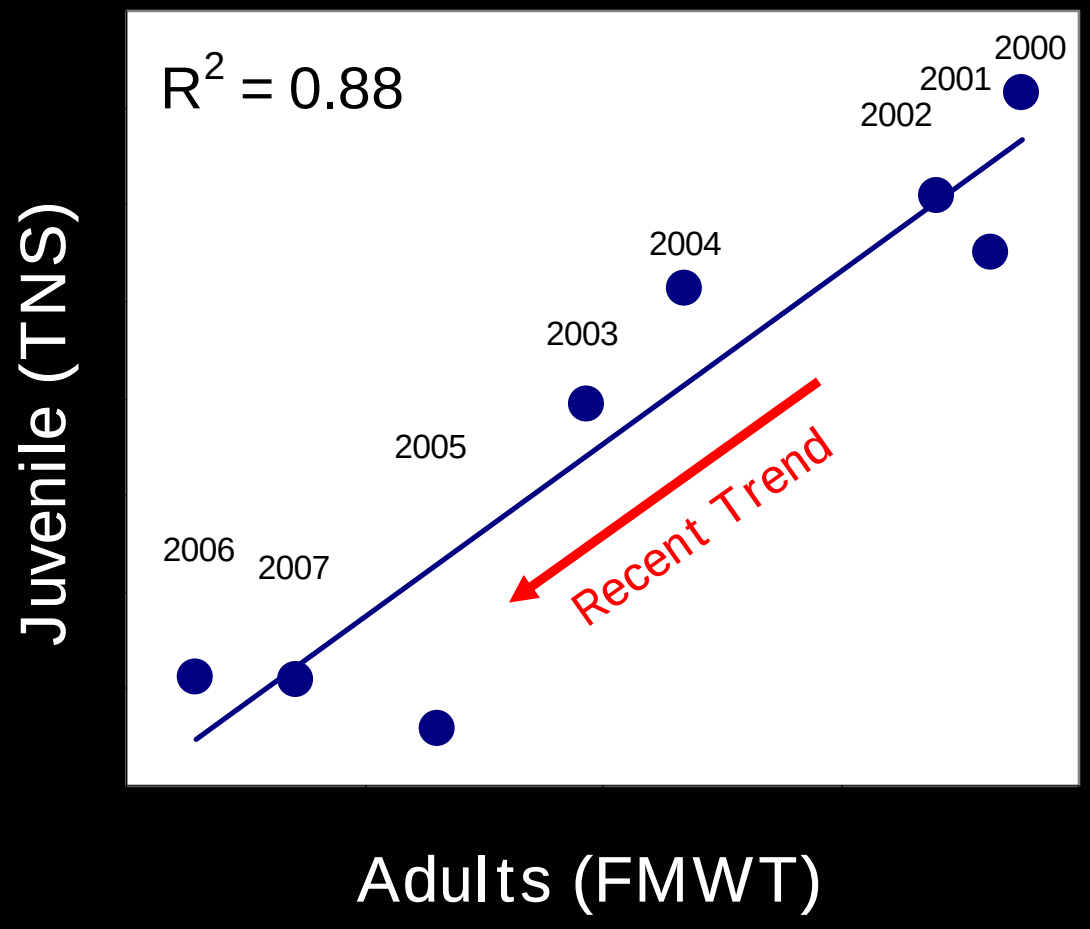
Threadfin shad



Delta smelt

Fall Midwater Trawl (Adults)

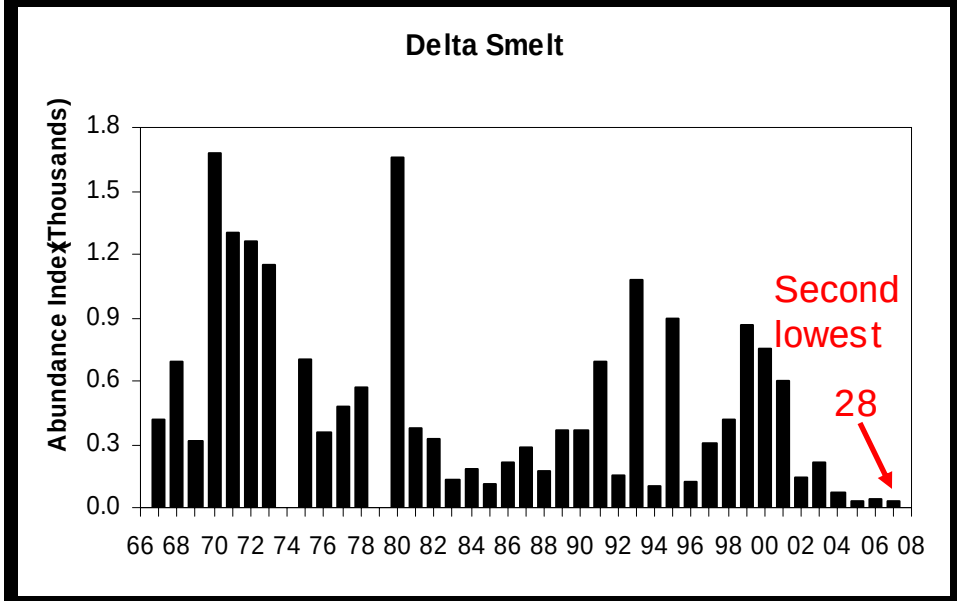
Have Delta Smelt Dropped Below Critical Population Levels?

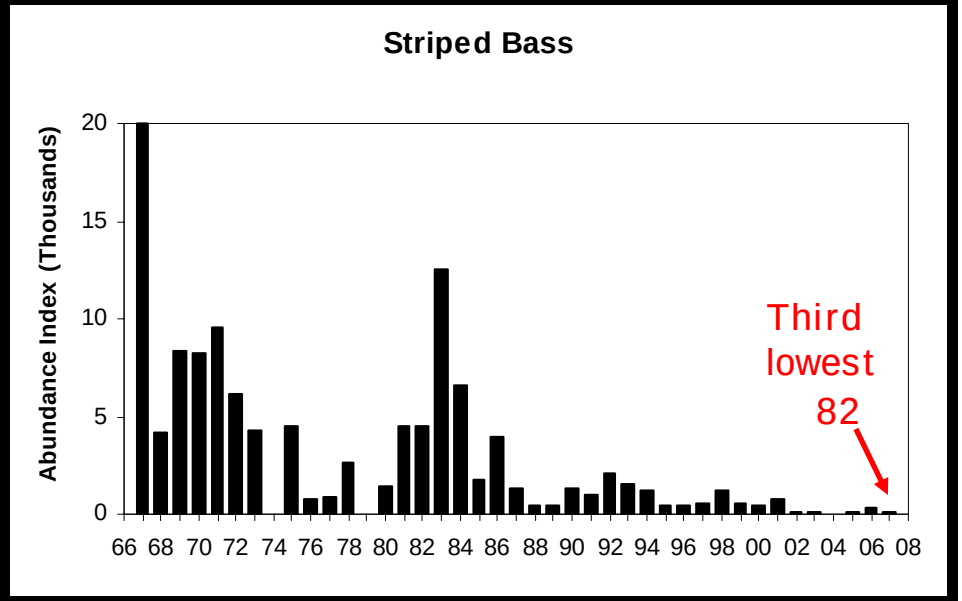


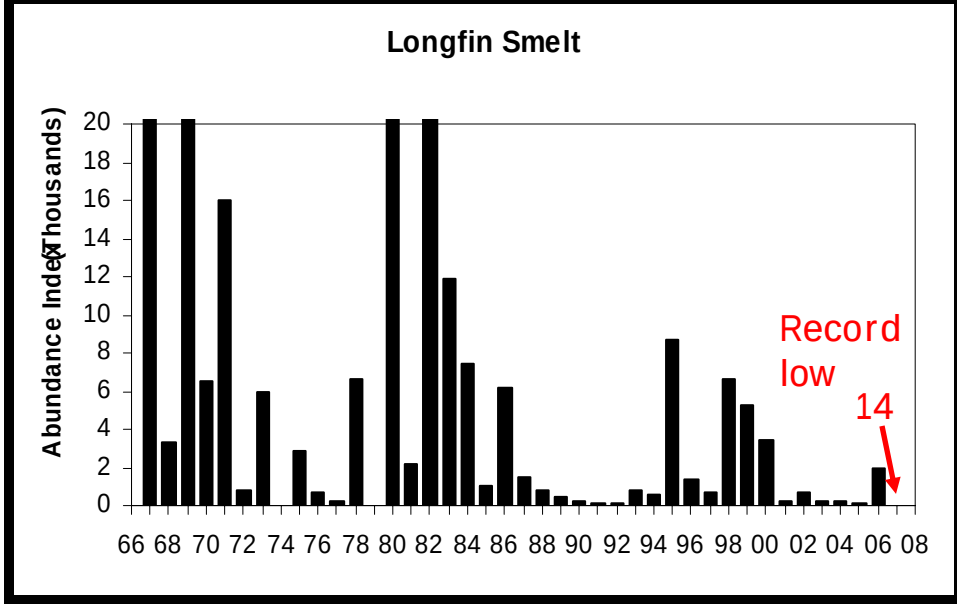
Source: Anke Mueller-Solger (DWR)

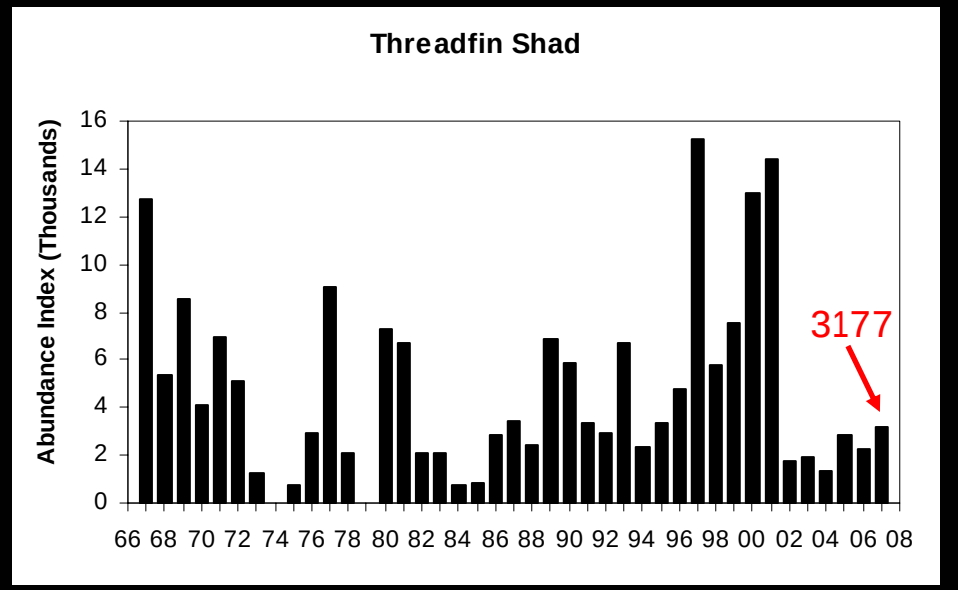
Fall abundance in 2007 continued to decline for all POD fishes.

Source: DFG 2007 Fall MW Trawl
No sampling 1974 and 1979









FISH
ABUNDANCE

PHYSICAL
&
CHEMICAL
FISH
HABITAT

FISH ABUNDANCE

PHYSICAL & CHEMICAL FISH HABITAT

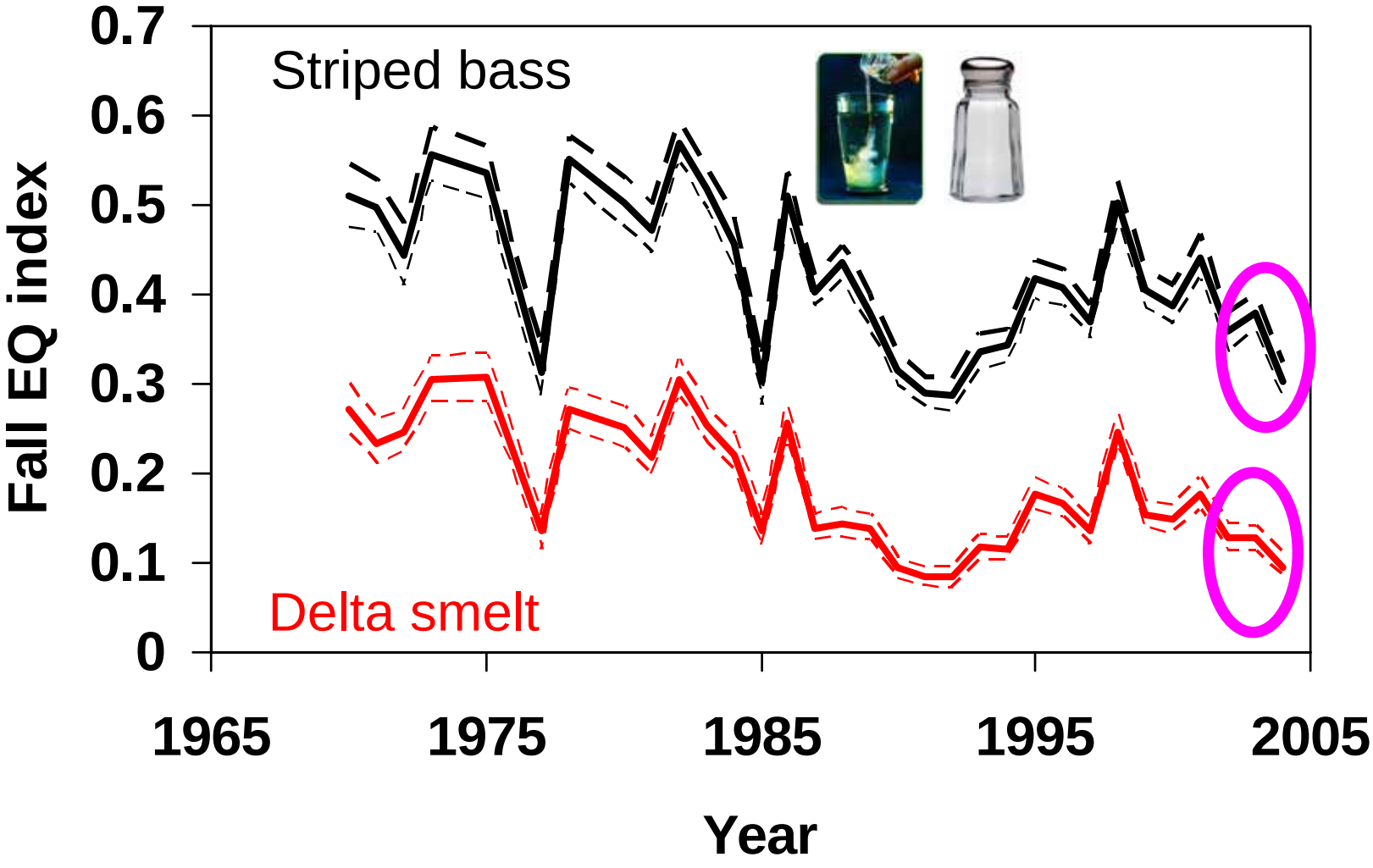
Temperature
Turbidity
Salinity
Nutrients

Contaminants

Disease

Toxic algae

Fall “habitat quality” deteriorated



Source: Feyrer et al. (CJFAS 2007)

Causes of Changes in Fall Turbidity

Reduced Sediment Inputs

Continued Spread by Egeria

Source: Erin Hestir (UCD), Dave Schoellhamer (USGS)

Causes of Changes in Fall Salinity

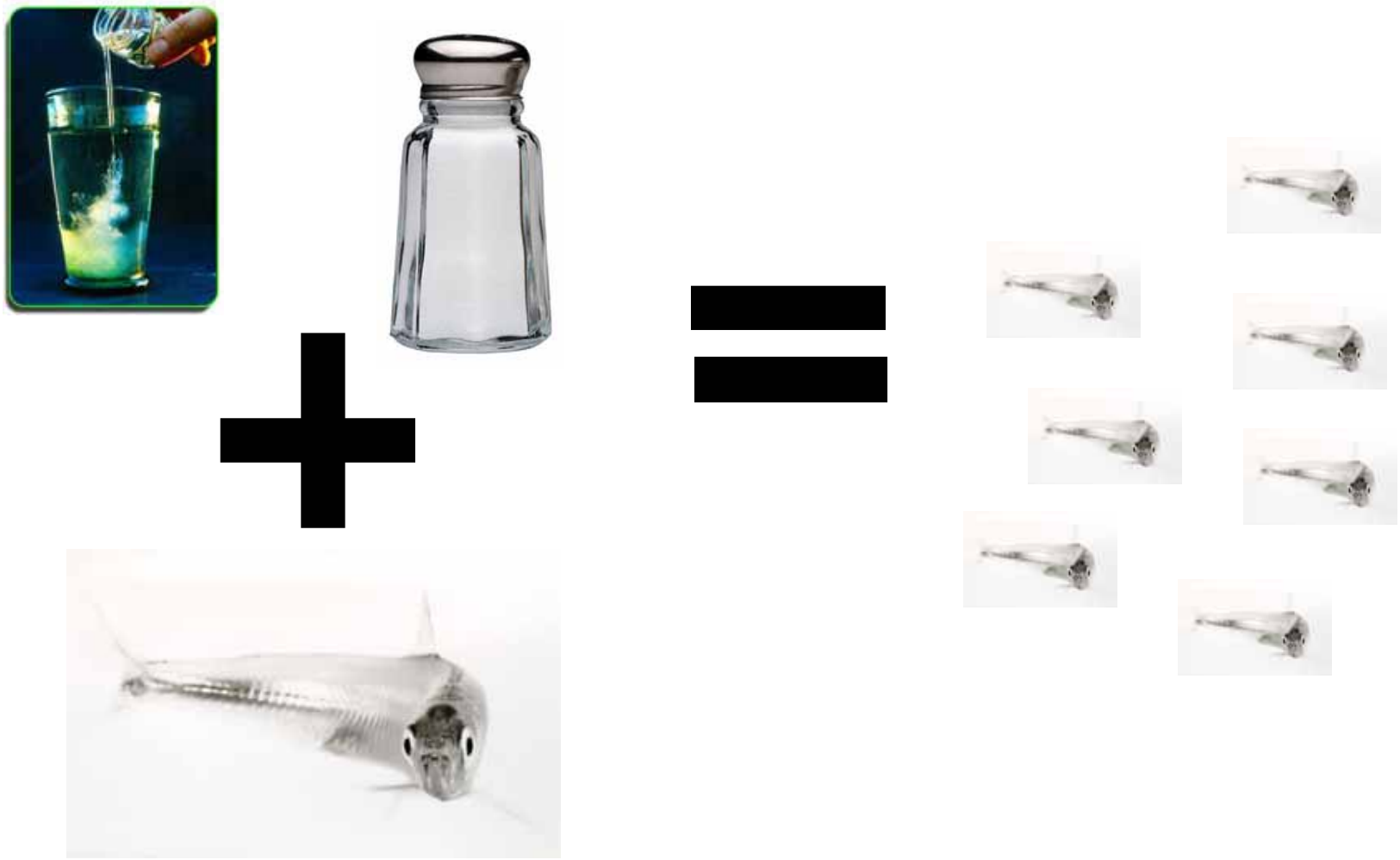
Suisun Marsh Salinity Control Gates

Delta Cross Channel

E/I Ratios

Source: Marianne Guerin (CCWD), Dave Fullerton (MWD), Wim Kimmerer (SFSU), Chris Enright (DWR)

Fall “habitat quality” matters to the delta smelt population



Fall EQ + Fall Abundance predicts juvenile production

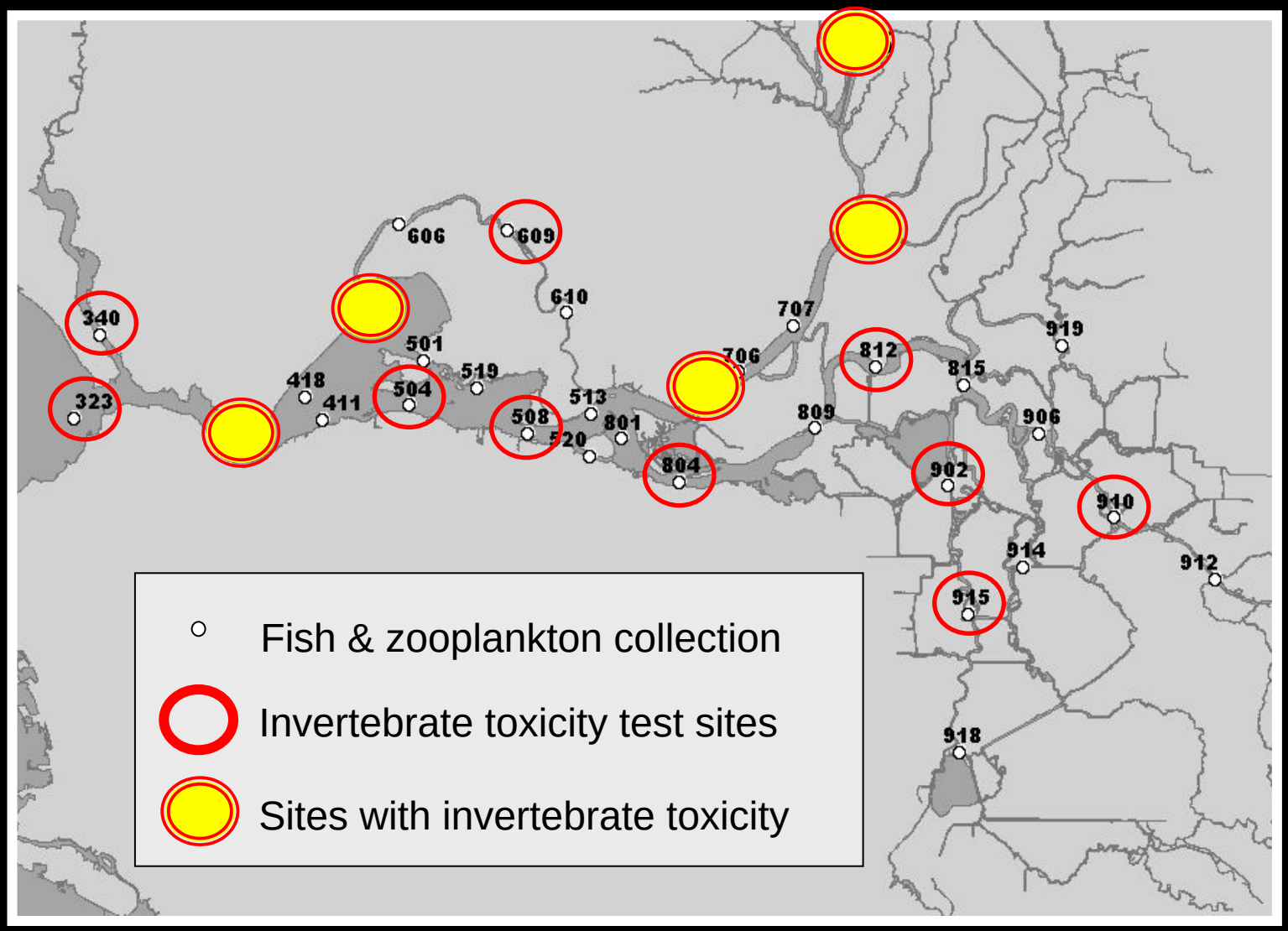
Other habitat stressors

- Bioassays showed little effect (<5 %) in 2005 or 2006.
- <15% adult delta smelt impaired
- 100 % of young striped bass show multiple infections

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

Increased Toxicity in 2007?

January – July Results



Source: Inge Werner (UCD)

POD & Nutrients

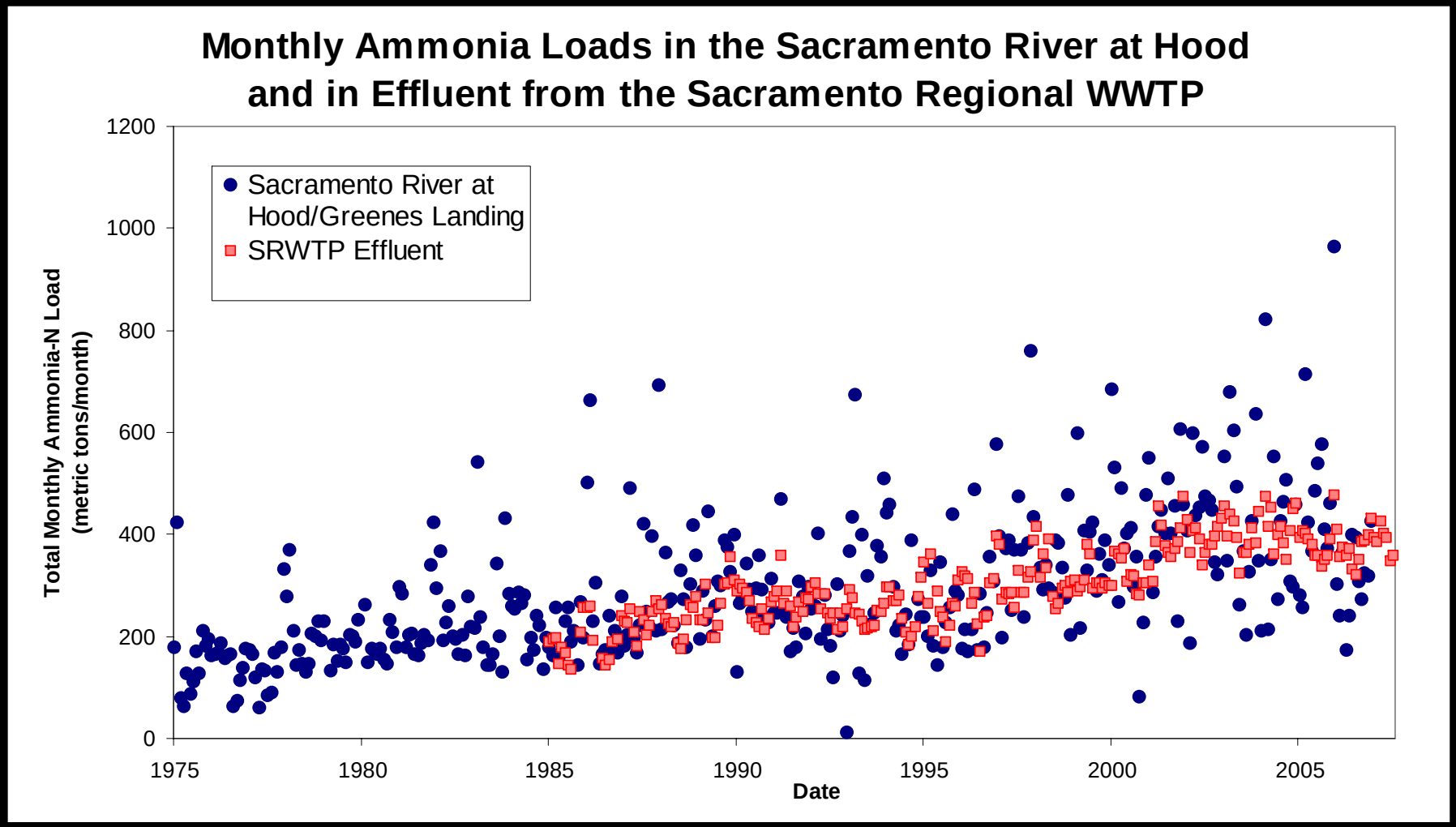
Example: Ammonia pollution

Sewage Treatment Plants

Increasing Ammonia levels in Delta and Suisun Bay

Potential Ecosystem Effects

~ 90% of the Ammonia Load at Hood comes from the Sacramento Regional Wastewater Treatment Plant



Sources: A. Mueller-Solger, DWR; A. Jassby, in press SFEWS

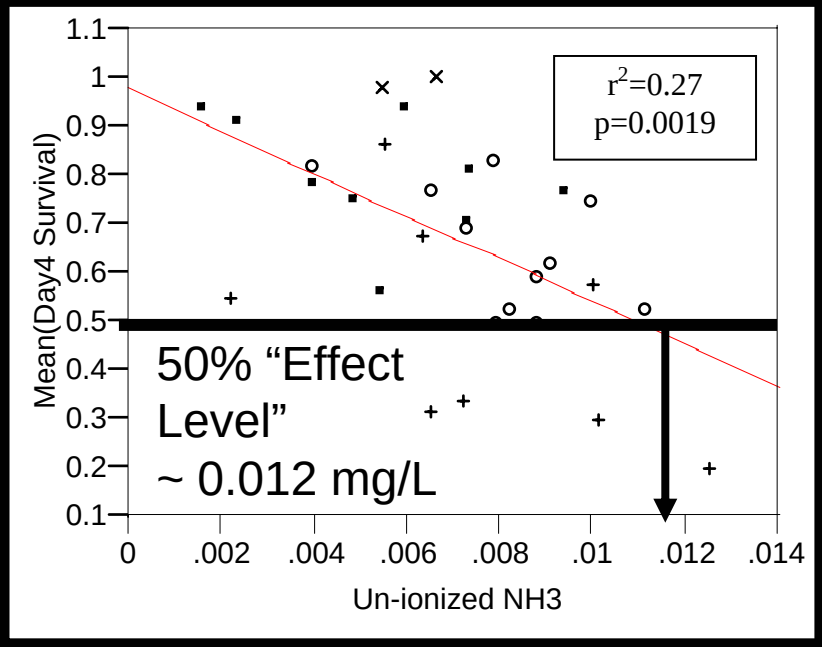
Unionized ammonia is toxic to fish

- Salmonids are particularly sensitive
- Delta smelt may be more sensitive
- More work needs to be done

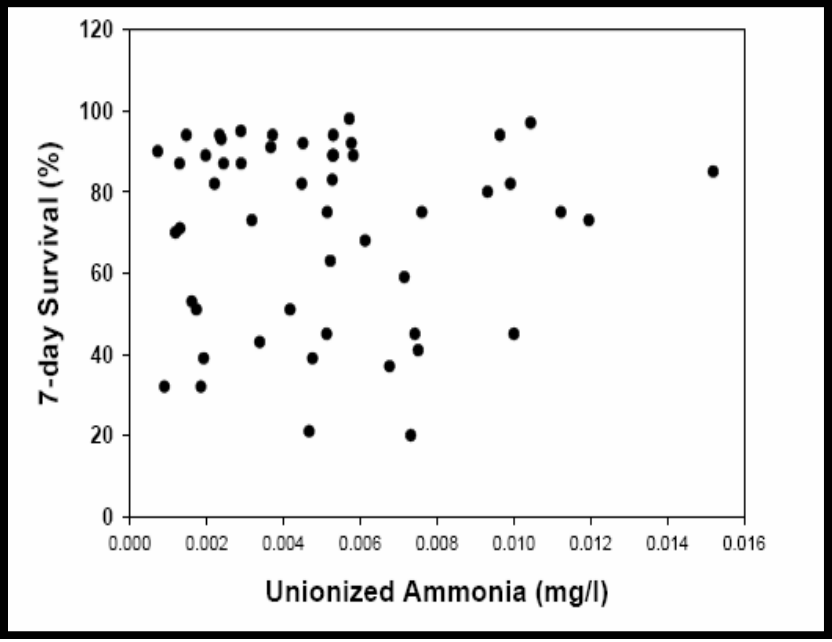
Delta smelt survival versus un-ionized ammonia (mg N/L) in ambient Delta water samples and control water

Graphs provided by Dr. Inge Werner, UCD-ATL

2006

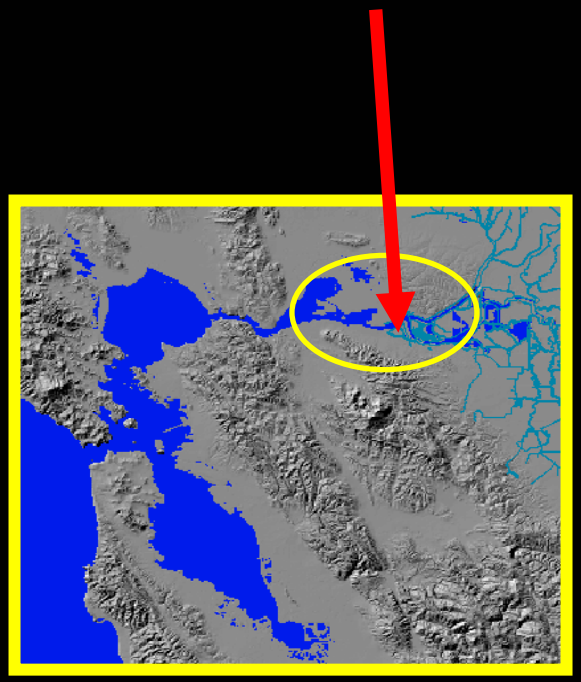


2007



Widespread blooms of the toxic alga *Microcystis* in 2007

August Levels: 1.3 million cells/mL



Core Habitat of Delta Smelt

Microcystis grows well on ammonia! (Diatoms don't)

Source: Peggy Lehman (DWR)

TOP-DOWN

Water Diversions

Predation

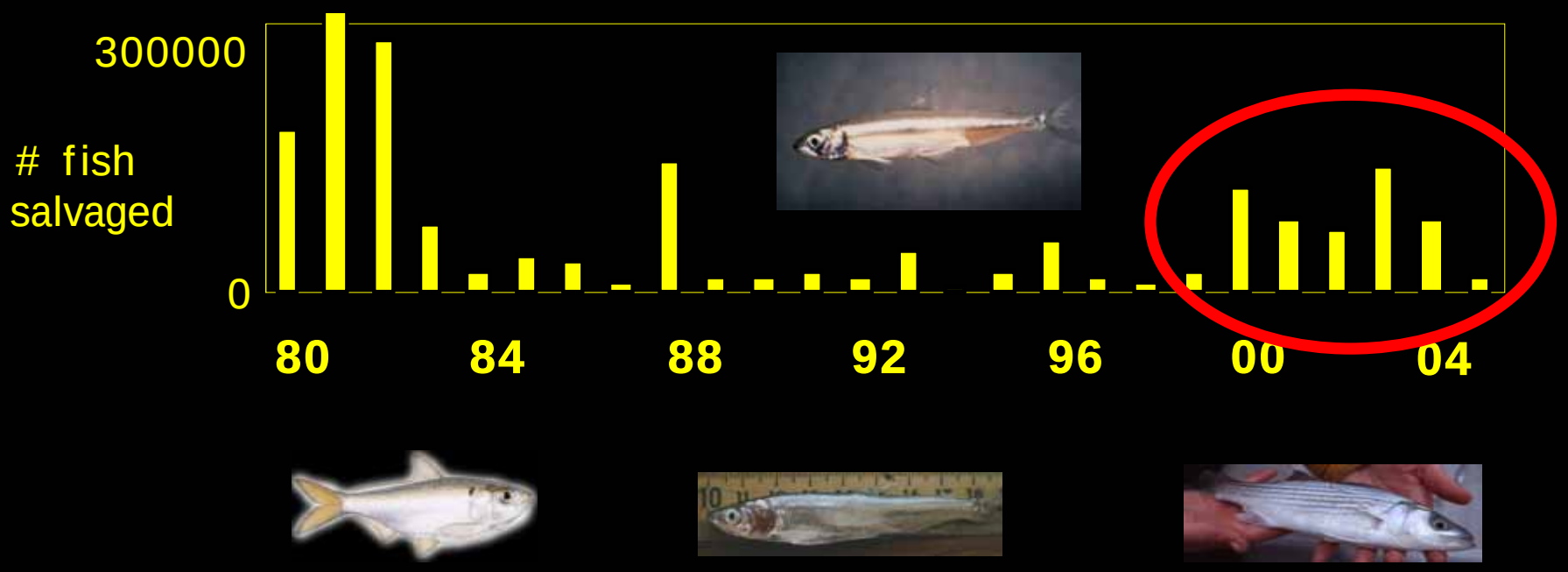
FISH ABUNDANCE

Water Project Losses

Up to 35-65 Percent of Delta Inflow

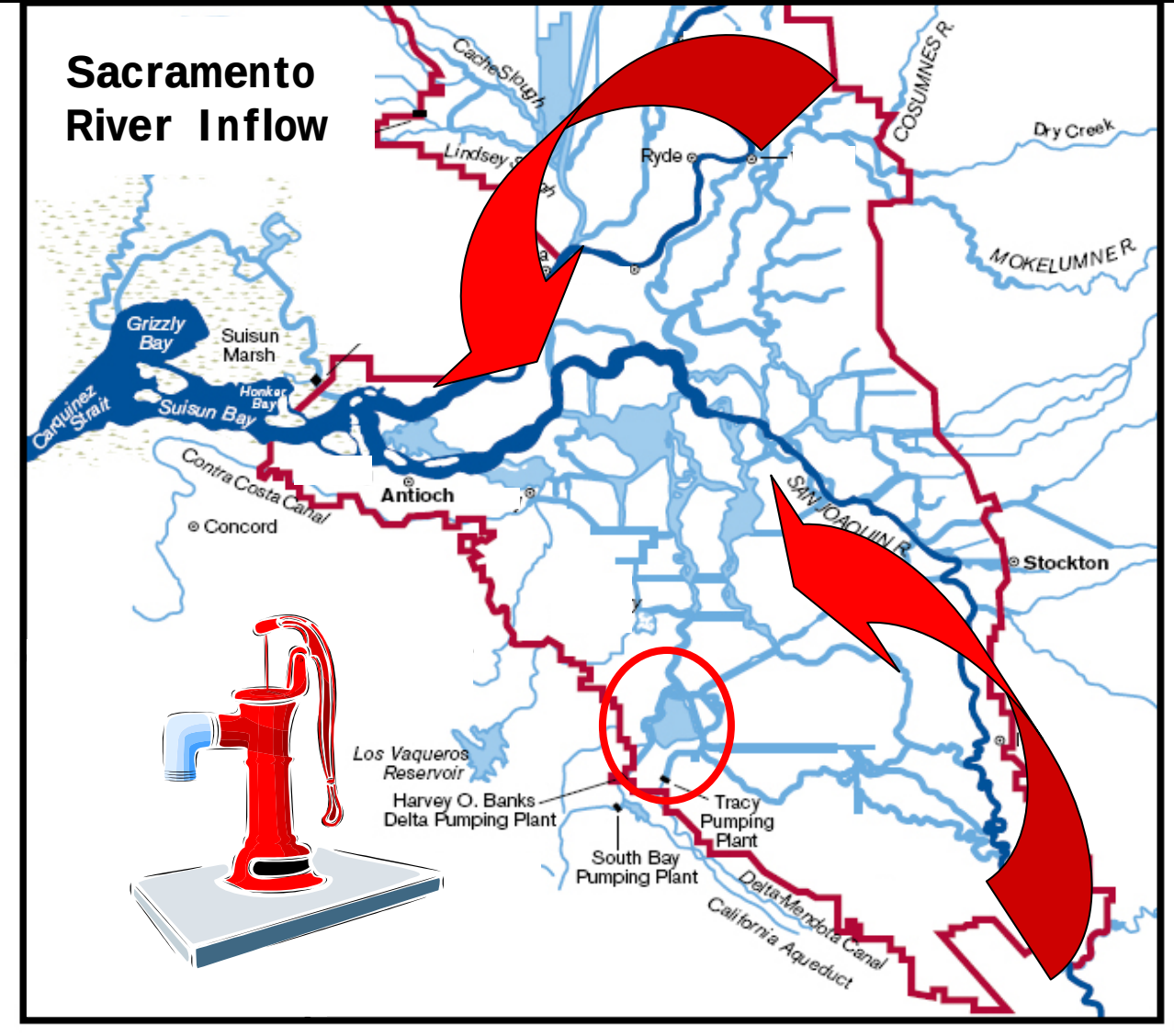
Fish Facilities Provide Data on Numbers Salvaged

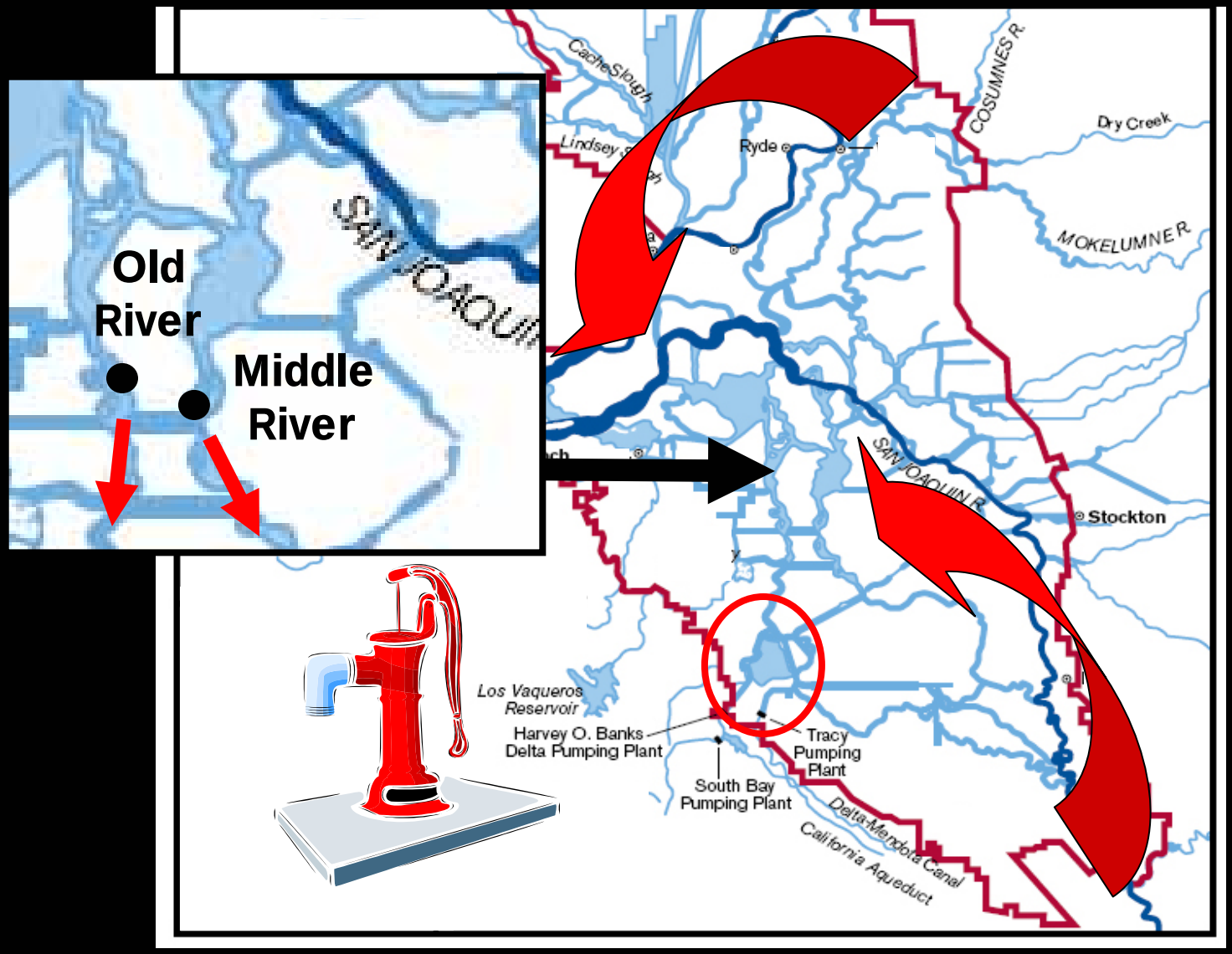
Evidence of Increased Entrainment of Adult Delta Smelt During Winter



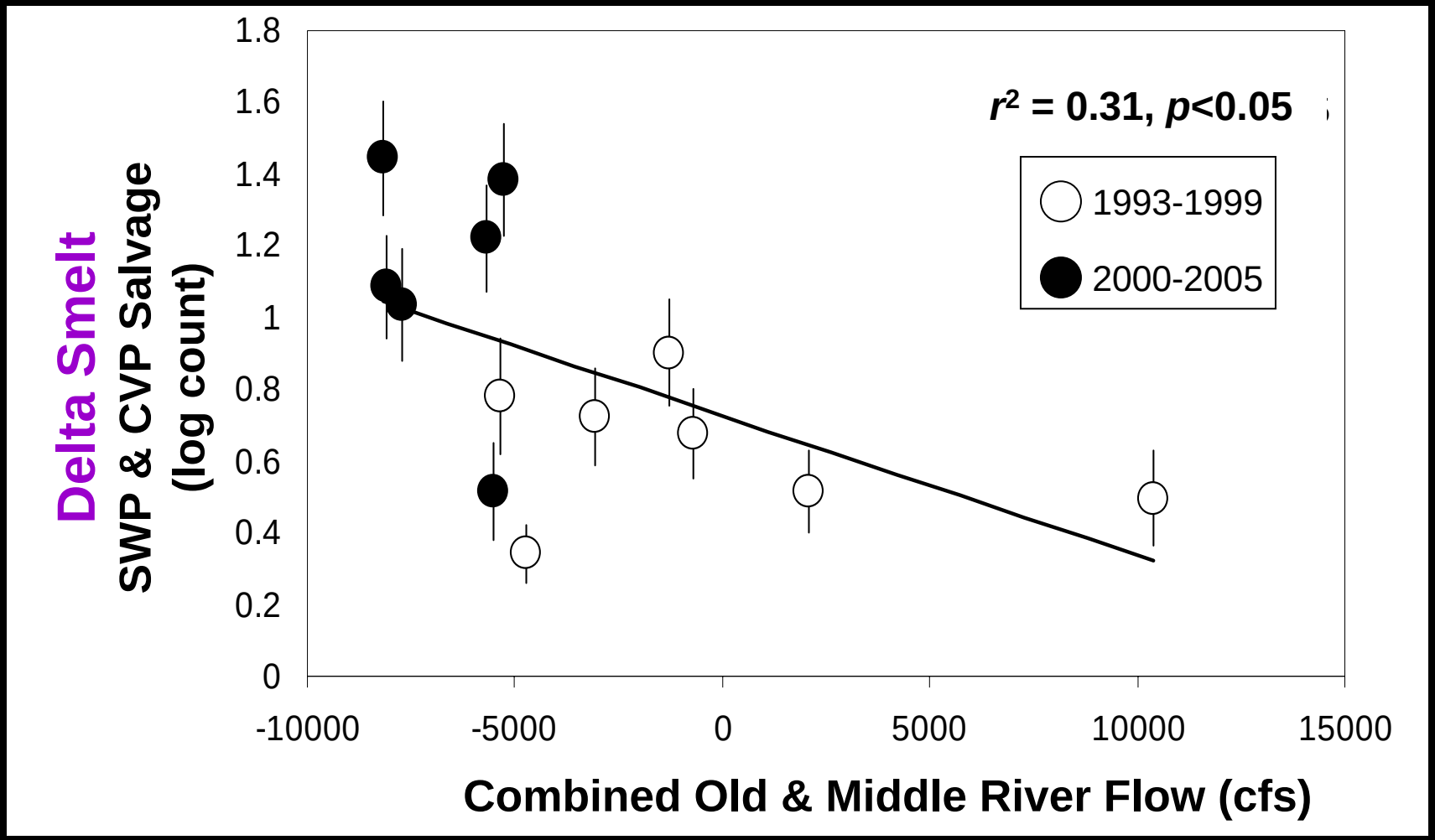
Source: IEP (2005), Grimaldo (In prep)

Sacramento River Inflow




Old River
Middle River
SAN JOAQUIN
Cache Slough
Lindsey
Ryde
COSUMNES R.
Dry Creek
MOKELUMNE R.
SAN JOAQUIN R.
Stockton
Los Vaqueros Reservoir
Harvey O. Banks Delta Pumping Plant
Tracy Pumping Plant
South Bay Pumping Plant
Delta-Mendota Canal
California Aqueduct

Negative Old & Middle River Flows Apparently Increase Adult Delta Smelt Entrainment



Mean Values for December - March

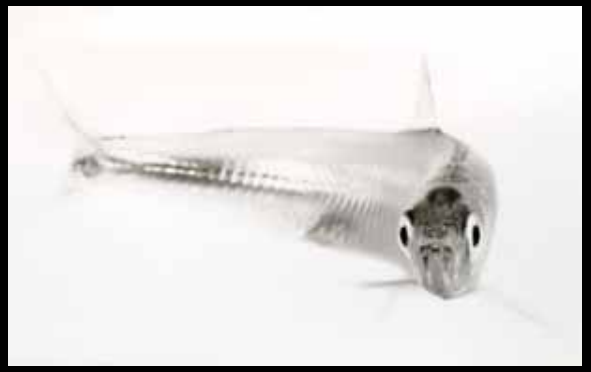
1993 - 2005

Source: Source Lenny Grimaldo (In Review)

Exports

or

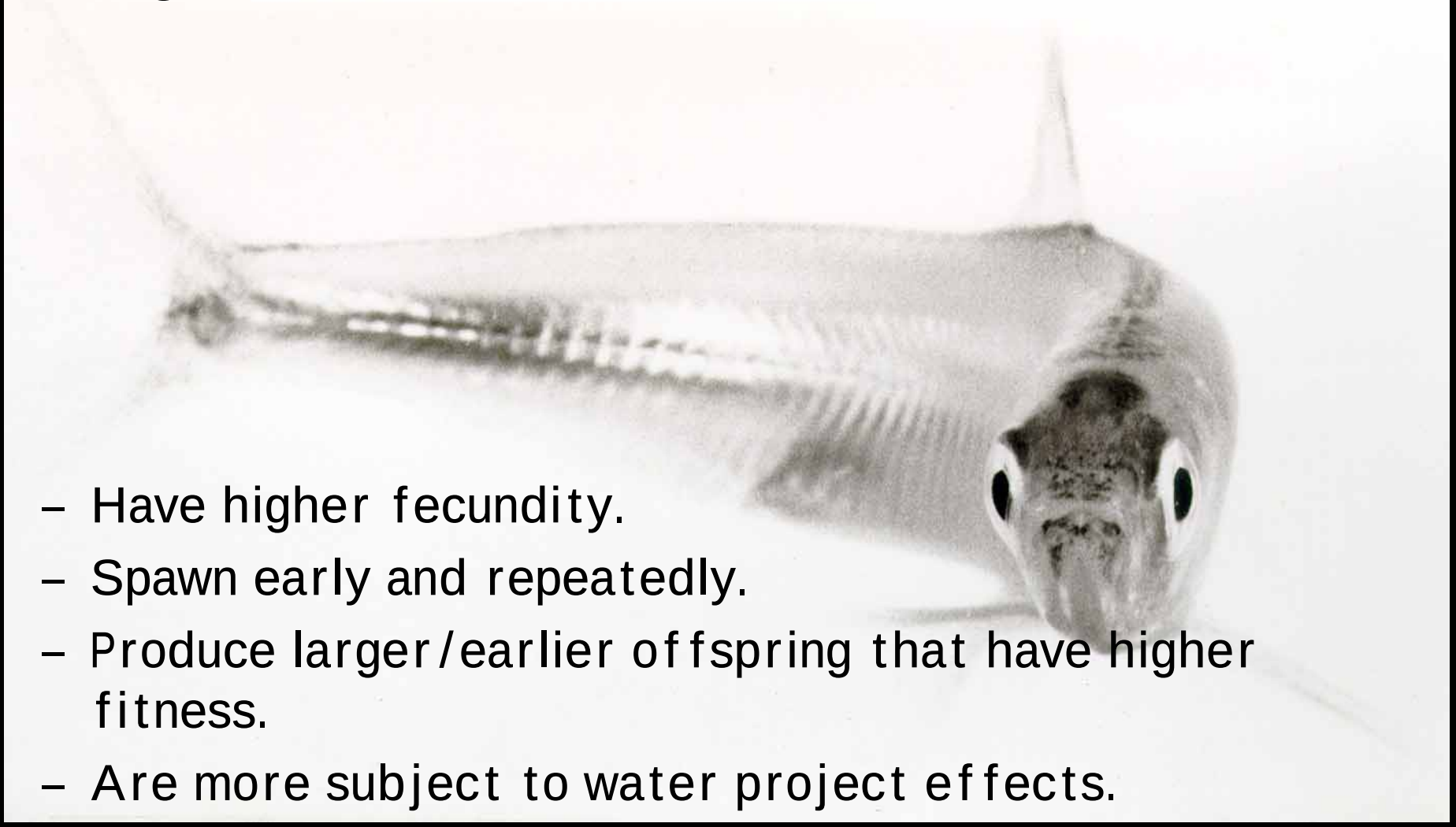
Old and Middle River Flow



Only 1.5% of
Variation Explained

Bill Bennett's BIG MAMA Hypothesis

Larger/older females:



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

FISH ABUNDANCE

Food availability

Food quality

BOTTOM-UP

Bigger Changes in Phytoplankton Quality Than in Quantity

Quantity:

- Low Biomass and Productivity in the Delta & Suisun Bay.
- Prior to 1995: Delta-wide Declines
- 1996-2005: **Positive or Neutral** Trends

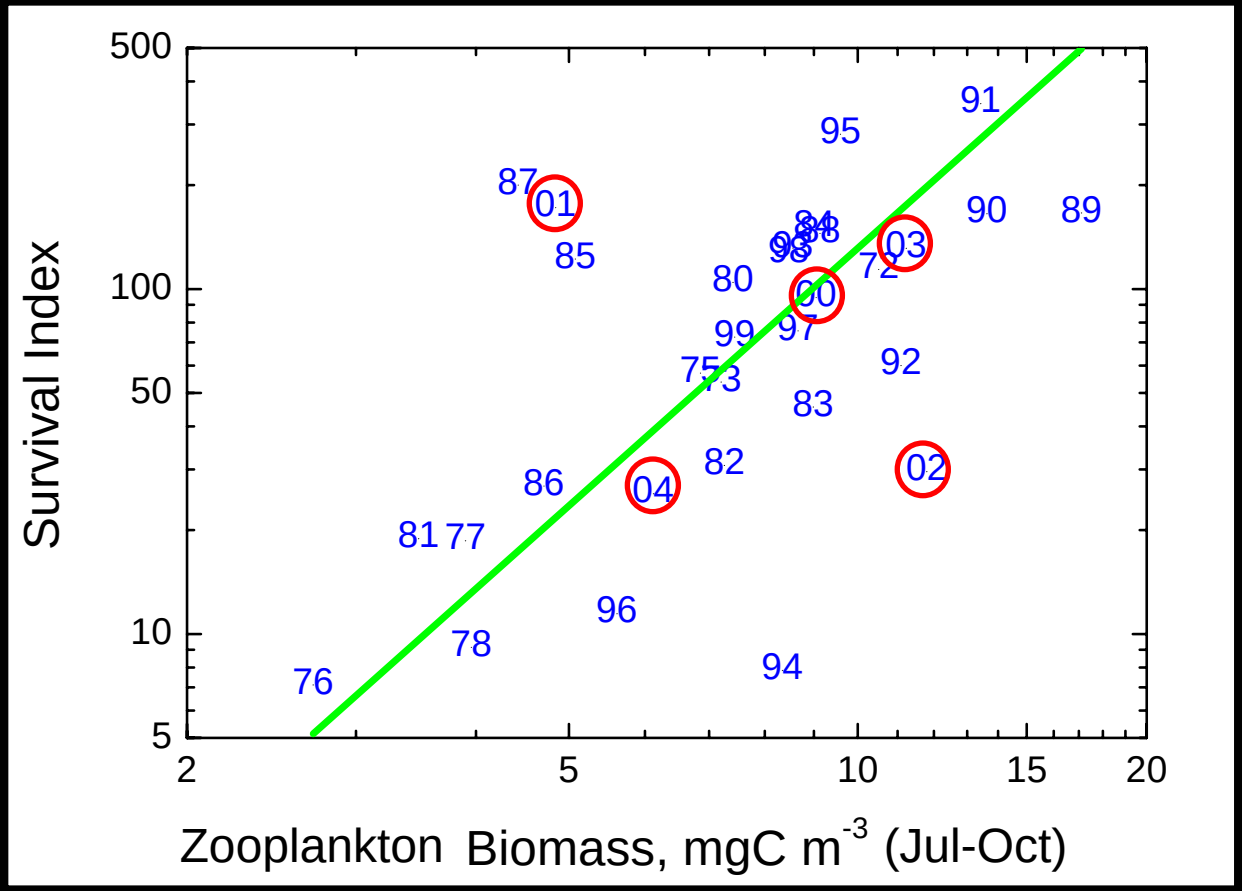
Quality:

- On the Rise: Less-Nutritious or Toxic Species, e.g. *Microcystis*

Source: Jassby et al. (2002, In press), Lehman et al. (2005: 2007)

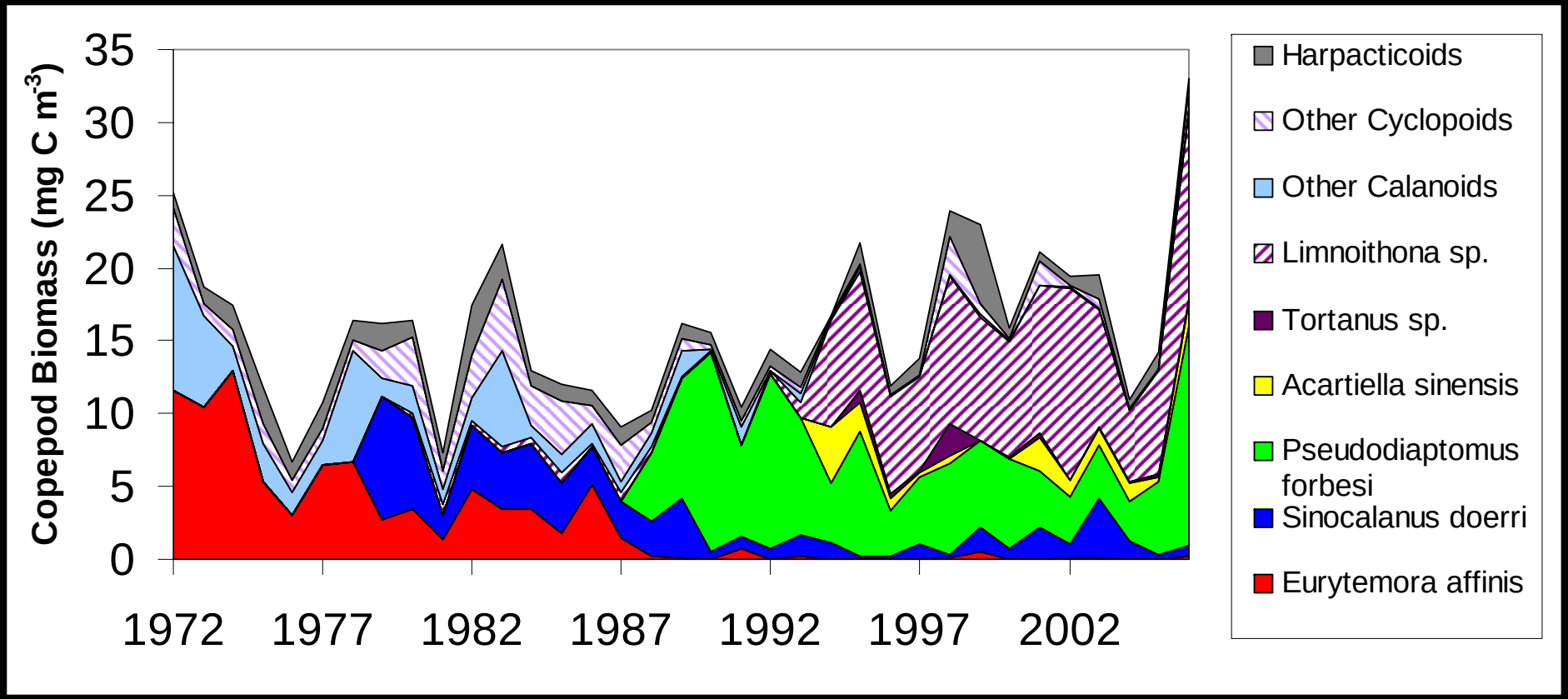
Food Affects Summer Smelt Survival

But Recent Levels Were Not Remarkable

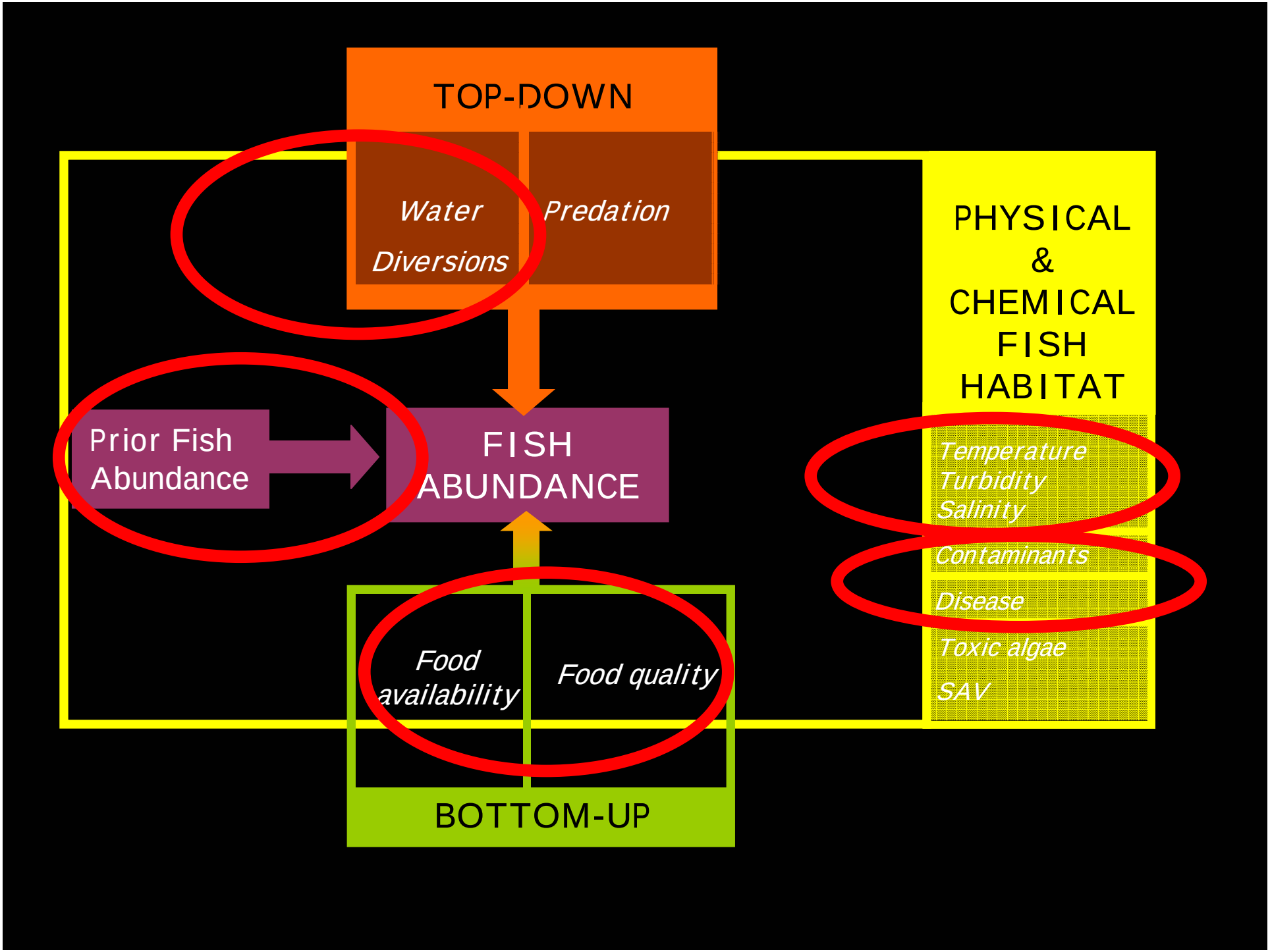


Source: Wim Kimmerer (In review)

No Major Change in Zooplankton Biomass, But Big Change In Species



Source: Anke Mueller-Solger (DWR); IEP (2007)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Contaminants
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Toxic algae
SAV
Food availability
Food quality
BOTTOM-UP